Interior Exploration Using Seismic Investigations, Geodesy, and Heat Transport (InSight) Mission

Heat Flow and Physical Properties Package (HP³) and Radiometer (RAD)

PDS Archive

Software Interface Specification

Rev. 1.0

October 15, 2018

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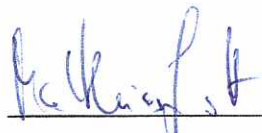matthias.grott@dlr.de

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InSight

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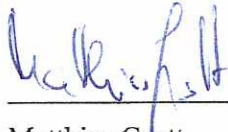
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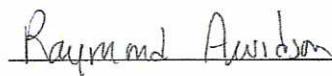
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1   Introduction

This software interface specification (SIS) describes the format and content of the Heat Flow and Physical Properties Package (HP^3) and Radiometer (RAD) Planetary Data System (PDS) data archive. It includes descriptions of the data products and associated metadata, and the archive format, content, and generation pipeline.

1.1   Document Change Log

Table 1: Document Change Log

Version	Change	Date	Affected portion
0.1	Initial draft	July 15, 2014	All
0.2	Included instrument description, clarification of minor issues	Sept 18, 2014	
0.3	P3 = Physical Properties Package; revised title page and Appx A; stated that products will be ASCII tables; updated Applicable Software.	Nov. 3, 2014	Title page, Appx A, 3.3.3, 3.4
0.4	Added coordinate system, file naming convention, updated Sec. 5	Nov. 11, 2014	Sec 3.2.2., Sec 3.3.2., Sec. 4.1.3., Sec. 5
0.5	Added lists of tables and figures. Minor cleanup.	Mar. 24, 2015	All
0.6	Added items to abbreviations, clarified time standards, minor cleanup	Apr. 1, 2015	All
0.9	Included editorial suggestions from peer review	Sep 1, 2015	All
1.0	Updated following derived data peer review	Oct. 1, 2018	All
1.0	Inserted post-peer-review versions of labels	Oct. 15, 2018	Appendix B

1.2   TBD Items

Item	Change	Affected portion
None		

1.3   Abbreviations

Table 2: Abbreviations and Their Meanings

Abbreviation	Meaning
ADC	Analog to Digital Converter

Abbreviation	Meaning
APSS	Auxiliary Payload Sensor Subsystem
ASCII	American Standard Code for Information Interchange
BEE	Backend Electronics
CDR	Calibrated Data Record
CODMAC	Committee on Data Management, Archiving, and Computing
DN	Digital Number
EDAC	Error Detection and Correction
EDR	Experiment Data Record
FET	Field Effect Transistor
FOV	Field of View
FPGA	Field Programmable Gate Array
FTP	File Transfer Protocol
GB	Gigabyte(s)
GEO	PDS Geosciences Node (Washington University, St. Louis, Missouri)
GSFC	Goddard Space Flight Center (Greenbelt, MD)
HK	Housekeeping
HP^3	Heat Flow and Physical Properties Package
HTML	Hypertext Markup Language
ICD	Interface Control Document
IDA	Instrument Deployment Arm
IM	Information Model
IPHT	Institute of Photonic Technology
IR	Infrared
ISO	International Standards Organization
JPL	Jet Propulsion Laboratory (Pasadena, CA)
LED	Light Emitting Diode
LID	Logical Identifier
LIDVID	Versioned Logical Identifier (logical identifier with version identifier)
LTST	Local true solar time
MAG	Magnetometer
MB	Megabyte(s)
MD5	Message-Digest Algorithm 5

Abbreviation	Meaning
MUX	Multiplexer
NAIF	Navigation and Ancillary Information Facility (JPL)
NASA	National Aeronautics and Space Administration
NSSDC	National Space Science Data Center (GSFC)
PCB	Printed Circuit Board
PDS	Planetary Data System
PDS4	Planetary Data System Version 4
PID	Proportional-Integral-Derivative (controller)
PT100	Platinum Temperature Detector
PWM	Pulse Width Modulation
RAD	Radiometer
RC filter	Resistor Capacitor Filter
RISE	Rotation and Interior Structure Experiment
RTD	Resistance Temperature Detector
SEIS	Seismic Experiment for Investigating the Subsurface
SIS	Software Interface Specification
SPICE	Spacecraft, Planet, Instrument, C-matrix, and Events (NAIF data format)
SPK	Spacecraft and Planetary ephemeris Kernel (NAIF)
STATIL	Static Tiltmeter
TBD	To Be Determined
TEM-A	Thermal Excitation and Measurement - Active
TEM-P	Thermal Excitation and Measurement - Passive
TLM	Tether Length Monitor
URN	Uniform Resource Name
UTC	Coordinated Universal Time
VID	Version Identifier
WU	Washington University, St. Louis
XML	eXtensible Markup Language

1.4 Glossary

Many of these definitions are taken from Appendix A of the PDS4 (Planetary Data System Version 4) Concepts Document, pds.nasa.gov/pds4/doc/concepts. The reader is referred to that document for more information.

Archive – A place in which public records or historical documents are preserved; also the material preserved, often used in plural. The term may be capitalized when referring to all of PDS holdings (i.e., the PDS Archive).

Basic Product – The simplest product in PDS4; one or more data objects (and their description objects), which constitute (typically) a single observation, document, etc. The only PDS4 products that are *not* basic products are collection and bundle products.

Bundle – A list of related collections. For example, a bundle could list a collection of raw data obtained by an instrument during its mission lifetime, a collection of the calibration products associated with the instrument, and a collection of all documentation relevant to the first two collections.

Class – The set of attributes (including a name and identifier) which describes an item defined in the PDS Information Model. A class is generic, i.e., a template from which individual items may be constructed.

Collection – A list of closely related basic products of a single type (e.g. observational data, browse files, documents, etc.). A collection is itself a product (because it is simply a list, with its label), but it is not a *basic* product.

Data Object – A generic term for an object that is described by a description object. Data objects include both digital and non-digital objects.

Description Object – An object that describes another object. As appropriate, it will have structural and descriptive components. In PDS4 a 'description object' is a digital object, such as a string of bits with a predefined structure.

Digital Object – An object which consists of electronically stored (digital) data.

Identifier – A unique character string by which a product, object, or other entity may be identified and located. Identifiers can be global, in which case they are unique across all of PDS (and its federation partners). A local identifier must be unique within a label.

Label – The aggregation of one or more description objects such that the aggregation describes a single PDS product. In the PDS4 implementation, labels are constructed using XML (eXtensible Markup Language).

Logical Identifier (**LID**) – An identifier that identifies the set of all versions of a product.

Versioned Logical Identifier (LIDVID) – The concatenation of a logical identifier with a version identifier, providing a unique identifier for each version of product.

Metadata – Data about data. For example, a 'description object' contains information (metadata) about an 'object.'

Object – A single instance of a class defined in the PDS Information Model.

PDS Information Model – The set of rules governing the structure and content of PDS metadata. While the Information Model (IM) has been implemented in XML for PDS4, the model itself is implementation independent.

Product – One or more labeled objects (digital, non-digital, or both) grouped together and having a single PDS-unique identifier. In the PDS4 implementation, if a product consists of multiple objects, their descriptions are combined into a single XML label. Although it may be possible to locate individual objects within PDS (and to find specific bit strings within digital objects), PDS4 defines 'products' to be the smallest granular unit of addressable data within its complete holdings.

Registry – A data base that provides services for sharing content and metadata.

XML schema – The definition of an XML document, specifying required and optional XML elements, their order, and parent-child relationships.

2 Overview

2.1 Purpose and Scope

The purpose of this Software Interface Specification (SIS) document is to provide users of the Heat Flow and Physical Properties Package/Radiometer (HP^3/RAD) archive with a detailed description of the data products and how they are generated, along with a description of the PDS4 archive bundle, the structure in which the data products, documentation, and supporting material are stored. The users for whom this document is intended are the scientists who will analyze the data, including those associated with the project and those in the general planetary science community.

This SIS covers raw data products generated by HP^3 and RAD and the higher level products derived from them that are intended to be archived in the Planetary Data System (PDS). In particular, these products are HP^3 active temperature (TEM-A) and passive temperature (TEM-P) raw, calibrated and derived data, static tilt (STATIL) and tether length monitor (TLM) raw, calibrated and derived data, and radiometer (RAD) raw, calibrated and derived data.

2.2 SIS Contents

This SIS describes how the HP^3 and RAD instruments acquire data, and how the data are processed, formatted, labeled, and uniquely identified. The document discusses standards used in generating the data products and software that may be used to access the products. The data structure and organization are described in sufficient detail to enable a user understand the instrument, data collection strategies, calibration, and data processing.

Appendices list cognizant persons involved in generating the archive.

2.3 Applicable Documents

[1] Planetary Data System Standards Reference, Version 1.10.1.0, May 10, 2018.

[2] PDS4 Data Dictionary, Abridged, Version 1.10.1.0, May 7, 2018.

[3] Planetary Data System (PDS) PDS4 Information Model Specification, Version 1.10.1.0, May 7, 2018.

[4] InSight Archive Generation, Validation, and Transfer Plan, Rev. A, August 16, 2017.

[5] InSight Heat Flow and Physical Properties Package (HP^3) and Radiometer Science Team and PDS Geosciences Node Interface Control Document (ICD), April 14, 2014.

[6] Sapritzky, V.I, et al., Blackbody Sources for the Range 100 K to 3500 K for Precision Measurements in Radiometry and Radiation Thermometry, in: Temperature: Its Measurement and Control in Science and Industry, vol. 7, 619-624 (2003), doi: 10.1063/1.1627196.

The PDS4 Documents [1] through [3] are subject to revision. The most recent versions may be found at pds.nasa.gov/pds4. The HP^3 and RAD PDS4 products specified in this SIS have been designed based on the versions current at the time, which are those listed above. Data products will be static and will not be changed if new versions of documents [1] to [3] become available.

2.4 Audience

This document serves both as a Data Product SIS and an Archive SIS. It describes the format and content of HP^3 and RAD data products in detail, and the structure and content of the archive in which the data products, documentation, and supporting material are stored. This SIS is intended to be used both by the instrument team in generating the archive and by data users wishing to understand the format and content of the archive. Typically these individuals would include scientists, data analysts, and software engineers.

2.5 InSight Mission

InSight will be launched in May 2018 and will place a single geophysical lander on Mars on November 26, 2018, to study its deep interior. The Surface Phase consists of Deployment and Penetration, and Science Monitoring. It ends after one Mars year plus 40 sols.

The science payload consists of two instruments: the Seismic Experiment for Interior Structure (SEIS) and the Heat-Flow and Physical Properties Package (HP^3). In addition, the Rotation and Interior Structure Experiment (RISE) will use the spacecraft X-band communication system to provide precise measurements of planetary rotation. SEIS and HP^3 are placed on the surface with an Instrument Deployment System (IDS) comprising an Instrument Deployment Arm (IDA), Instrument Deployment Camera (IDC), and Instrument Context Camera (ICC). There are also several supporting instruments. The Auxiliary Payload Sensor Subsystem (APSS) includes the pressure sensor, the magnetometer, and Temperature and Wind for InSight (TWINS) sensors and collects environmental data in support of SEIS. These data will be used by SEIS to reduce and analyze their data. The radiometer (RAD) will be used by the HP^3 team to measure surface temperature and thermal properties to support their data analysis. This document describes HP^3, its radiometer, and the associated data products.

2.6 HP^3/RAD Instrument Description

The purpose of the HP^3 instrument is to determine the geothermal heat flow at the landing site. This measurement is augmented by a determination of the surface brightness temperature using the HP^3 radiometer (RAD) to determine the forcing function for the subsurface temperatures. To measure heat flow, a self-hammering mole will emplace a suite of temperature sensors and heaters (the TEM sensor suite) into the subsurface. The progress of the mole is monitored by the tether length monitor (TLM), which examines the amount of tether being paid out, as well as the

static tilt meter (STATIL), which determines the orientation of the mole with respect to vertical. In summary, the instrument consists of the following functional subunits:

- *Back End Electronics* (BEE), located in the lander warm electronics box
- *Support System* (including TLM, the science tether, and the mole), which will be deployed onto the surface
- *Science Tether* (TEM-P), which will be emplaced into the ground by the mole
- *Mole* (including TEM-A and STATIL)
- *Radiometer* (RAD), which is mounted under the lander deck

The main hardware elements are shown in Figure 1, where the deployed elements of HP³ (Mole, TLM, and Science Tether) are shown in the left panel, whereas the lander mounted elements (RAD and BEE) are shown on the right panel.
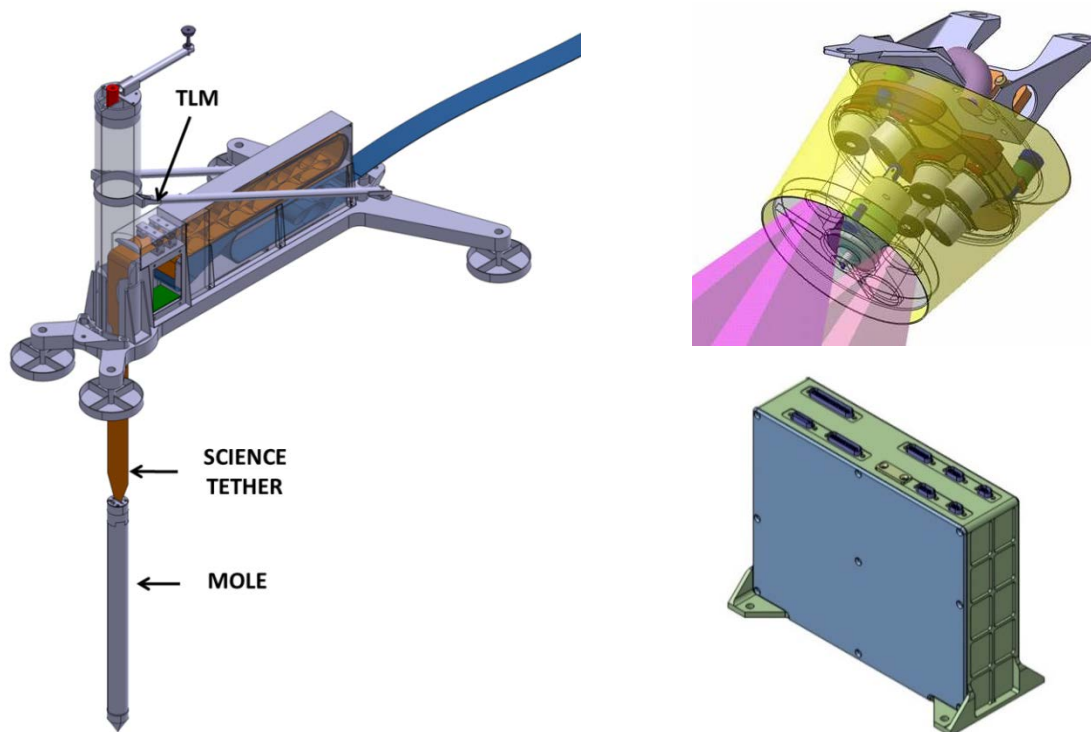
Figure 1: Left: HP³ Deployed Elements including the Mole, Science Tether, and Tether Length Monitor (TLM). Top Right: Radiometer, mounted under the lander deck, indicating the location of the six thermopile sensors and their respective fields of view. Analog to digital conversion is performed in the radiometer sensor head. Bottom Right: Backend electronics housing the circuitry for temperature (TEM) and tilt (STATIL) measurements.

A functional block diagram of the instrument is shown Figure 2, where science sensors are indicated in yellow. TEM-A heaters/sensors are copper based resistors, which simultaneously act as heaters and sensing elements. This is possible because of the large temperature coefficient of resistance for copper, and the $R(T)$ curve for the heaters has been calibrated in the lab. TEM-A

heaters/sensors are operated from the BEE, routing the signals through the engineering and science tethers. In this way, thermal disturbance of the regolith is kept at a minimum while operating these subsystems. The same approach is followed for the STATIL and TLM systems, where analog to digital (A/D) conversion is also performed by the BEE. On the other hand, the radiometer does have A/D conversion electronics integrated in the sensor head, having a purely digital interface to the BEE.
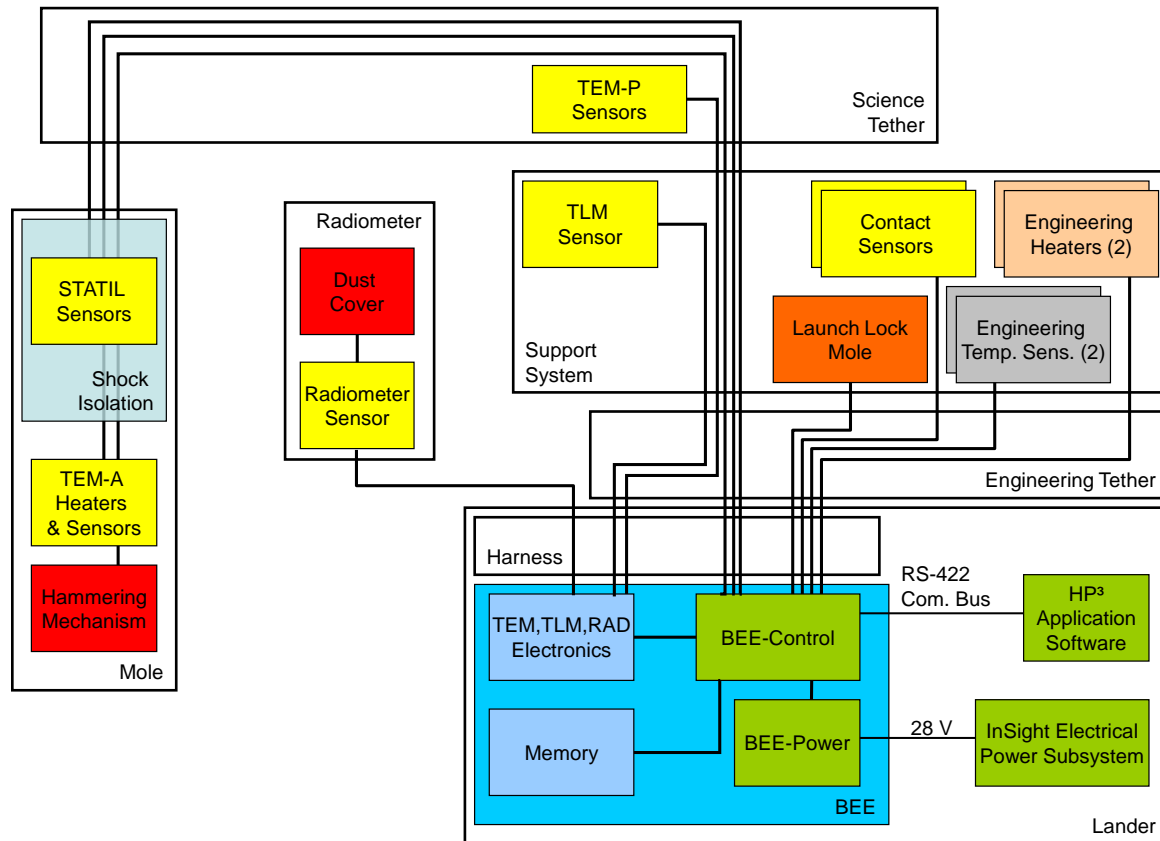
Figure 2: Functional block diagram of the HP³ instrument indicating the lander mounted backend electronics (BEE), the engineering tether connecting the BEE to the deployed elements, the support system, the science tether, and the mole. Sensors are indicated in yellow, whereas mechanisms are indicated in red. The BEE is indicated in blue, software and power interfaces in green, launch locks in orange, engineering heaters in brown, and engineering temperature sensors in gray.

2.6.1 Science Objectives

2.6.1.1 Heat Flow Determination

The level 1 science objective of the HP³ experiment is a determination of the surface heat flow F at the landing site with an uncertainty of better than ±5 mW m⁻². Heat flow, or to be more precise the heat flux density, is given by

$$F = k\frac{dT}{dz}$$

where k is the regolith thermal conductivity, T is temperature, and z is depth. HP^3 measures kinetic temperature T using the TEM-P platinum resistance temperature detectors (PT100), depth z using the inclinations determined by STATIL and length determined by TLM, and thermal conductivity k using a the TEM-A heaters.

2.6.1.2 Surface Brightness Determination

The HP^3 RAD will measure the surface brightness temperature of the Martian regolith inside its field of view away from the lander with an uncertainty of better than 4 K. From these measurements, the shape of the forcing function for subsurface temperature fluctuations will be determined. In addition, measurements of surface brightness temperatures will allow for a determination of the surface thermal inertia at the landing site.

2.6.2 Lander Geometry

2.6.2.1 HP^3 deployment

The HP^3 instrument will be deployed onto the surface of Mars by InSight's robotic arm, and the general geometry of potential placement sites is given in Figure 3. The lander will land in an east-west orientation, putting the workspace for instrument deployment to the south of the lander. It is desired to place HP^3 as far away from the lander as possible, but this will need to be weighed against potential engineering constraints after landing.
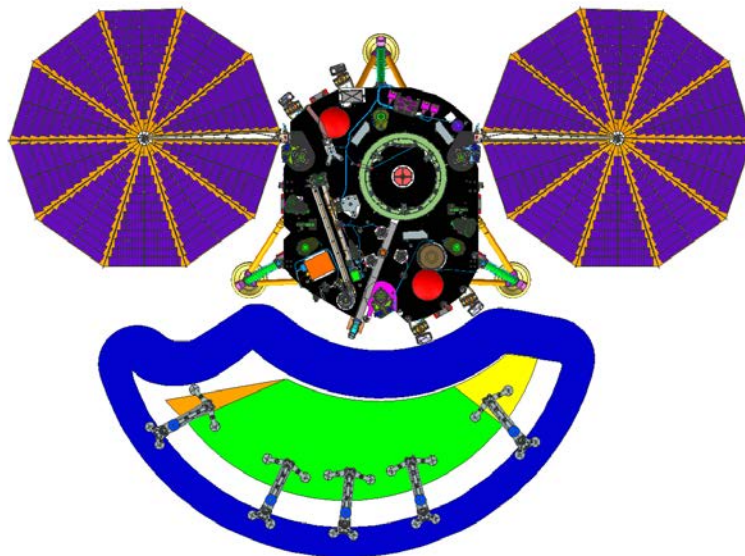
Figure 3: InSight lander and the workspace accessible by the robotic arm. Blue contour indicates the maximum deployable distance of HP³, green, yellow, and orange indicate potential placement areas with green being the most favorable from an engineering perspective, orange being the least favorable.

2.6.2.2 Radiometer FOVs

The radiometer is mounted under the lander deck and observes the surface opposite the space where the SEIS and HP^3 instruments will be deployed. In the nominal case of landing on flat ground with the solar panel oriented East-West, the radiometer will observe the surface at azimuth 20° West (counting azimuth counter-clockwise starting from north), with boresights -55° and –25° relative to the horizon. The FOV is approximately 20° in azimuth direction, and

approximately 12° in elevation. This asymmetry is caused by the calibration target permanently in the instrument's FOV.

The approximate locations of the radiometer FOVs relative to the lander and its shadow at the time of landing are shown in Figure 4. The solar panel shadows will pass through the closer FOV in the morning and afternoon, thus providing an estimate of the effect of the shadow on the surface temperature forcing. Nominally the shadow of the Eastern solar panel will pass through shortly after sunrise, and the shadow of the western panel around 2-3 pm LTST. Depending on the actual orientation of the lander, the footprint geometry, and the surface properties, several tens of K difference are expected between the two FOVs if one of them is in shadow. However, for the purpose of supporting the interpretation of the subsurface temperatures determined by TEM, only average daily surface temperatures need to be known, such that transient shadows can be eliminated from the analysis. It is also worth noting that the temperature perturbed by lander emission is the relevant quantity when trying to constrain the relevant forcing function for temperature at the HP^3 deployment site.

The shadow trajectories change with the season so that the closer FOV will not experience any shadow over half of the year. The farther FOV is mostly unaffected by shadows even if there is some lander tilt. In case of extreme lander tilts of 12 deg (likelihood of 1%) both FOVs might observe shadow from the lander. The difference in temperature between the two FOVs during the periods of no shadow will allow some constraint on the effect of thermal emission from the lander.
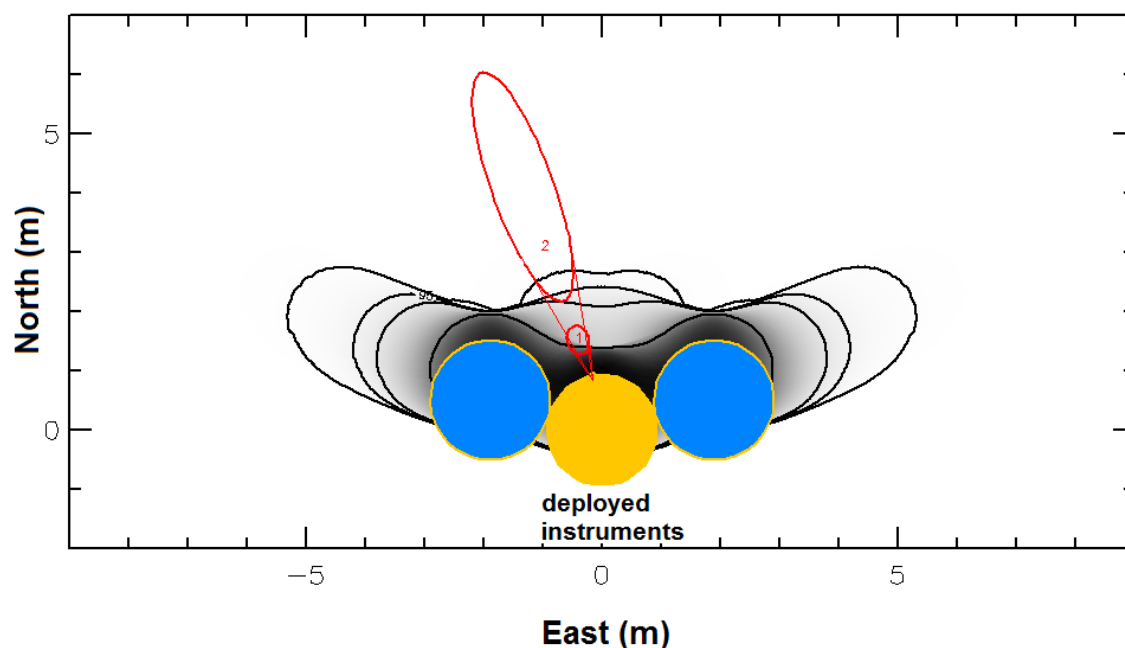
Figure 4 Sketch of landing site top view with radiometer footprints, lander (yellow) and solar panels (blue), and the shadow of the landers expressed as relative daily insolation (at season of landing), with black isolines indicating 99%, 95%, 90% and 50% of normal insolation.

The predicted amount of shadowing for a nominal landing case is shown in Figure 5. For each field of view, 100 rays are traced, and the percentage of shadow coverage is then calculated. The areal percentage of shadows in the two fields of view is calculated as shown in Figure 5, and will be archived together with the calibrated data. In Figure 5, a flat surface has been assumed, but after landing a digital terrain model will be used to calculate shadowing including the local and regional slopes. The percentage of shadows in each field of view is then calculated from the amount of rays in shadow, and is archived along with the calibrated RAD data.
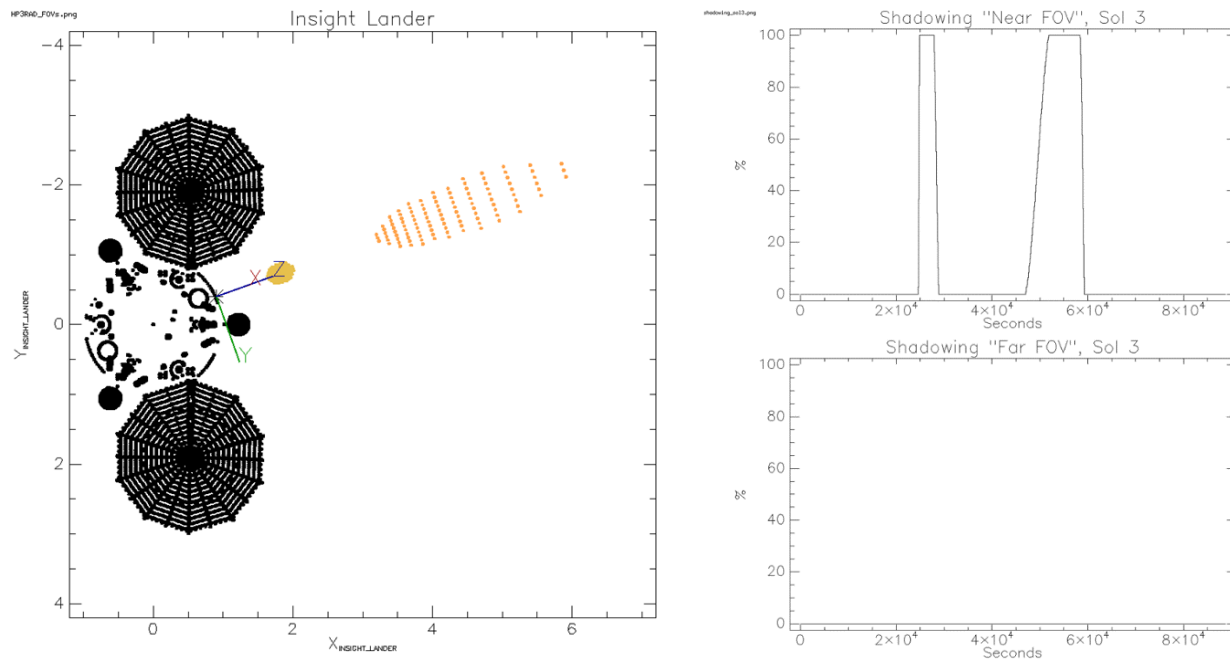
Figure 5: Left: Model used to determine the percentage of shadow in the radiometer fields of view. 100 rays indicated in yellow are traced for each FOV. Right: Example of time and percentage coverage of shadows for each FOV for sol 3after landing.

2.6.3 Detectors

2.6.3.1 Science Tether Temperature Measurements

Number	Depth [m]	Distance [cm] (sensors)
14	4.5030	23 (14 to 13)
13	4.2730	25 (13 to12)
12	4.0230	27 (12 to11)
11	3.7530	29 (11 to 10)
10	3.4630	30 (10 to 9)
9	3.1630	33 (9 to 8)
8	2.8330	35 (8 to 7)
7	2.4830	36 (7 to 6)
6	2.1230	39 (6 to 5)
5	1.7330	40 (5 to 4)
4	1.3330	42 (4 to 3)
3	0.9130	45 (3 to 2)
2	0.4630	46 (2 to 1)
1	0.0030	
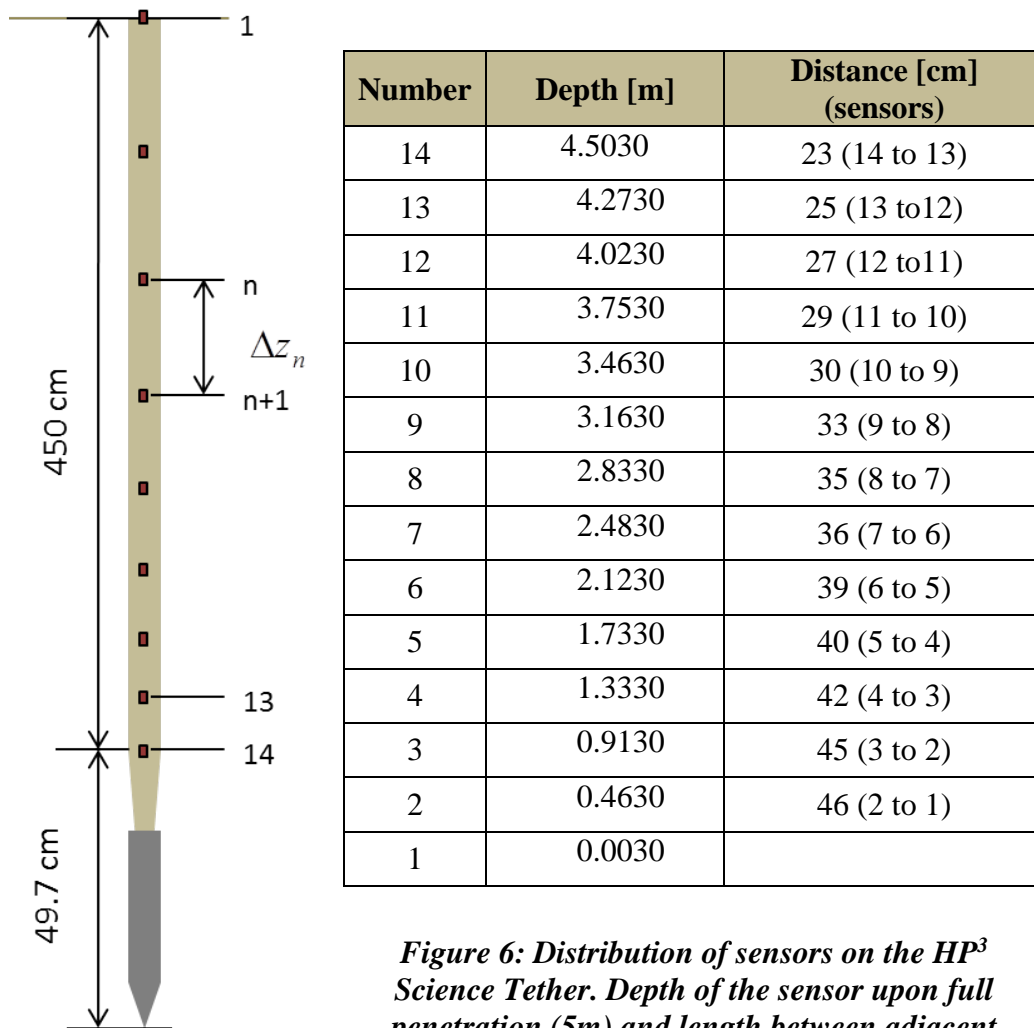
Figure 6: Distribution of sensors on the HP³ Science Tether. Depth of the sensor upon full penetration (5m) and length between adjacent sensors are given.

HP³ measures the subsurface temperature gradient using PT100 sensors mounted on the science tether. The distribution of temperature sensors along the tether are shown in Figure 6. Sensors are stacked more closely towards the mole to increase the number of sensors unaffected by the annual temperature wave. At the same time, sensors near the surface can be utilized to determine the thermal diffusivity of the regolith from an analysis of the attenuation of the annual temperature wave as a function of depth.

2.6.3.2 Tether Length Measurement
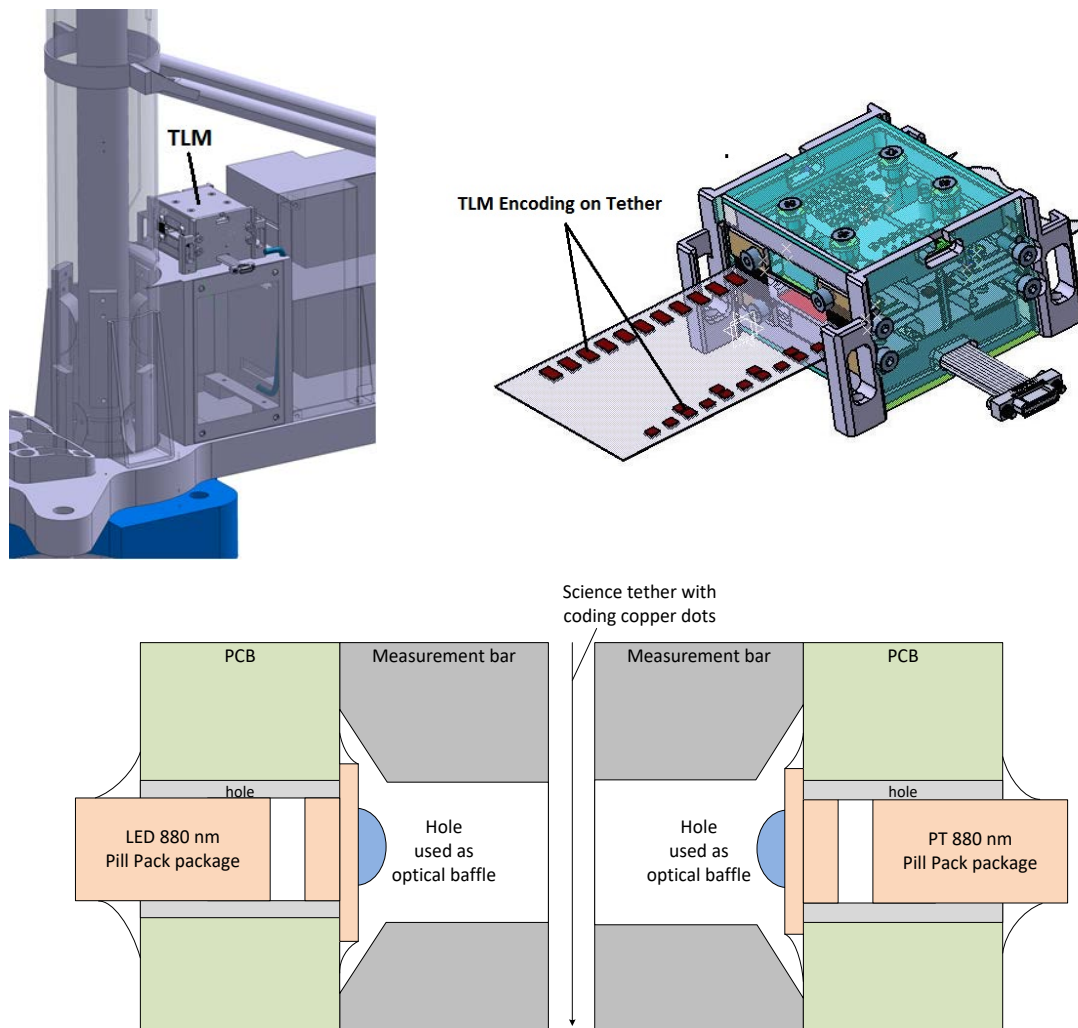
Figure 7: Top left: Accommodation of the tether length monitor (TLM) on the support structure. Top right: Threading of the science tether through the TLM unit. The length encoding on the science tether is indicated. Bottom: Simplified optical transmitted-light measuring mode principle: The tether is pulled between the LED and phototransistor, and transmission of infrared light is measured thus recording passing of the tether encoding.

The length of extracted tether is determined by optical sampling of position codes on the science tether by the tether length measurement system (TLM). The mounting of TLM on the support structure as well as the basic working principle of the subsystem are shown in Figure 7. The top left panel shows the location of TLM in the support structure, while the right panel shows the tether being pulled through the sensor array. One side of the tether encodes a relative distance measure with coding dots 2 mm long and 3 mm wide (perpendicular to the pull direction), equally spaced apart 2 mm apart. The opposite side of the tether encodes absolute length using

14 bits per datum and a Gray-code. TLM works in a transmitted-light mode as shown in the bottom panel of Figure 7: The transparent Kapton-tether is the carrier of relative and absolute coding dots made of opaque copper. The trace of code dots is illuminated by light emitting diodes (LEDs) of 880 nm. A phototransistor on the opposite side detects the opaque and transparent segments and delivers a digital signal (light/no light) to the backend electronics (BEE). The phototransistor signal is amplified by an operational amplifier with input hysteresis to reduce jitter and signal ringing. The relative and absolute position decoding is done in digital field programmable gate array (FPGA) logic. The TLM measurement principle leads to a tether movement driven measurement. TLM can only detect changes at the code track due to tether movement. It is not possible to capture the current position in a static configuration. Therefore, TLM is operated always during Mole release and Mole operation.

In the 14 bit encoding system used by TLM some redundancy allows for single bit errors to be corrected in case a reading is invalid due to, e.g., dust accumulation on the tether. I.e., the BEE can detect non-valid data from the code that has been read and can correct the absolute distance counter in case a one bit error occurs. If more than one bit is rejected by the BEE (two-bit error in the data archive), the absolute value cannot be reconstructed from the coding and the absolute measure is rejected. In this case, only the relative counter keeps incrementing.

The first measurements taken by TLM after switch on increment the relative distance counter until 14 bits have been processed and a new absolute code mark is available. Absolute length along the tether is then obtained by multiplying the absolute distance code by 14 times 4 mm, and the relative distance code is updated accordingly. The relative distance code is then incremented by 4 mm every time a new relative code is read, until 14 bits have again been collected and a new absolute code is available. In this way, intermittent data loss can be recovered by reading a new absolute code.

For a vertical penetration, the depth of the mole tip is obtained by adding an offset, which takes the distance between the TLM sensor and the surface as well as the distance from the mole tip to the first code on the tether into account. Thus, for vertical penetration, tip-of-the-mole-depth below the surface of Mars is given by

$$z_{mole} = (N_{abs} \cdot 14 + TLM_{\text{off}} + \Delta N_{rel}) \cdot 4 [\text{mm}]$$

where the offset is given in units of TLM coding (4 mm), N_{abs} is the absolute counter, and ΔN_{rel} is the amount of relative codes read since the last absolute code. The TLM offset is 87 units for the TLM main sensor and 93 units for the redundant TLM sensor. In the raw data, conversion to absolute depth is automatically done in the instruments FPGA, including switching between main and redundant sensors and offsets if applicable.

2.6.3.3 Mole Tilt Measurement
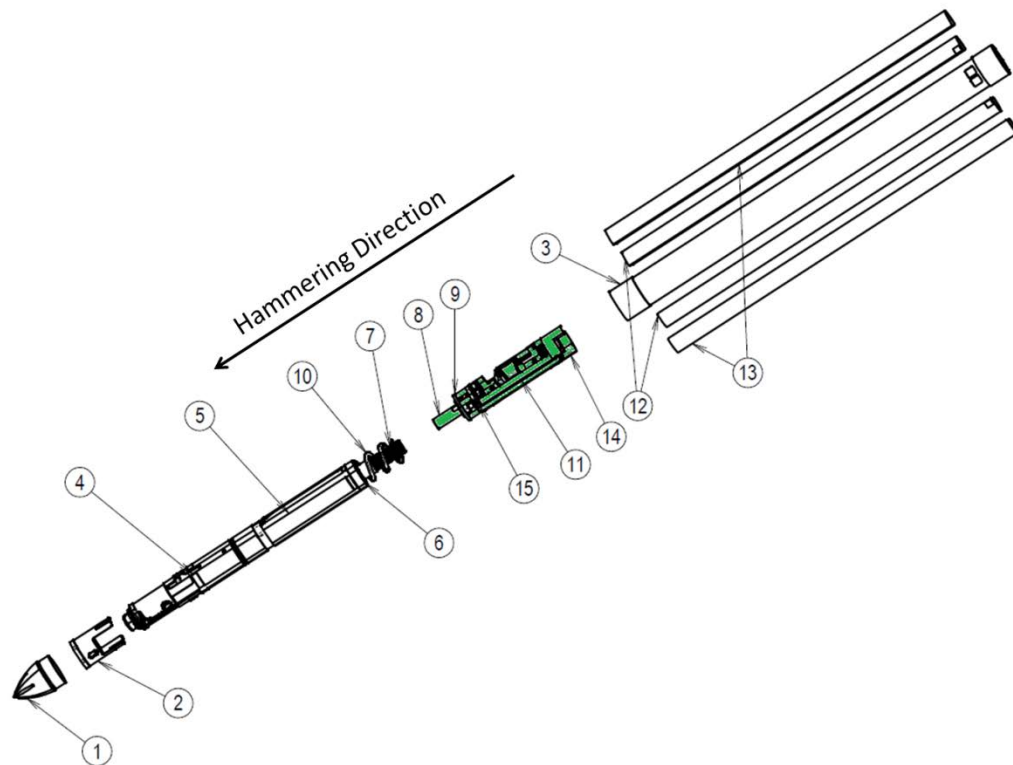
Figure 8: Expanded view of the mole, indicating the static tilt (STATIL) assembly (8, 9, 11, 14, 15) in green. Other parts refer to the tip (1, 2) hammering mechanism(4, 5, 6, 7, 10) and active temperature sensor (TEM-A, 3, 12, 13) assembly

The STATIL subsystem uses two Dual-Axis Accelerometers to determine the attitude of the HP³ mole in reference to the planetary gravity vector. It is used together with the Tether Length Measurement system (TLM) to determine the depth of the mole in the Martian subsurface. Signal output is a voltage that is proportional to the angle of the mole vs. the gravity vector. The accelerometers are mounted on two printed circuit boards (PCBs) which are attached to a sled made of stainless steel. The sled is fixed to two double shock mitigation springs, to avoid high shock loads (see Figure 9). In nominal working position the longitudinal axis of the sled is equal to the hammering axis of the mole (see Figure 8).

Hammering Direction
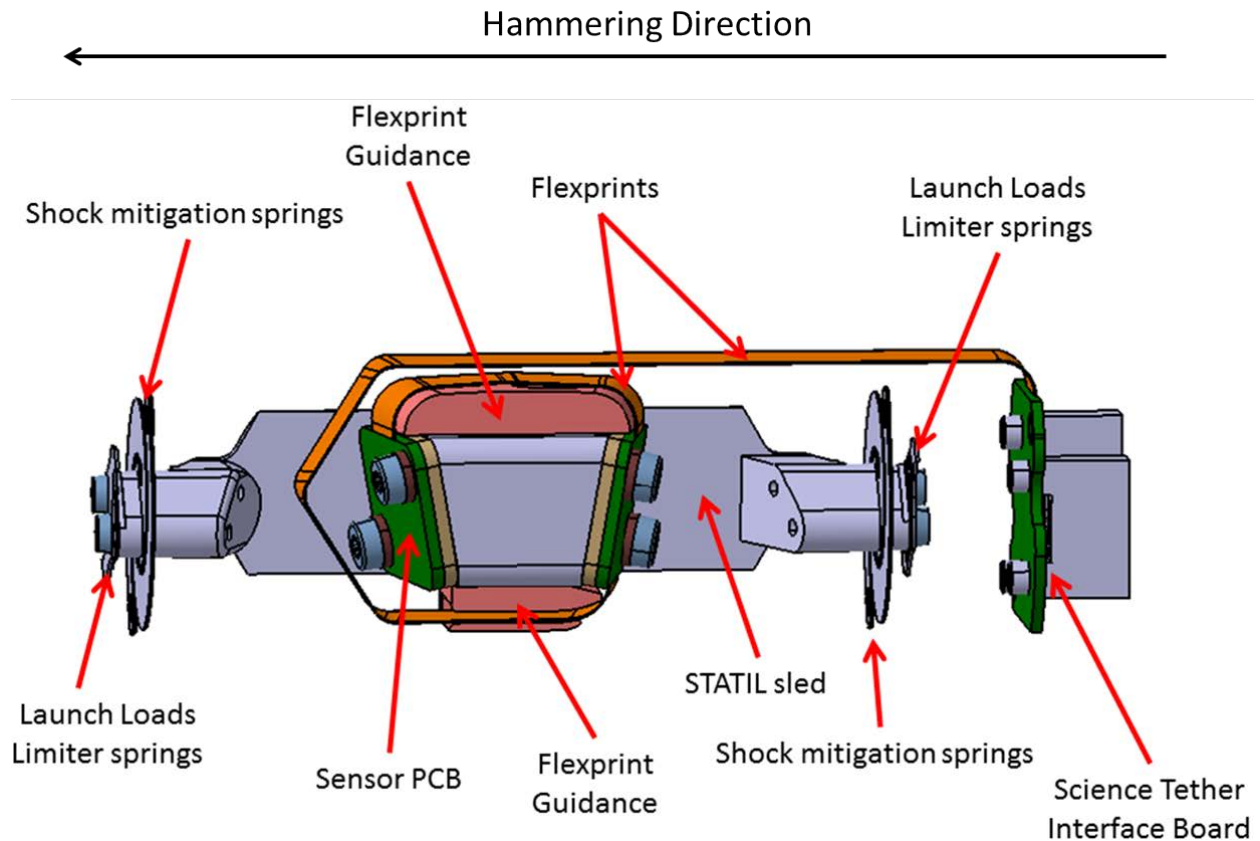
Figure 9: Static tilt (STATIL) assembly mounted on mole sled. Springs are used to reduce shock loads on the sensors.

The shape of the sled and mounting orientation of the sensors has been designed such that the sensors yield maximum signal. Therefore the sensor PCBs are almost perpendicular to the hammering axis. For redundancy two sensors have been used. The accelerometers are 10° tilted in two axes to provide the highest sensitivity measurement position within the range of the deployment angle of HP³. The orientation of the accelerometers in the mole coordinate frame is shown in Figure 10.
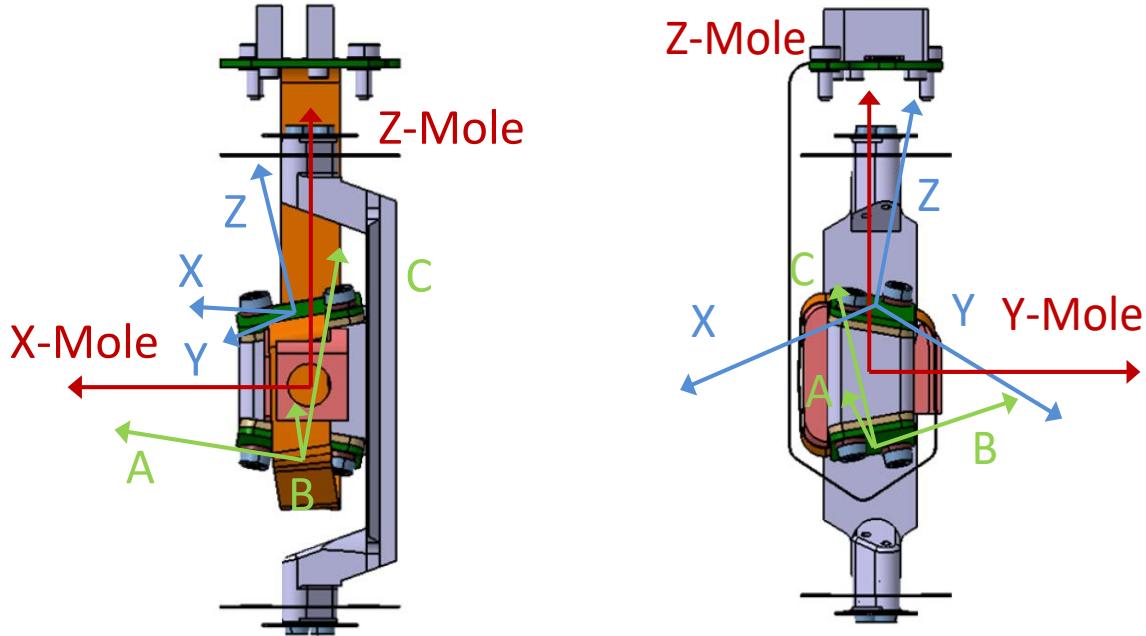
Figure 10: Orientation of the accelerometers in the mole coordinate frame. The mole coordinate system is shown in red, while the two accelerometer systems are shown in blue and green, respectively. Accelerometers are mounted on the planes with normal directions Z and C. Mounting is not parallel to the edges of the PCBs (shown in green), so the axes X,Y and A,B are at an angle with the sides of the PCBs.

As the two accelerometers are redundant, two different realizations of the local gravity vector can be calculated, but in general, one of the two calculations will be more accurate due to the way the tiltmeters are mounted. So, given STATIL angles ϕ_A, ϕ_B, ϕ_X, and ϕ_Y (see Section 2.6.4.3) with respect to local gravity, gravity vectors can be reconstructed by

$$\vec{g}_{A,B} = \begin{pmatrix} \sin(\phi_A) \\ \sin(\phi_B) \\ \sqrt{1 - \sin^2(\phi_A) - \sin^2(\phi_B)} \end{pmatrix}$$

and

$$\vec{g}_{X,Y} = \begin{pmatrix} \sin(\phi_X) \\ \sin(\phi_Y) \\ \sqrt{1 - \sin^2(\phi_X) - \sin^2(\phi_Y)} \end{pmatrix}$$

in the STATIL coordinate frames. The gravity vector directions carry one degree of freedom and are only defined on a cone around the gravity vector. However, for the purpose of depth determination, this is sufficient.

In a next step, these vectors need to be transformed to the mole coordinate frame X-Mole, Y-Mole, Z-Mole in order to determine the mole angle w.r.t. the gravity vector. The transformation can be achieved using Euler Angles α, β, γ, and the transformation from the Mole to the STATIL

A/B and X/Y coordinate systems can be achieved by using the Euler angles given in Table 3. Note that we use the y-convention, also known as the z-y´-z´´ convention, for the Euler angle transformation.

Table 3: Euler angles for transforming the Mole coordinate frame into the STATIL PCB Coordinate Frame.

Euler Angle	X/Y PCB [°]	A/B PCB [°]
α	45	45
β	14	-14
γ	-80	-55

The direction of the gravity vector in the mole coordinate system is then obtained by the inverse transformations

$$\vec{g}_{A,B,mole} = \boldsymbol{M}^T_{\alpha\beta\gamma}\vec{g}_{A,B}$$

and

$$\vec{g}_{X,Y,mole} = \boldsymbol{M}^T_{\alpha\beta\gamma}\vec{g}_{X,Y}$$

where $\boldsymbol{M}^T_{\alpha\beta\gamma}$ are the inverse Euler transformation matricies using the Euler angles given in Table 3. An integration of the length of paid-out tether length will be used together with the mole vector w.r.t. gravity to reconstruct the mole path and take the potentially curved path of the mole into account.

The selected STATIL sensors are dual-axis ADXL203 accelerometers built by *Analog Devices*. These are high precision, low power, complete dual-axis accelerometers with signal conditioned voltage outputs, all on a single, monolithic IC. The STATIL subsystem is connected to the HP³ backend electronics (BEE) via the Science Tether, the Support Structure and the Engineering Tether. To decrease the influence of electronics noise, a low-pass filter is implemented in the BEE. One filter is used for every analog STATIL signal and voltages are converted using 24-bit analog-to-digital converters. The BEE is able to trigger on STATIL signatures caused by hammer strokes, and the trigger level is adjustable.

2.6.3.4 Thermal Conductivity Measurement

EXPLODED VIEW OF MOLE
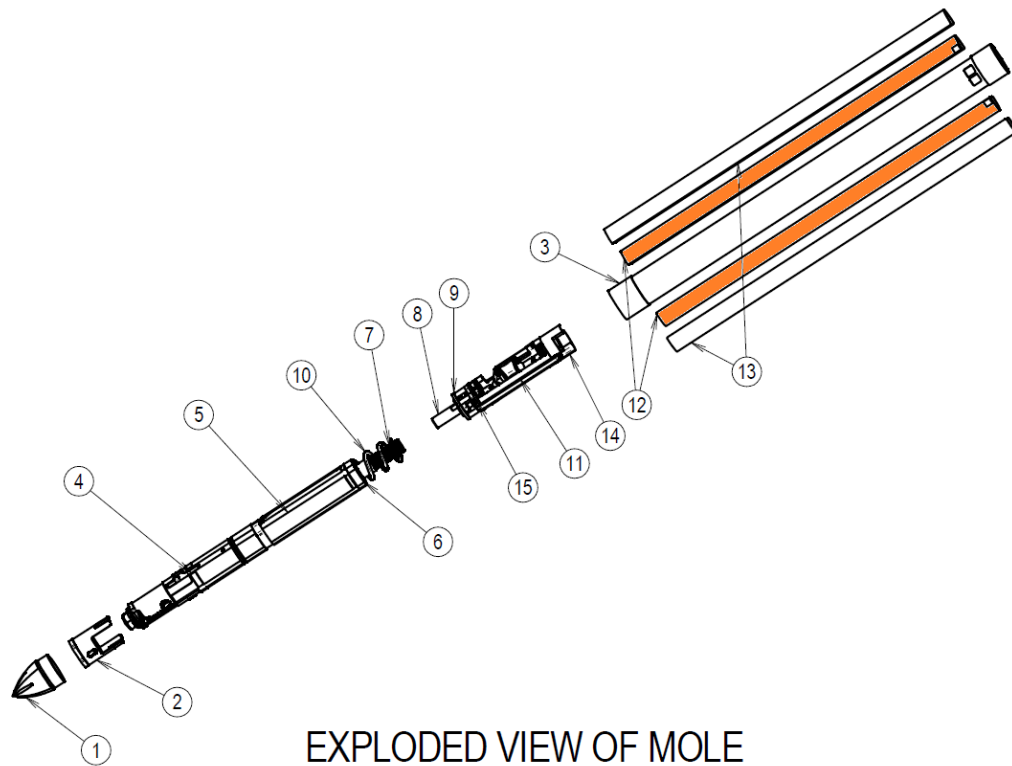
Figure 11: Exploded view of the mole, indicating the active temperature (TEM-A) heating foils (12) in orange. The foils are glued to the mole outer casing (3) and protected against abrasion by the TEM-A covers (13). Other parts refer to the tip (1, 2) hammering mechanism(4, 5, 6, 7, 10) and static tilt (STATIL (8, 9, 11, 14, 15) assembly.

HP^3 measures thermal conductivity by using the mole as a modified line heat source. This approach consists of injecting a known amount of heat into the probe and measuring the probe's self-heating curve. For a finite length cylinder such as the mole, the heating curve takes the form

$$\Delta T = C_1 \ln(t) + C_2$$

where t is time, and the constant C_1 is primarily a function of heating power and regolith thermal conductivity, while C_2 is a function of the probe's heat capacity and the contact conductance between probe and regolith. Therefore, thermal conductivity can be determined from

$$C_1(k, Q) = \frac{\partial \Delta T}{\partial \ln(t)}$$

by direct numerical simulations if the heating power is known. Parameters necessary for setting up the numerical model will be archived together with the HP^3 calibration report. The TEM-A heaters are Kapton based copper heaters, which are glued to the outer casing of the mole and protected against abrasion by aluminum covers. Due to the large temperature coefficient of resistance of copper, the heaters simultaneously act as temperature sensors, and the TEM-A

electronics inside the BEE measures the heating power Q as well as the resistance of the heaters to determine the self-heating curve as a function of heating power.

In the archived data, heating power is archived by the combination of heating current and heater resistance, such that the power can be calculated from

$$Q_{1,2}(t) = I_{1,2}(t)^2 R_{1,2}(t)$$

Total heating power is then given by $Q(t) = Q_1(t)+Q_2(t)$. Note that although the heaters are made of copper and therefore the resistance of the heaters will change during the heating experiment, the BEE changes the heating current accordingly, such that heating power will be constant during the heating experiment and $Q(t) = Q$.

2.6.3.5 Surface Brightness Measurement
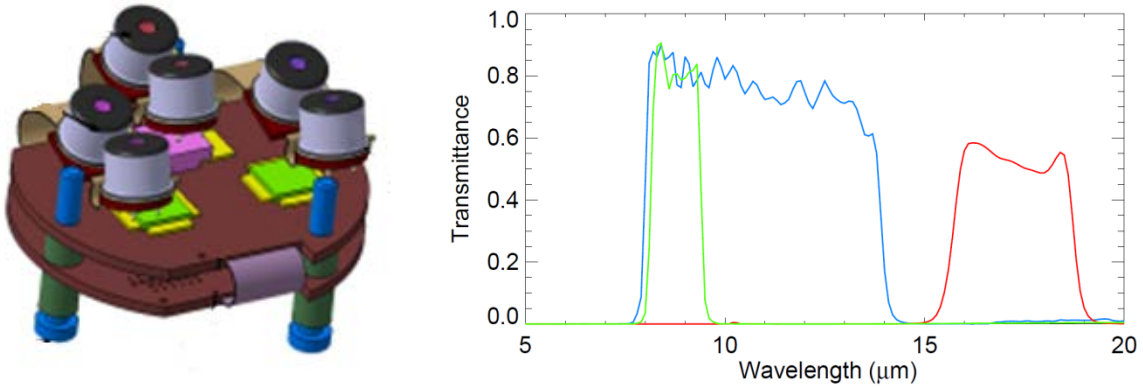
Figure 12: Left: Printed circuit boards and sensor assembly of the radiometer. Six thermopile sensors are accommodated, and each filter wavelength is used in 2 sensors. Right: Transmittance of the three spectral filters multiplied with the spectral absorbance of the thermopiles. Blue: 8-14 μm bandpass, green: 7.8-9.6 μm bandpass , red: 16-19 μm bandpass.

The radiometer measures surface brightness temperatures using IPHT TS 72 thermopile sensors. The sensors consist of an IR filter and absorbing surface, which is in radiative equilibrium with the target surface in the instrument's field of view. The temperature of the absorbing surface is determined using Bi0.87Sb0.13/Sb (Bismuth-Antimony) thermopairs with an electro-motive force of EMF = 135 μV/K. The absorber size is $D = 0.5$ mm. The generated thermal voltage measures the temperature difference between the junctions of the thermocouples, which in turn is a measure for the net radiative flow of heat between absorber and target. The measured thermal voltage is given by

$$U_{th} = SA_d\pi \left(\varepsilon v \int_{\lambda_1}^{\lambda_2} \tau(\lambda)\left(B_\lambda(T) - B_\lambda(T_{ref})\right)d\lambda + \varepsilon_H v_H \int_0^\infty \left(B_\lambda(T_H) - B_\lambda(T_{ref})\right)d\lambda \right)$$

where S is sensor sensitivity (in V/W), A_d is absorber area (in m^2), ε is target surface's emissivity, v is the target's view factor, τ is sensor transmissivity, B is the Planck-function, T is surface temperature, T_{ref} is the temperature of the sensor's cold junction, ε_H is the emissivity of the sensor housing, and v_H is the view factor of the sensor housing. In order to eliminate the second term in the equation, the sensor head's temperature is stabilized such that $T_H = T_{ref}$.

Sensors are mounted such that 3 thermopiles cover two fields of view each. PT100 sensors mounted inside the sensor housing measure the cold junction temperature. Therefore, a total of 12 signals is recorded: 6 thermopile voltages corresponding to 3 bandpass filters in two fields of view each, and 6 corresponding cold-junction temperatures measured by PT100 sensors.

The fields of view are geometrically limited by the sensorhead apertures to 20°. In addition to that a calibration target obscures a part of this 20° circular FOV view. Its temperature provides part of the thermopile signal and is measured by another PT100 sensor.
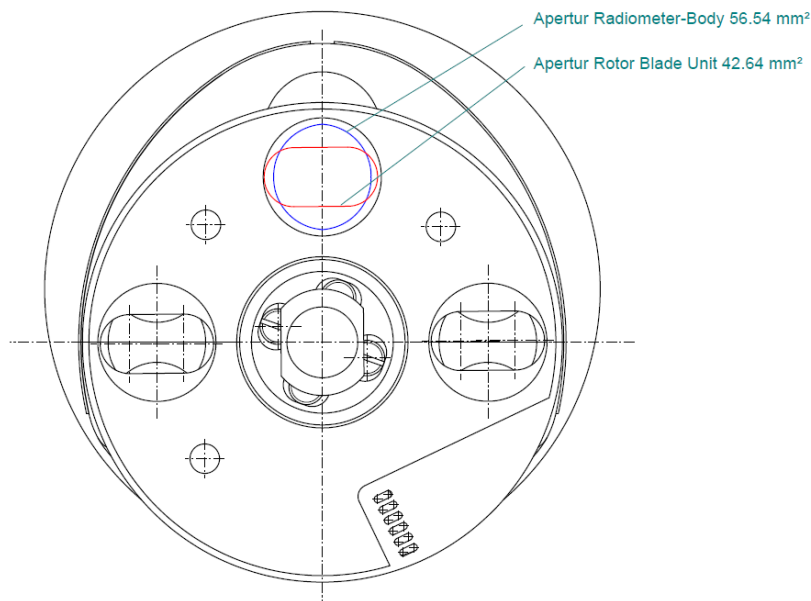
Figure 13: Front view of the sensor head outlining the geometry of body apertures (blue) to calibration target apertures (red). There are two sensors per aperture.

2.6.4 Electronics

2.6.4.1 Science Tether Temperature Measurements

TEM-P measures temperatures using 14 PT100 temperature sensors, which are distributed over the entire length of the Tether. Sensors are read by the HP^3 BEE by sourcing current and measuring the voltage drop over the sensor elements in a 4-wire (Kelvin Method) configuration. The basic layout of the measurement is schematically shown in Figure 14, where the two redundant measurement circuits are shown. PT100 sensors are alternately routed to one out of two ADCs, such that all even numbered PT100 are measured by one ADC and all odd numbered sensors by a second ADC
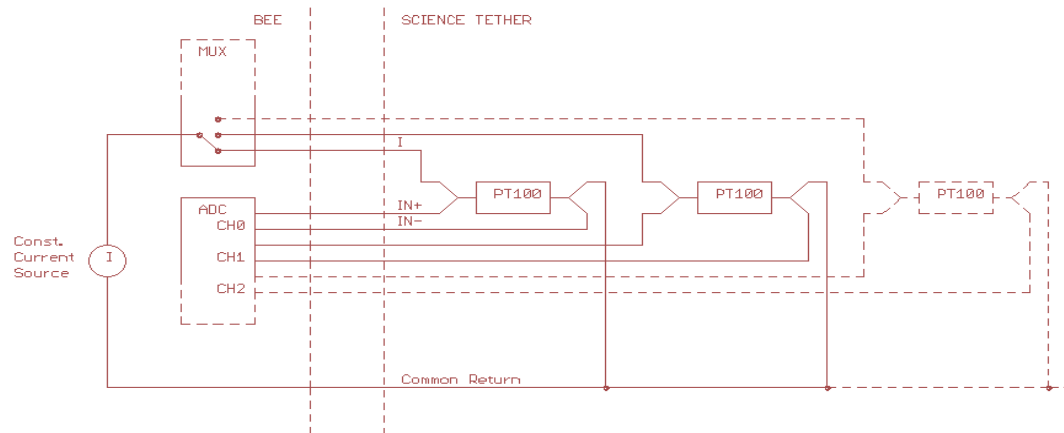
Figure 14: Schematic setup of platinum resistance (PT100) measurement. The backend electronics (BEE) side of the measurement circuit is shown on the left hand side, while the science tether is shown on the right. A multiplexer (MUX) is sourcing current to the sensors, and the voltage drop is measured using a 4-wire technique.

Inside the BEE, a constant current source is sourcing the measurement current of 0.5 mA to the multiplexer, which switches the current to one of the 7 PT sensors or the 100 Ω reference resistor, which is located on the BEE board. A demultiplexer inside the 24 bit ADC switches the voltage drop over the PT100 measurement signal to the instrumental amplifyer for signal conditioning. A gain of 10.09 has been chosen, amplifying the ~50 mV PT100 signal to 0.5 V. The amplified signal is then converted inside the employed sigma-delta ADC. In addition to measuring the voltage drop over the sensor when sourcing current, an offset measurement is performed with no current sourced to subtract signals caused by, e.g., thermal voltages. The reference voltage is supplied both to the ADC and the current source simultaneously. In this way, drift of the reference voltage is eliminated from the converted voltages, reducing measurement errors.

The ADC is operated at an oversampling rate of 4.8 kHz, and values are averaged in the FGPA to one sample. Typically, 600 samples are taken per channel, the first 88 of which are discarded to avoid transient effects after switching of a multiplexer (MUX) channel. The 512 remaining samples are then again averaged to one value. Sampling all channels of the ADC then takes 2s, and this measurement includes the nominal and offset voltages.

In addition to the measurement of the PT100 sensors, the voltage drop over a high precision 100 Ohm reference resistor is also measured in the same configuration, and PT100 measurements are referenced to the voltage drop of the reference measurement. Taken together, a measurement of the PT100 resistance then consists of the following steps:

1. Measure the voltage drop over the PT100 U_{PT} when sourcing 0.5 mA
2. Measure the voltage drop over the PT100 $U_{PT,off}$ without current to eliminate offsets
3. Measure the voltage drop over the reference resistor U_{Ref} when sourcing 0.5 mA

4. Measure the voltage drop over the reference resistor $U_{Ref,off}$ without current to eliminate offsets

The resistance of the PT100 sensor is then given by

$$R_{PT} = \frac{U_{PT} - U_{PT,off}}{U_{Ref} - U_{Ref,off}} \cdot R_{Ref}$$

This resistance reading is then converted to temperatures using the $R(T)$ calibration curves.

2.6.4.2 Tether Length Measurement

The TLM electronics are located on two PCBs mounted inside the TLM mechanical frame, making TLM fully redundant. One set of TLM electronics includes a four channel opto-electrical measurement. The opto-electrical measurement relies on a transmitted-light mode principle with an IR LED as illumination source and a phototransistor as detector.

When moving through the TLM, the tether coding dots interrupt the illumination of the receiving photo transistor, and the output signal changes from a low voltage level, representing logic zero, to a high voltage level, representing logic 1. This analog signal is converted to a digital logic signal inside the BEE.
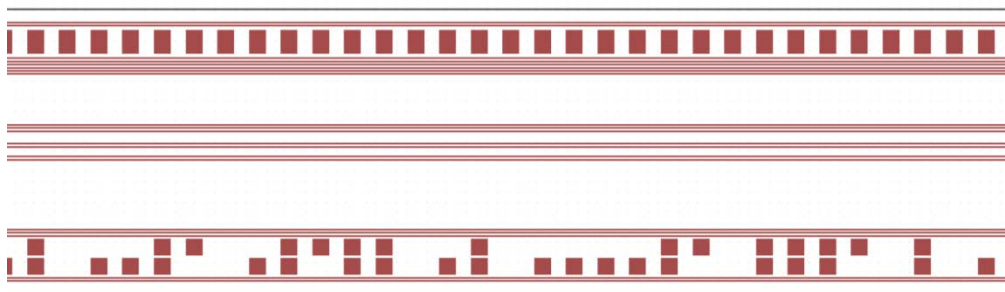
Figure 15: Example of tether length monitor (TLM) encoding on the tether. Top row is the relative encoding, while the bottom row is the absolute encoding.

The TLM detects tether movements by scanning the tether relative and absolute coding traces, which have a size of 2 mm and a spacing of also 2 mm (see Figure 15). Two LED/photo transistor pairs are used to discriminate the movement direction on the relative code. The remaining two pairs scan the data and clock trace of the absolute code. The decoding is realized in the BEE FPGA. The relative and absolute codes are aligned in a way that in the middle of a relative code dot, the absolute code can also be sampled. This sample location is derived from the relative code measurement direction discrimination. Whenever the tether moves 4 mm from the previous sample point a new sample event is generated and the relative and absolute counter values are stored.

Scanning the 14 bit serial code on the absolute coding trace provides the input for the absolute tether position measurement. The absolute code is based on a 7 bit gray code counter, a 5 bit EDAC code and two synchronization bits. This results in a tether position synchronization interval of 5.4 cm.

The EDAC coding protects the gray code against single bit sampling errors and detects multi bit errors. If one of the gray code or EDAC bits was sampled from a corrupted sensor signal this bit is corrected automatically. This improves measurement reliability if the tether was partly contaminated by dust. The EDAC status information is sampled in the BEE and used for data interpretation.

2.6.4.3 Mole Tilt Measurement

The STATIL inclination measurements will be taken in between strokes of the mole when the STATIL sled is in its nominal position. Ten samples will be taken every tenth mole stroke.
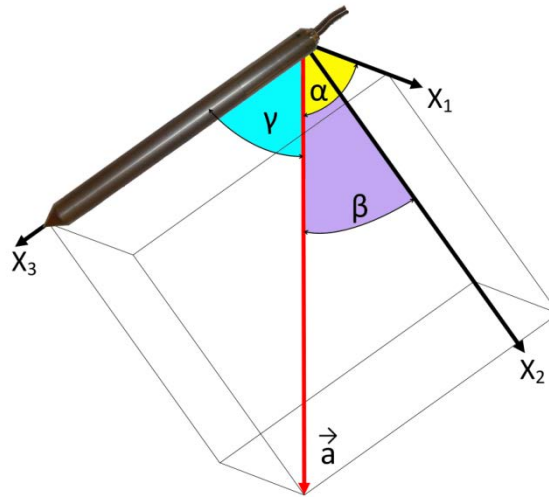
Figure 16: Sketch for the application of the directional cosine for the mole inclination determination. X1 and X2 represent two static tilt (STATIL) axes including their mounting angles inside the mole.

The inclination of the accelerometer axes vs. gravity will be calculated from the received digital numbers (DN) as determined by the BEE ADCs using

$$\theta = arcsin\left(\frac{DN - (DN_{max} + DN_{min})/2}{(DN_{max} - DN_{min})/2}\right)$$

Here, DN is the measured value and DN_{max} and DN_{min} are the minimum and maximum values of the designated axis as determined during calibration. The resulting measure is in units of radians. The mole inclination vs the gravity vector can then be determined with the directional cosine from the inclination of two STATIL axes.

The calculation of the mole path will be performed via vector addition, The single vector elements which will be summed are defined by the calculated mole angle from STATIL measurements and the mole forward motion measured by TLM in-between successive STATIL measurement sets. The location of the TEM-P sensors on the mole penetration path will be

derived from the known distances of the sensors to the mole tip. The depth of the sensors are derived from its location on the mole path by a projection on the Mars gravity vector.

2.6.4.4 Thermal Conductivity Measurement
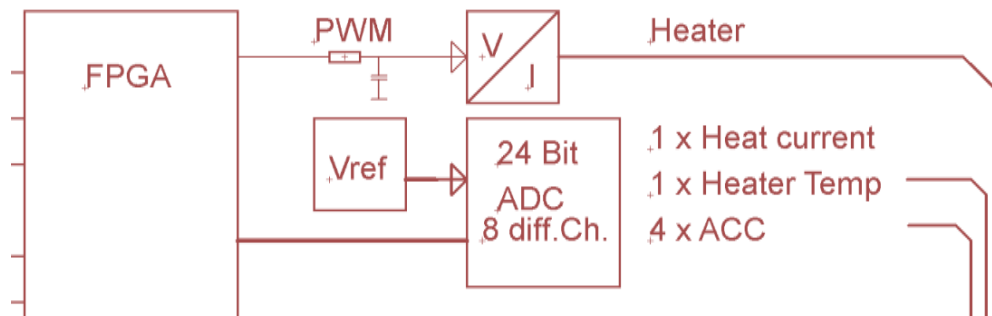
Figure 17: Schematics of the active temperature sensor (TEM-A) Heater Current Source and analog to digital conversion (ADC) channels. Each TEM-A heating foil has its own pulse width modulation (PWM) driven current source. The current through the heater is measured by the voltage drop over a 10 Ω shunt resistor. The resistance of the heater and thus heater temperature is measured by the voltage drop over the heater.

TEM-A electronics are fully redundant and each heating foil has its own current source and ADC on the HP^3 BEE board. The TEM-A current source is controlled by a PWM generated by the FPGA. The PWM is low-pass filtered by a resistor-capacitor(RC)-filter, and the generated constant voltage is used to control the FET responsible for sourcing the current. In this way, heating power is provided to the TEM-A heating foils. The sourced current is measured by the TEM-A ADC by determining the voltage drop over a 10 Ω shunt resistor in the heating circuit.

The resistance of the foils is determined from a voltage drop measurement in a 4 wire configuration over the copper based heaters. The copper heaters have a temperature coefficient of resistance of 0.00415 1/K and simultaneously act as temperature sensors. Given the calibration of the TEM-A heaters in terms of $R(T)$, the temperature of the heaters can be determined from the voltage measurement. A block diagram of one of the two redundant TEM-A circuits is shown in Figure 17.

The measurement circuitry containing the TEM-A ADC includes the ADC reference voltage, which is generated by a bandgap reference. The instrumental amplifier implemented for signal conditioning has a gain of 2. In addition to the heating current and the heater resistance, the TEM-A ADCs measure the STATIL accelerometer output voltages and the Mole motor current. In order to shift the level of the voltage drop over the TEM-A heaters to the working range of the ADCs, a voltage divider of 10 kΩ to 200 kΩ is used.

The current through the TEM-A heaters equals the current through the 10 Ω shunt resistor, and is given by

$$I_{TEM-A} = \frac{U_{Shunt}}{10\Omega}$$

The resistance of the TEM-A heating foils is then given by

$$R_{TEM-A} = \frac{U_{TEM-A}}{I_{TEM-A}}$$

U_{Shunt} and U_{TEM-A} are measured by the ADC. The TEM-A resistance reading is converted to temperatures using the $R(T)$ calibration curve of the TEM-A heaters.

2.6.4.5 Surface Brightness Temperature Measurement
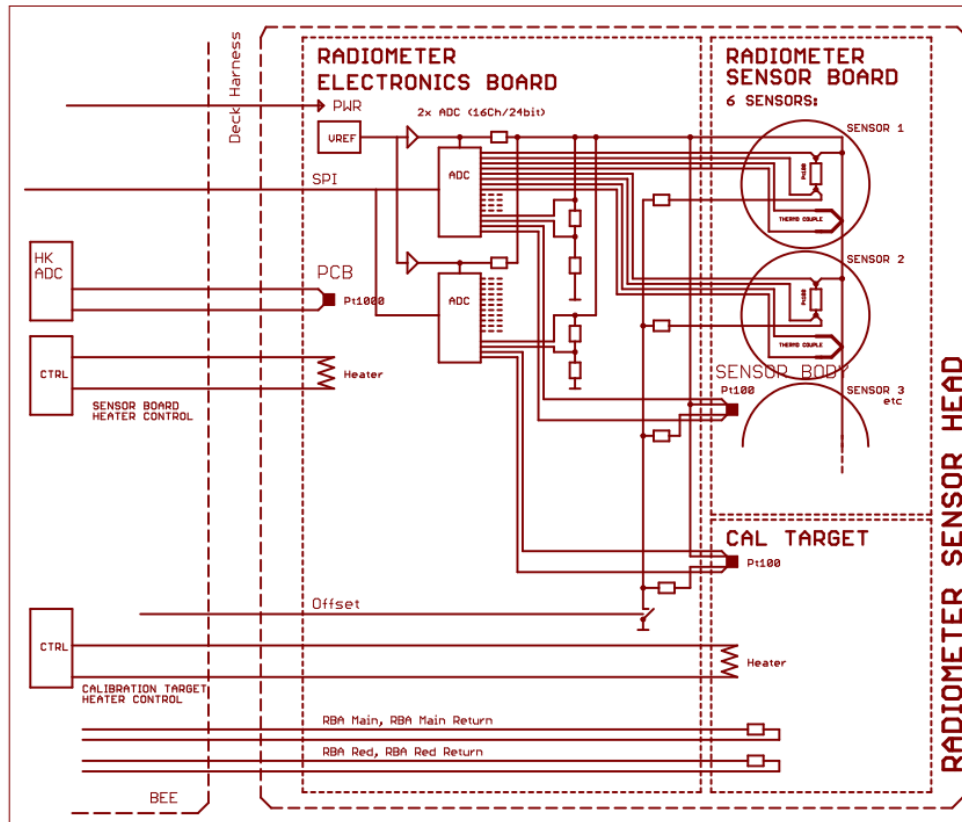
Figure 18: Schematic digram of the Radiometer Electronics. Thermopile sensors for each of the two fields of view are routed to one analog to digital converter (ADC), which therefore samples 3 thermopile and 3 platinum resistance temperature detector (PT100) signals. In addition, a 100 Ω reference resistor is sampled by each ADC. One ADC also measures the sensor body temperature, while the second ADC measures the CalTarget temperature.

Radiometer electronics are located inside the radiometer sensor head, and the RAD has a digital and power interface to the BEE board. In addition, the BEE controls the RAD switch-on temperature via housekeeping sensors and engineering heaters. After switch-on, the temperature of the RAD sensor head is controlled by a PID controller inside the RAD sensor head electronics.

Schematics of the RAD electronics are shown in Figure 18, and the two RAD ADCs measure 3 sensors in one field of view each. Thermopile signals of the three filters in each field of view are

fed to the ADC via a low pass input filter. The thermopile voltage is converted to a surface brightness temperature using the thermopile calibration curves.

PT100 sensors inside the thermopile sensors measure the cold-junction temperatures. PT100 are sourced with a current limited by a 47 kΩ resistor, resulting in a permanent current of 50 µA, small enough to eliminate self-heating effects. A FET can switch the measurement ground of all PT100 sensors, which is used to measure voltage offsets for the PT100 lines.

A low drift 100 Ω reference resistor is measured in the same configuration as the PT100 sensors for each ADC, and PT100 readings are referenced to this resistor. This eliminates drift of the reference voltage. A measurement of PT100 resistance therefore includes 4 steps (as also described in Section 2.6.4.1)

1. Measure the voltage drop over the PT100 U_{PT}
2. Measure the voltage drop over the PT100 $U_{PT,off}$ with open ground line to eliminate offsets
3. Measure the voltage drop over the reference resistor U_{Ref}
4. Measure the voltage drop over the reference resistor $U_{Ref,off}$ with open ground line to eliminate offsets

The resistance of the PT100 sensor is then given by

$$R_{PT} = \frac{U_{PT} - U_{PT,off}}{U_{Ref} - U_{Ref,off}} \cdot R_{Ref}$$

This resistance reading is then converted to temperatures using the $R(T)$ calibration curves.

The temperature of the sensor head and calibration surface are controlled by a PID controller in the HP^3 BEE board. Temperatures for the control loop are determined using one PT100 sensor on the RAD body and one sensor on the calibration target. Both temperatures can be controlled independently. The measurement circuit for these PT100 sensors is identical to the thermopile PT100 cold junction measurements. The same ADCs and reference resistors are used.

2.6.5 Instrument Operation

2.6.5.1 HP^3 Operations

After deployment of the instrument onto the surface of Mars by the InSight robotic arm, operations of the HP^3 instrument is split into two main phases:

1. The penetration phase
2. The monitoring phase

During the penetration phase, the HP^3 mole will hammer itself into the subsurface, trailing behind the science tether, which is equipped with temperature sensors to measure the thermal gradient. At intervals of 50 cm, hammering will be interrupted, and the heat introduced into the regolith will be allowed to dissipate for a period of at least 2 days. After this time, a TEM-A measurement will be performed, and the thermal conductivity of the regolith will be determined.

Heating times for the TEM-A measurement will be up to 24 h to sample a volume of regolith away from the mole. After the conductivity measurement, hammering is resumed until the next stop. In this way, a profile of thermal conductivity at the landing site will be compiled. During the penetration phase, 10 stops and measurements are foreseen. The timeline for this mission phase is schematically illustrated in Figure 19.

Progress of the mole is continuously monitored by the STATIL tilt meters and TLM, which measures the amount of paid out science tether. Taken together, this information uniquely determines the mole depth, from which the depth of individual temperature sensors can be derived.

After reaching the final depth, which is limited to 5 m by the length of the tether, but might be smaller depending on the penetration performance of the mole, HP^3 enters the monitoring phase. During this phase, HP^3 takes periodic temperature measurements using the sensors on the tether. Readings are to be taken during 5 min every hour, and values are averaged to yield a sampling of the subsurface temperature field every hour to the end of mission.
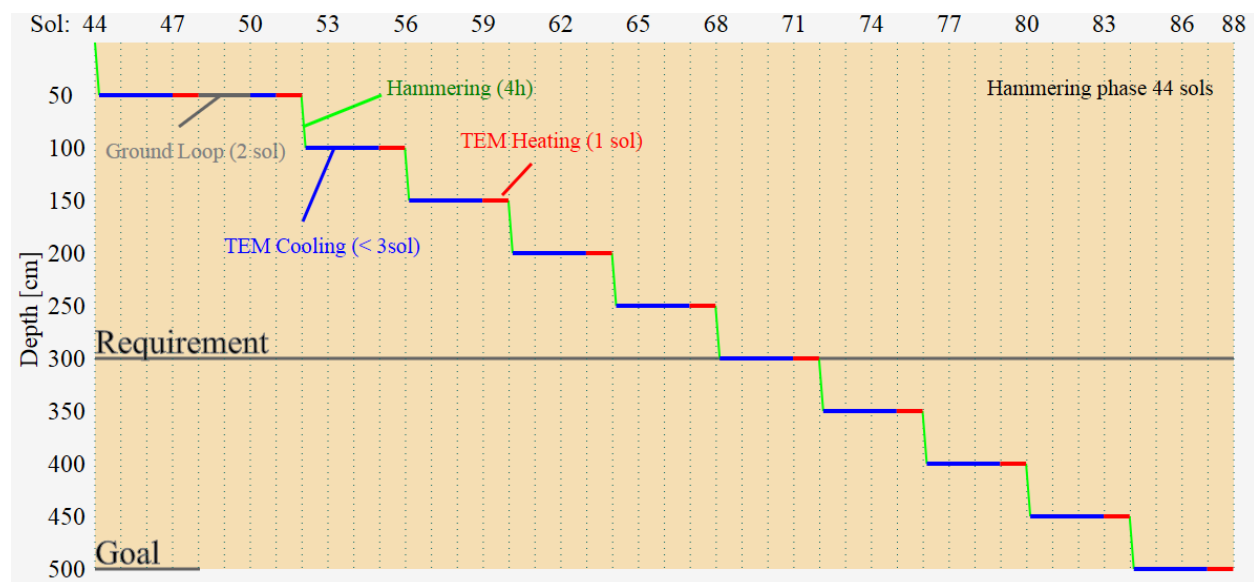
Figure 19: Operations of the HP^3 instrument after deployment. Phases of hammering, cooldown, and thermal conductivity measurements (TEM-A) are indicated.

2.6.5.2 RAD Operations

The radiometer typically operates in one of four modes, which determine the timing of measurements and temperature of the instrument.

1. The 'Hourly' mode acquires 24 measurements per sol, each 40 samples over 5 min. This mode is run for at least one sol within each interval of 29 sols. If sufficient energy is available the mode is run continuously.
2. The 'Standard' mode acquires 4 measurements per sol, each 40 samples acquired over 5 min. This mode is run continuously unless there is another mode or the radiometer has to remain off due to power/energy constraints.

3. The 'Single' mode is equivalent to a single observation of the standard mode. After entering the mode the radiometer warms up to one of the calibration points, equilibrates for 1 hour and then acquires 40 samples over 5 min with the default parameters. Timing of telecommand execution, and telecommands to adjust the sampling rate (up to 0.5 Hz), equilibration duration and measurement duration are available to allow for flexible observations of events that are expected to occur at certain times of the day, such as eclipses and shadows moving into the FOV.
4. Calibration mode acquires 6 measurements in 6 h, each with 200 samples

Modes 1 and 2 run continuously until commanded to idle. In these modes the measurements are roughly synchronized with local solar time in the mode by choosing the durations for waiting between measurements, warm-up and data acquisition such that they add up to 88776 seconds, approximately 1 sol. The alignment of measurements with specific local solar time happens by timing of entering the mode. For standard mode the four measurements are planned for approximately 2 am, 5 am, 2 pm, and 5 pm local time.

The radiometer sensors head is temperature stabilized using heaters, and as thermopile sensitivity is a function of temperature the instrument is operated at pre-launch calibrated setpoints As no cooling is performed, the radiometer temperature must be above the ambient temperature for efficient cooling to the environment. To reduce energy consumption and measurement uncertainty the radiometer temperature control is adjusted to the diurnal cycle. There is one setpoint for night ($T_{night} = -35°C$) and one for day ($T_{day} = -5°C$). A third temperature setpoint ($T_{hot} = 25°C$) is used instead of T_{day} if the environment is unexpectedly warm.

The switch from the night to the day/hot day setpoint occurs at approximately 9 am local time in the hourly mode, and between the am and pm measurements in the standard mode. The switch from day to night temperature setpoint occurs at approximately 7 pm local time in the hourly mode and between the pm and the am measurements in the standard mode. In the single and calibration modes one of the three temperature setpoints is selected upon entering the mode.

The temperature of the calibration target/dust cover is stabilized at the same temperature as the sensorhead body for the 'Hourly', 'Standard' and 'Single ' modes. During the 'Calibration' mode the target temperature is varied relative to the sensorhead body.

2.6.6 Ground Calibration

2.6.6.1 Science Tether Temperature Sensor Calibration
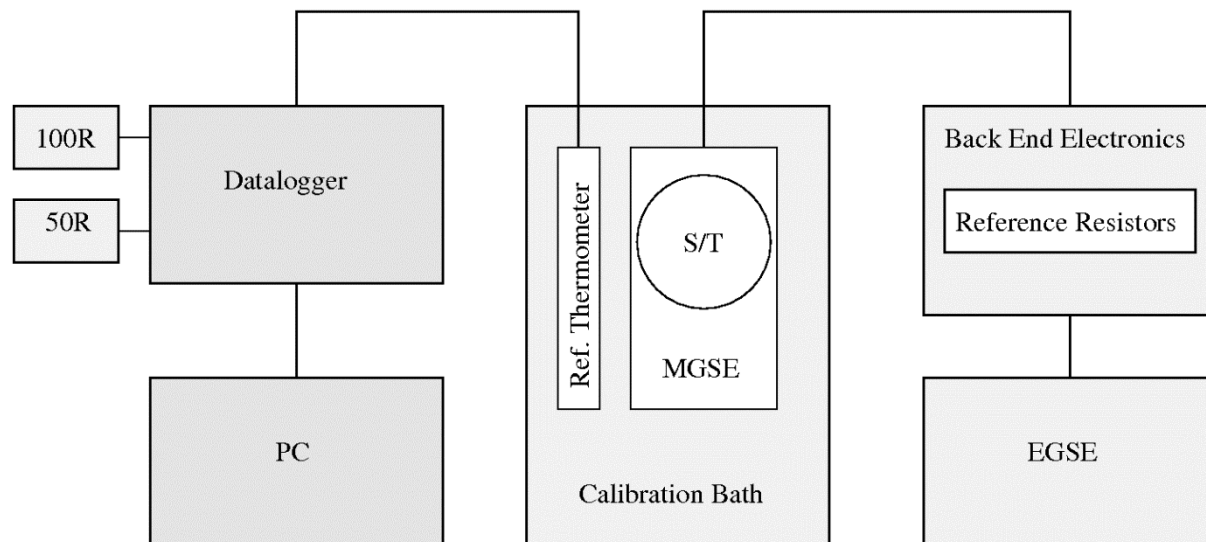
Figure 20: Schematic setup for the calibration of the science tether temperature sensors.

HP³ temperature sensors are calibrated using a comparison calibration approach, in which the science tether including the PT100 sensors is exposed to a controlled temperature environment, whose temperature is simultaneously monitored by a calibrated reference sensor. The measurement setup is schematically shown in Figure 20, and the measurement approach is as follows: The reference thermometer resistance is measured using a datalogger, and the resistance measurements are calibrated against two reference resistors of 100 and 50 Ohm. This data is used to correct for offset in gain of the datalogging electronics. The PT100 sensors on the science tether are measured using the HP³ BEE. In this way, an end-to-end calibration is performed. All measurements are executed using a 4-wire (Kelvin) resistance measurement.

During calibration, the temperature in the calibration bath is varied from 0 to +20, +40, +55, +40, +20, 0, -20, -40, -60, -75, -60, -40, -20, and 0°C. At each setpoint, a soak time of 75 min is used to make sure thermal equilibrium is reached at each point. The employed equilibrium condition is a temperature stability of better than 1 mK over a period of 5 m. The resistance readings recorded for the reference thermometer at the setpoints are then averaged over 5 m after thermal equilibrium has been reached to determine the average temperature at the calibration setpoints.

Reference sensor resistance is corrected for offset and gain using the readings of the calibrated 50 and 100 Ω reference resistors. The true (corrected resistance) value of the measured resistance is then given by

$$R_t = \frac{R_m - R_{off}}{g}$$

where R_m is the measured resistance. The gain factor g and the offset R_{off} are given by

$$g = \frac{R_{m,50} - R_{m,100}}{R_{t,50} - R_{t,100}}$$

$$R_{off} = R_{m,50} - g \cdot R_{t,50}$$

where subscripts m refer to measured, and t refer to true (calibrated) resistance values, respectively. By measuring the resistance of the reference thermometer, the temperature at the setpoints can be determined from its $R(T)$ calibration curve.

The R(T) calibration curve of the science tether PT100 sensors is then determined from the BEE resistance readings using the Callendar-van Dusen equation:

$$R(T) = R_0\left[1 + AT + BT^2 + (T - 100)CT^3\right] \qquad T < 0°C$$

$$R(T) = R_0\left(1 + AT + BT^2\right) \qquad T \geq 0°C$$

The results of the calibration are the fitting coefficients R_0, A, B, and C, along with the misfit of $R(T)$ with respect to the Callendar-van Dusen equation, from which the uncertainty of the Calibration can be obtained.

The error budget for the calibration takes into account contributions from the measurement electronics, as well as contributions from the thermal setup. Major factors controlling the error budget are the homogeneity and stability of the calibration bath, the calibration uncertainty of the reference thermometers, as well as the fitting residuals with respect to the Callendar-van Dusen equation. Contributions from the electronics are generally small. In total, the 1-sigma confidence interval for the calibration uncertainty of the HP^3 PT100 sensors is 12 mK.

2.6.6.2 Tether Length Measurement Calibration

The TLM measures relative and absolute codes and does not need to be calibrated.

2.6.6.3 Mole Tilt Measurement Calibration

For calibration, the STATIL accelerometers are mounted flat on a 3D rotation table. The rotation table is then rotated in 0.5° increments along the gravity vector to determine the sensor characteristics and the min and max output of the accelerometers for the different axes. Values are recorded using the HP^3 BEE. The calibration is performed before STATIL assembly and integration into the HP³ mole. An in-flight calibration is not possible. The main goal of the calibration of the STATIL subsystem is to measure the minimum and maximum output voltage of each axis of each accelerometer under 1 g conditions.

2.6.6.4 Thermal Conductivity Sensor Temperature Calibration
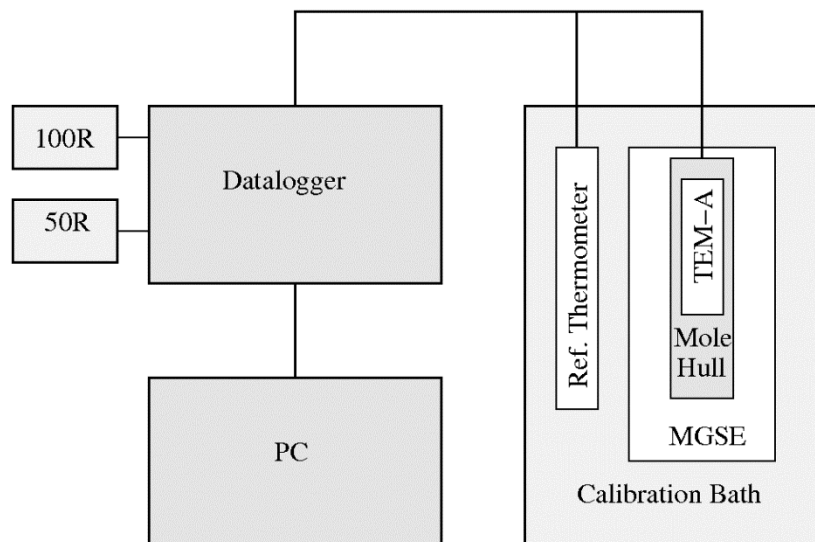
Figure 21: Schematic setup for temperature calibration of the active temperature (TEM-A) foils.

The calibration procedure for the resistance vs. temperature calibration of the TEM-A foils follows the same reasoning as that of the science tether PT100 sensors and uses similar hardware (see Section 2.6.6.1). However, the TEM-A foils need to be calibrated prior to system integration as a whole, and cannot be directly connected to the BEE. Therefore, the TEM-A foils cannot be calibrated using the BEE. Instead, they are calibrated using bench electronics. The calibration setup is schematically shown in Figure 21.

TEM-A foils are connected to the datalogger using a 4-wire (Kelvin) measurement configuration. Calibration data is corrected for offset and gain as described in Section 2.6.6.1. The results of the calibration are the fitting coefficients R_0, A, B, and C, along with the misfit of $R(T)$ with respect to the Callendar-van Dusen equation for the two TEM-A foils. The error budget for the calibration carries similar contributions as that for the PT100 sensors (Section 2.6.6.1), but is dominated by the misfit with respect to the Callendar-van Dusen equation. In total, the 1-sigma confidence interval for the calibration uncertainty is 30 mK.

2.6.6.5 Radiometer Calibration

The radiometer undergoes radiometric and geometric calibration prior to integration into the lander.

The radiometric calibration was carried out under an atmosphere of 8 mbar Ar. As a calibration target, a cavity blackbody, type BB100 (Sapritzky et al. 2003) was used. The blackbody is temperature stabilized at temperatures of T_{BB} = 150 K to 300 K with an accuracy and homogeneity of ~50mK. The blackbody cavity is open to the pressure vessel and the instrument is mounted to view into the cavity. The radiometer was mounted inside a thermal shroud that was temperature controlled within the temperature range of expected Mars environment temperatures of T_{shroud} = 150 K to 270 K.

For calibration, the different temperatures were varied and thermopile voltages have been recorded after reaching thermal equilibrium to determine the different characteristics of the instrument.

The calibration is created using a linear regression of thermopile voltage U_{tc} at thermal equilibrium from each setpoint using net radiative heat flux P_{rad} and body heater power P_{SH} as parameters:

$$U_{tc} = C_1 + C_2 P_{rad} + C_3 P_{SH}$$

The body heater power is calculated from the externally measured heater current P_{SH}. P_{rad} is the net radiative heat flux exchanged between the thermopile cold junction at temperature T_{ref} and the surfaces within the field of view, which during calibration are the internal calibration target at temperature T_{CT} and the external cavity blackbody at temperature T_{BB}. The total radiative heat flux results from the integral over wavelength of the incoming and outgoing specific radiances as determined by the Planck-function B(T) weighted by the spectral response of the filter absorber combination $\tau(\lambda)$. Integration over the solid angle of the field of view and detector surface area are treated as geometry factors f_{ct} and f_{BB}, to be determined during geometric calibration. Thus it is:

$$P_{rad} = \int_0^\infty \tau(\lambda)\{ f_{ct} \left[B(\lambda, T_{\text{CT}}) - B(\lambda, T_{\text{ref}}) \right] + f_{BB} \left[B(\lambda, T_{BB}) - B(\lambda, T_{\text{ref}}) \right] \}d\lambda$$

The geometric calibration characterized the relative sensitivity of each sensor within the radiometer frame. During geometric calibration the radiometer is mounted in a pan tilt unit in front of a collimated infrared light source. The pan tilt unit moves the radiometer to different angles relative to the collimated beam. The nominal FOVs of the radiometer are 20° cones with boresights at -20° azimuth and -25° and -55° elevation.

Space simulation chamber:
8 mbar CO_2

Cavity
blackbody:
emissivity 0.999
T_{BB}= 150 K to 300 K

Radiometer:
T_{sh} = 238, 268, 298 K
Different mounting positions for
the two FOVs

Thermal shroud
T_{env} = 170 K to 270 K
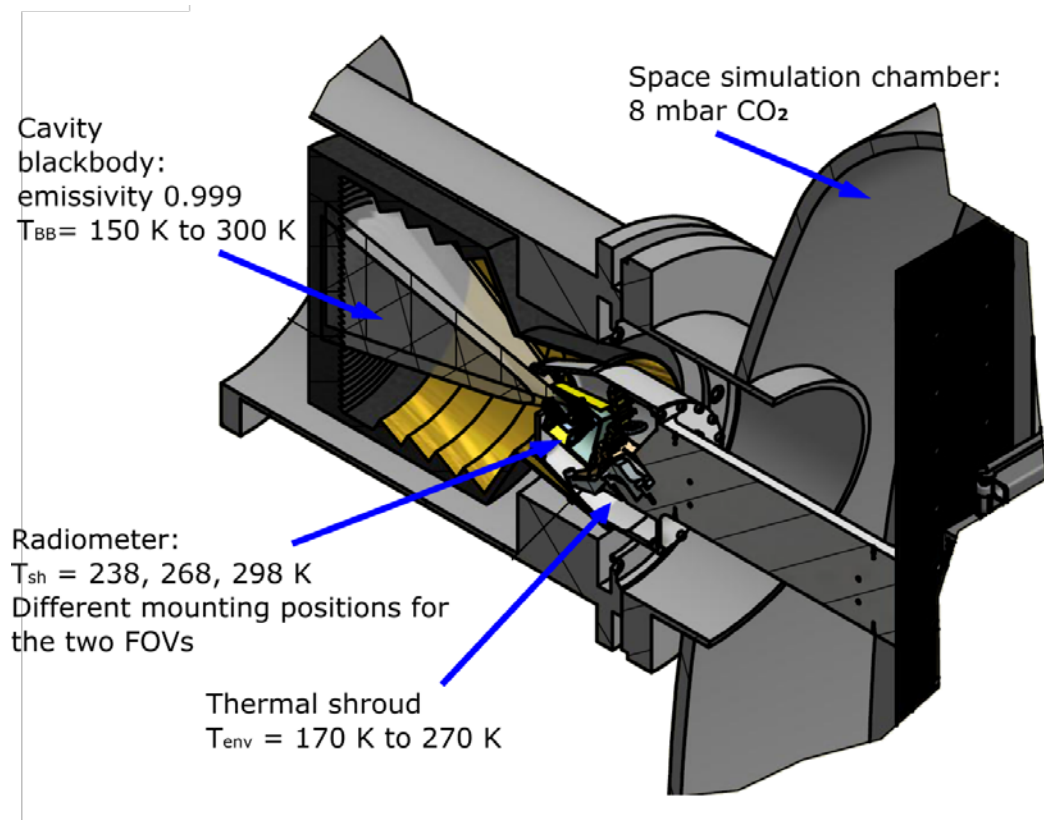
Figure 22: Setup for radiometric calibration showing the cavity blackbody, instrument, and thermal shroud that controls instrument environmental temperature.

2.6.7 Inflight Calibration

2.6.7.1 Radiometer Sensor Inflight Calibration

The radiometer will be calibrated after landing to check for sensor drift. The inflight calibration consists of two measurement sequences, one of which will be executed during the night at the instrument's nighttime setpoint (T_{night} = -35°C) and the other during the day (T_{hot} = +25°C). For each setpoint, the temperature of the calibration target will be varied to six setpoints. From this data, the sensitivity of the individual thermopile sensors can be derived.
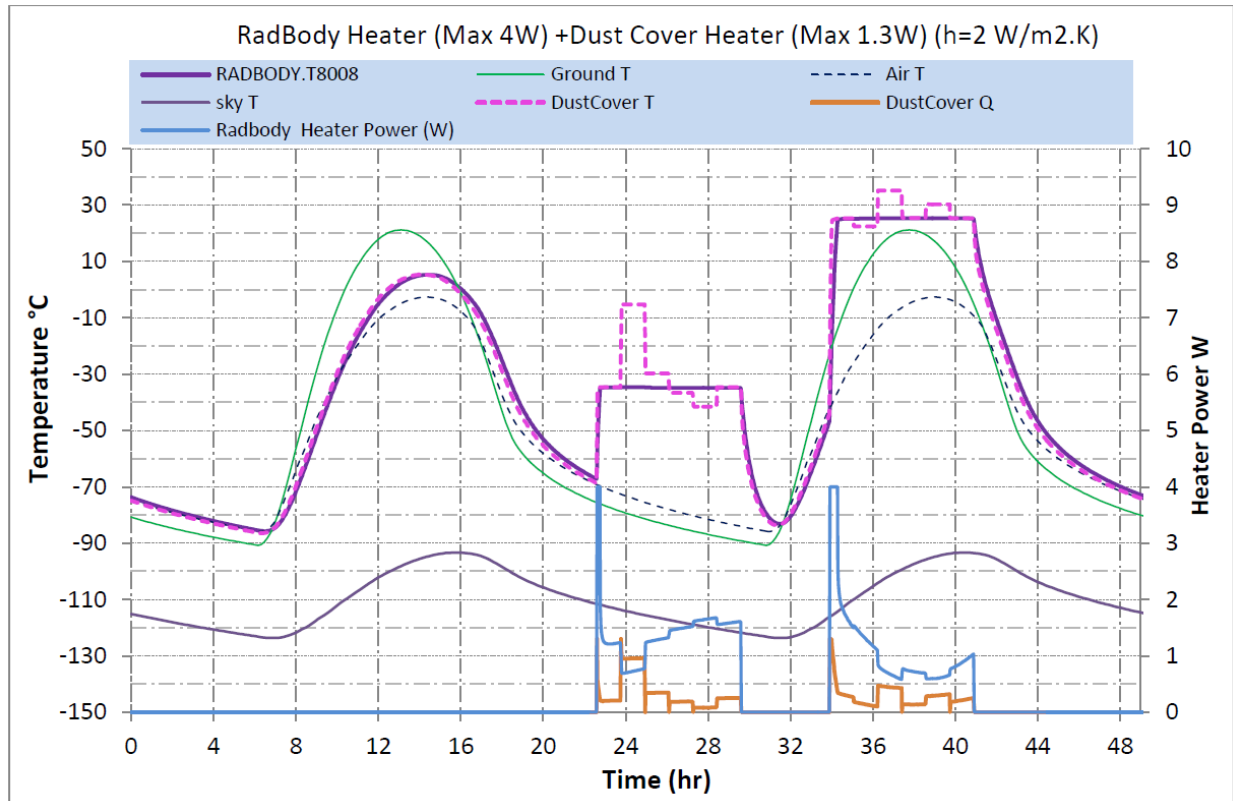
Figure 23: Radiometer operations for re-calibration after landing (solid and dashed violet lines). The dust cover doubles as a calibration target and is varied around the night and day temperature setpoints at -35°C and + 25°C as indicated at around 24-28 hr and 36-40 hr in the 48 h timeframe shown in the figure.

3   HP³ and RAD Data Products

3.1   Data Product Overview

The HP³ instrument acquires active temperature (TEM-A) and static tilt (STATIL) measurements from sensors in the mole, passive temperature measurements (TEM-P) from sensors embedded in the tether, and data from the tether length monitor (TLM). The temperature data gathered by TEM-A and TEM-P will be archived in a combined product, as these subunits will be operated simultaneously. The radiometer measures the brightness temperature in three spectral bands in two directions. Raw, calibrated and derived data products are generated from these measurements, as summarized in Table 4. See Table 5 for processing level definitions. Details about each product are given in Section 5.1, Data Product Formats.

Table 4: HP³ and RAD Data Products

Instrument - Sensor	Processing Level	Product	First Release, Delivery Frequency	Storage Format	Volume [Mbit]
HP³-All	Derived	Calibration Report	Landing – 1 m	Text or PDF	10
HP³-All	Derived	Ground calibration files	Landing – 1 m	ASCII table	0.1
HP³-STATIL/TLM	Raw	Raw voltages vs. time	Start Monitoring + 3 m; one-time delivery	ASCII table	100
HP³-STATIL/TLM	Calibrated	Voltages vs. time	Start Monitoring + 4 m; one-time delivery	ASCII table	120
HP³-TEM	Raw	Raw temperature vs. time	Start Monitoring + 15 m; quarterly	ASCII table	1100
HP³-TEM	Calibrated	Temperature vs. Time	Start Monitoring + 15 m; quarterly	ASCII table	250
HP³-RAD	Raw	Raw voltages vs. time	Start Monitoring + 6 m; quarterly	ASCII table	1500
HP³-RAD	Calibrated	Brightness temperature vs. time	Start Monitoring + 7 m; quarterly	ASCII table	300
HP³-RAD	Derived	Surface temperature vs time	End Primary Mission + 5 m	ASCII table	30

3.2   Data Processing

This section describes the processing of HP³/RAD data products, their structure and organization, and their labeling.

3.2.1   Data Processing Levels

Data processing levels mentioned in this SIS refer to PDS4 processing levels.

Table 5 provides a description of these levels along with the equivalent designations used in other systems.

Table 5: Data Processing Level Definitions

PDS4 processing level	PDS4 processing level description	CODMAC Level (used in PDS3)	NASA Level (used in PDS3)
Telemetry	Telemetry data with instrument data embedded. PDS does not archive telemetry data.	1	0
Raw	Original data from an instrument. If compression, reformatting, packetization, and/or other translation has been applied to facilitate data transmission or storage, those processes are reversed so that the archived data are in a PDS approved archive format. Often call EDRs (Experimental Data Records).	2	1A
Reduced	Data that have been processed beyond the raw stage but which have not yet reached calibrated status. These and more highly processed products are often called RDRs (Reduced Data Records).	2	1A
Calibrated	Data converted to physical units, which makes values independent of the instrument.	3	1B
Derived	Results that have been distilled from one or more calibrated data products (for example, maps, gravity or magnetic fields, or ring particle size distributions). Supplementary data, such as calibration tables or tables of viewing geometry, used to interpret observational data should also be classified as 'derived' data if not easily matched to one of the other three categories.	4+	2+

3.2.2   Data Product Generation

Data products are generated by the HP³/RAD science team at DLR. During the penetration phase, TEM-A and STATIL/TLM data products are generated for each sol. In the baseline scenario, 10 stops are foreseen for the mole, and an equal number of calibrated data products will be generated for each Sensor.

During the monitoring phase, TEM-P data will be accumulated into a single product for each data delivery, spanning a period of several months. Again, this applies to raw and calibrated data. RAD data products will be generated on a sol-by-sol basis for raw and calibrated data.

3.2.3 Data Flow

This section describes only those portions of the InSight data flow that are directly connected to HP^3/RAD archiving. A full description of InSight data flow is provided in the InSight Archive Generation, Validation, and Transfer Plan [4].

HP^3/RAD data are downlinked by InSight Project Operations at JPL. The JPL Advanced Multimission Operations System (AMMOS) Multimission Image Processing Laboratory (MIPL) delivers raw CCSDS telemetry packets to the HP^3/RAD science team at DLR. The HP3/RAD team extracts raw data products from the packets and generates calibrated and derived products. The team generates PDS4 labels for all the data products, assembles the data and documentation into HP3/RAD archive bundles, and delivers the bundles to the PDS Geosciences Node. Deliveries take place according to the release schedule agreed upon by the InSight Project and PDS and specified in the InSight Archive Plan. The Geosciences Node validates the bundles for PDS4 compliance and for compliance with this SIS document, and makes them available to the public online.

3.3 Standards Used in Generating Data Products

HP^3/RAD products and labels comply with Planetary Data System standards, including the PDS4 data model, as specified in applicable documents [1], [2] and [3].

3.3.1 Time Standards

HP3/RAD, TEM-A, TEM-P and STATIL/TLM have the spacecraft clock as system time. After each lander wake-up they are synchronized from the lander with the current spacecraft time. For raw data products, spacecraft clock will be archived, whereas for calibrated data products, spacecraft clock will be converted to UTC and then archived. The tabulated spacecraft clock values provide seconds elapsed since 1.1.2000, 12:00:00 UTC with decimal fractions. The clock drift between HP^3 and spacecraft time is expected to be below 1 sec, small compared to the expected temperature change rates. The number of sols in the mission as well as the true local time will be archived where appropriate.

3.3.2 Coordinate Systems

HP^3 positioning data (STATIL and TLM) is referenced to the tip of the mole after mole release from its launch locks inside the support system. The HP^3 coordinate system is a right-handed (north-east-down) coordinate system with its origin at the surface where the mole tip enters the ground. The location of the origin in the lander coordinate frame will be provided in the dataset documentation.

3.3.3 Data Storage Conventions

HP^3/RAD products are stored as ASCII fixed-width tables.

3.4   Applicable Software

HP^3/RAD data in ASCII tables may be read using many text editors and spreadsheet programs. No special software is required for use with HP^3/RAD data.

3.5   Backups and Duplicates

The Geosciences Node keeps online copies of each archive product. One copy is the primary online archive copy. Another is a backup copy. Once the archive products are fully validated and approved for inclusion in the archive, another copy of the archive is sent to the National Space Science Data Center (NSSDC) for long-term preservation in a NASA-approved deep-storage facility. The Geosciences Node may maintain additional copies of the archive products, either on- or off-site as deemed necessary according to the Node's backup and disaster recovery plan.

4   HP^3/RAD Archive Organization, Identifiers and Naming Conventions

This section describes the basic organization of the HP^3/RAD data archive under the PDS4 Information Model (IM) (Applicable Documents [1] and [3]), including the naming conventions used for the bundle, collection, and product unique identifiers. The formation of logical identifiers is described in Section 4.1. Bundles, collections and products are defined and given identifiers in Section 4.2.

4.1   Logical Identifiers

Every product in PDS is assigned a Logical Identifier (LID) that allows it to be uniquely identified across the PDS system. A LIDVID (Logical Identifier with Version Identifier) includes product version information, and allows different versions of a specific product to be referenced uniquely. A product's LID and VID are defined as separate attributes in the product label. LIDs and VIDs are assigned by PDS and are formed according to the conventions described in the following sections. The uniqueness of a product's LIDVID may be verified using the PDS Registry and Harvest tools.

4.1.1   LID Formation

LIDs take the form of a Uniform Resource Name (URN). LIDs are restricted to ASCII lower case letters, digits, dash, underscore, and period. Colons are used only to separate prescribed components of the LID. Within one of these prescribed components, the dash, underscore, and period may be used as separators. LIDs are limited in length to 255 characters.

InSight HP^3 and RAD LIDs are formed according to the following conventions:

- Bundle LIDs are formed by appending a bundle specific ID to the base ID:

    urn:nasa:pds:<bundle ID>

    Example: urn:nasa:pds:insight_hp3_tem

  The bundle ID must be unique across all bundles archived with the PDS.

- Collection LIDs are formed by appending a collection specific ID to the collection's parent bundle LID:

urn:nasa:pds: <bundle ID>:<collection ID>

Example: urn:nasa:pds:insight_hp3_tem:data_tem_raw

Since the collection LID is based on the bundle LID, which is unique across PDS, the only additional condition is that the collection ID must be unique across the bundle. Collection IDs correspond to the collection type (e.g. "browse", "data", "document", etc.). Additional descriptive information may be appended to the collection type (e.g. "data-raw", "data-calibrated", etc.) to ensure that multiple collections of the same type within a single bundle have unique LIDs.

- Basic product LIDs are formed by appending a product specific ID to the product's parent collection LID:

    urn:nasa:pds: <bundle ID>:<collection ID>:<product ID>

    Example:

    urn:nasa:pds: urn:nasa:pds:insight_hp3_tem:data_tem_raw:<product_id>

Since the product LID is based on the collection LID, which is unique across PDS, the only additional condition is that the product ID must be unique across the collection. Often the product LID is set to be the same as the data file name without the extension. See Section 4.4 below for examples of HP3 and RAD data product LIDs.

4.1.2 VID Formation

Product Version IDs consist of major and minor components separated by a "." (M.n). Both components of the VID are integer values. The major component is initialized to a value of "1", and the minor component is initialized to a value of "0". The minor component resets to "0" when the major component is incremented. The PDS Standards Reference [1] specifies rules for incrementing major and minor components.

4.1.3 File Naming Convention

All HP^3/RAD data products are named according to the following file naming convention:

HP3_[Subsystem]_[Type] [Mode]_[Start Sol]_[yyyy][mm][dd]_[hh][mm][ss].tab

The product's [Subsystem] parameter can be one of the following: TEM, STATIL, TLM, RAD.

The [Type] identifier signifies the processing level and can be one of the following: raw, cal (for calibrated), and der (for derived).

The [Mode] identifier is an optional parameter and only applies to RAD data products. It specifies the operation mode of the RAD and can be one of the following: std (standard mode with 4 measurements per sol), hrl (hourly mode with 24 measurements per sol), sgl (single mode with only one measurement), and ifc (in-flight calibration mode).

The [Start Sol] identifier specifies the Martian sol (counted after InSight landing) when data started to be collected by the instrument as a four digit number.

The time tag parameters [yyyy][mm][dd]_[hh][mm][ss] are respectively the numerical value of year, month, day, hours, minutes and seconds UTC when the data started to be collected by the instrument.

The file extension is .tab for all HP^3/RAD data products.

Example data product names are hp3_tem_raw_0060_20160922_123145.tab and hp3_rad_cal_std _0007 _20160901_045534.tab. The former file contains raw data collected by TEM starting on sol 60 of the mission, starting data acquisition on the 9th of September 2016 at 12:31:45 UTC. The latter file contains calibrated data collected by the RAD on sol 7 of the mission in its standard (4 measurements per sol) measurement mode, starting data acquisition on the 9th of September 2016 at 04:55:34 UTC.

4.2   HP³/RAD Bundles

The highest level of organization for a PDS archive is the bundle. A bundle is a set of one or more related collections that may be of different types. A collection is a set of one or more related basic products that are all of the same type. Bundles and collections are logical structures, not necessarily tied to any physical directory structure or organization.

The complete InSight HP³/RAD science data archive is organized into the bundles described in Table 6.

Table 6: HP³ and RAD Data Bundles

Bundle Logical Identifier	Description
urn:nasa:pds:insight_hp3_tem	HP³ TEM (active and passive) experiment - raw, calibrated and derived data acquired during active heating and monitoring
urn:nasa:pds:insight_rad	Radiometer experiment - raw, calibrated and derived data from measurements of emitted surface thermal radiation

In addition to the HP³ and RAD data bundles, the InSight archives will include a Document Bundle that will contain documentation for all InSight data bundles. The contents of the Document Bundle are described in the following section.

4.3   HP³/RAD Collections

Collections consist of basic products all of the same type. The following tables show the collections found in each of the HP³/RAD data bundles. These are described further in Section 5.1.

Table 7: Collections in the HP³ TEM Data Bundle

Collection Logical Identifier	Description
urn:nasa:pds:insight_hp3_tem:data_tem_raw	TEM-RAW: temperature measurements during active heating along drive path and at final depth
urn:nasa:pds:insight_hp3_tem:data_tem_calibrated	TEM-CAL: data as temperatures
urn:nasa:pds:insight_hp3_tem:data_statil_raw	STATIL/TLM-RAW: mole position as a function of time during drilling

urn:nasa:pds:insight_hp3_tem:data_statil_calibrated	STATIL/TLM-CAL: calibrated mole position and angle

Table 8: Collections in the RAD Data Bundle

Collection Logical Identifier	Description
urn:nasa:pds:insight_rad:data_raw	RAD-RAW: measurements of emitted surface thermal radiation
urn:nasa:pds:insight_rad:data_calibrated	RAD-CAL: emitted thermal measurements reduced to surface brightness temperature
urn:nasa:pds:insight_rad:data_derived	RAD-DER: surface temperature as function of time

4.4 HP³/RAD Products

A PDS product consists of one or more digital objects and an accompanying PDS label file. PDS labels provide identification and description information for labeled objects. The PDS label includes a Logical Identifier (LID) by which any PDS labeled product is uniquely identified throughout all PDS archives. PDS4 labels are XML-formatted ASCII files.

The table below give examples of LIDs for data products in the HP³ and RAD collections. The term <file name> would be replaced by a product file name minus the extension.

Table 9: Examples of HP³ and RAD Data Product LIDs

HP³ TEM Bundle	
Collection	**Example LID**
TEM-RAW	urn:nasa:pds:insight_hp3_tem:data_tem_raw:<file name>
TEM-CAL	urn:nasa:pds:insight_hp3_tem:data_tem_calibrated:<file name>
STATIL/TLM-RAW	urn:nasa:pds:insight_hp3_tem:data_statil_raw:<file name>
STATIL/TLM-CAL	urn:nasa:pds:insight_hp3_tem:data_statil_calibrated:<file name>
RAD Bundle	
Collection	**Example LID**
RAD-RAW	urn:nasa:pds:insight_rad:data_raw:<file name>
RAD-CAL	urn:nasa:pds:insight_rad:data_calibrated:<file name>
RAD-DER	urn:nasa:pds:insight_rad:data_derived:<file name>

4.5 InSight Document Bundle and Collections

Documents are also considered products by PDS, and have LIDs, VIDs and PDS4 labels just as data products do. The InSight archives include an InSight Document Bundle, which consists of

collections of documents relevant to the mission itself and all the science experiments. The HP^3/RAD Team is responsible for the HP^3/RAD document collection in this bundle.

Table 10: Collections in the InSight Document Bundle

Collection Logical Identifier	Description
urn:nasa:pds:insight_documents:document_mission	InSight mission, spacecraft and lander descriptions
urn:nasa:pds:insight_documents:document_apss	APSS SIS, instrument description, and other relevant documents
urn:nasa:pds:insight_documents:document_camera	Camera SIS, instrument description, and other relevant documents
urn:nasa:pds:insight_documents:document_hp3rad	HP^3/RAD SIS (this document) , instrument description, and other relevant documents
urn:nasa:pds:insight_documents:document_ida	IDA SIS, instrument description, and other relevant documents
urn:nasa:pds:insight_documents:document_mag	MAG SIS, instrument description, and other relevant documents
urn:nasa:pds:insight_documents:document_rise	RISE SIS, instrument description, and other relevant documents
urn:nasa:pds:insight_documents:document_seis	SEIS SIS, instrument description, and other relevant documents
urn:nasa:pds:insight_documents:document_spice	SPICE relevant documents

Documents in the InSight Document Collections are assigned LIDs based on file names such that they are unique identifiers.

5   HP^3/RAD Archive Product Formats

Data that compose the HP^3/RAD data archive are formatted in accordance with PDS specifications (Applicable Documents [1], [2] and [3]). This section provides details on the formats used for each of the products included in the archive.

5.1   Data Product Formats

This section describes the format and record structure of each of the data file types. All HP^3 and RAD data products will be stored as ASCII text tables.

5.1.1   HP^3 Active Data Products

All times given in the following refer to the spacecraft time, which can be converted to other desired time formats using the appropriate SPICE tools.

5.1.1.1 TEM-RAW

TEM measurements consist of active heating experiments to determine thermal conductivity during the penetration phase of the mission, as well as passive temperature monitoring. During active heating, at least 48 hours of mole cooldown monitoring (temperature monitoring at all sensors, data every 15 sec, 14 Sensors, 2 references, 2 heaters, 2 currents, 24 bit per sensor, one timestamp, 48 bit) will be performed. Offsets of all voltages are also measured, doubling the amount of data), as well as up to 24 hours of TEM-A heating (same data as in the 48-hour period). A data vector is thus 114 bytes. The total amount of raw data for one TEM-A measurement is (assuming one measurement every 16 seconds) 14.7 Mbit. The total number of measurements is 10 stops. 392.7 Mbit of TEM-A raw data will be generated. Raw data will be archived as digital numbers. Depth information for each sensor is given in the corresponding labels. Passive temperature monitoring acquires the same data, but without powering the TEM-A heaters. The structure of the data vectors is therefore identical, and a flag ('heater') in the calibrated data indicates whether the TEM-A heaters were active for a given measurement. This information can also be extracted from the TEM-A heating current, which is 1 mA during monitoring, but up to 50 mA during active heating. Archived time is spacecraft clock and sol number.

Table 11: HP³ TEM Raw Data Columns

Column	Signal	Column	Signal	Column	Signal	Column	Signal
1	Spacecraft Clock Time	11	PT5	21	Offset PT9	31	R-Ref Odd
2	Sol	12	PT6	22	Offset PT10	32	R-Ref Even
3	PT1	13	Offset PT5	23	PT11	33	Offset R-Ref Odd
4	PT2	14	Offset PT6	24	PT12	34	Offset R-Ref Even
5	Offset PT1	15	PT7	25	Offset PT11	35	TEM-A Current Odd
6	Offset PT2	16	PT8	26	Offset PT12	36	TEM-A Current Even
7	PT3	17	Offset PT7	27	PT13	37	R-Temp Odd TEM-A
8	PT4	18	Offset PT8	28	PT14	38	R-Temp Even TEM-A
9	Offset PT3	19	PT9	29	Offset PT13		
10	Offset PT4	20	PT10	30	Offset PT14		

5.1.1.2 TEM-CAL

For the calibrated data, the DN of the raw data will be corrected for offsets and converted to Kelvin, Ohm, and Ampere. Calibrated data will thus contain a timestamp, 16 temperatures, 2 resistances, and 2 heating currents. A single thermal conductivity measurement will thus produce 8.34 Mbit of calibrated data. The total produced calibrated data will be 226.8 Mbit. Depth information for each sensor is given in the corresponding labels. The areal percentage of shadows in the HP^3 deployment area will be calculated in a way equivalent to that presented in Section 2.6.2. and archived together with the TEM-CAL data. Archived time is UTC in addition to sol number and Mars True Local Time. The lander shadow will be evaluated at the point at which the mole is inserted into the ground and will be either 0% or 100%.

Table 12: HP³ TEM- Calibrated Data Columns

Column	Signal	Column	Signal	Column	Signal
1	Universal Coordinated Time	26	Depth Error T5	51	Temp T12
2	Sol	27	Temp T6	52	Temp Error T12
3	Mars True Local Solar Time	28	Temp Error T6	53	Depth T12
4	Solar longitude LS	29	Depth T6	54	Depth Error T12
5	Sun Azimuth	30	Depth Error T6	55	Temp T13
6	Lander Shadow	31	Temp T 7	56	Temp Error T13
7	Temp T1	32	Temp Error T7	57	Depth T13
8	Temp Error T1	33	Depth T7	58	Depth Error T13
9	Depth T1	34	Depth Error T7	59	Temp T14
10	Depth Error T1	35	Temp T 8	60	Temp Error T14
11	Temp T2	36	Temp Error T8	61	Depth T14
12	Temp Error T2	37	Depth T8	62	Depth Error T14
13	Depth T2	38	Depth Error T8	63	Temp T15
14	Depth Error T2	39	Temp T9	64	Temp Error T15
15	Temp T3	40	Temp Error T9	65	Depth T15
16	Temp Error T3	41	Depth T9	66	Depth Error T15
17	Depth T3	42	Depth Error T9	67	Temp T16
18	Depth Error T3	43	Temp T10	68	Temp Error T16
19	Temp T4	44	Temp Error T10	69	Depth T16
20	Temp Error T4	45	Depth T10	70	Depth Error T16
21	Depth T4	46	Depth Error T10	71	R1

22	Depth Error T4	47	Temp T11	72	R2
23	Temp T5	48	Temp Error T11	73	I1
24	Temp Error T5	49	Depth T11	74	I2
25	Depth T5	50	Depth Error T11	75	Heater

5.1.1.3 STATIL/TLM-RAW

The STATIL data consist of 10 individual measurements taken once every tenth stroke of the mole. Each readout contains a timestamp and the measured voltage of each of the four axes of the tiltmeters. In addition, the mole motor current will be archived. The data will be stored as digital numbers in ASCII format. Archived time is spacecraft clock and sol number.

Table 13: HP³ STATIL Raw Data Columns

Column	Signal
1	Spacecraft Clock Time
2	Sol
3	X-Axis Sensor A
4	Y-Axis Sensor A
5	X-Axis Sensor B
6	Y-Axis Sensor B

The TLM data consist of the relative length counter, the absolute length counter, and a timestamp. A dataset will be generated whenever either the relative or absolute depth changes. The data will be stored as digital numbers in ASCII format. Archived time time is spacecraft clock and sol number. See Section 2.6.3.2 for a definition of absolute vs. relative length.

Table 14: HP³ TLM Raw Data Columns

Column	Signal
1	Spacecraft Clock Time
2	Sol
3	Relative Length
4	Absolute Length
5	New Abs
6	1bit Error
7	2bit Error

5.1.1.4 STATIL/TLM-CAL

Raw data will be converted to angles for STATIL and length for TLM. Calibrated motor current will not be archived for STATIL. Archived time time is UTC. See Section 2.6.3.2 for a definition of absolute vs. relative length.

Table 15: Calibrated STATIL Data Columns

Column	Signal
1	Universal Coordinated Time
2	Sol
3	X-Axis Sensor A, angle
4	Y-Axis Sensor A, angle
5	X-Axis Sensor B, angle
6	Y-Axis Sensor B, angle
7	Absolute length, mm
8	Relative length, mm

5.1.2 RAD Data Products

The HP³ radiometer (RAD) consists of six thermopile sensors measuring the brightness temperature in three spectral bands in two directions fixed within the lander frame. The radiometer data is most useful if interpreted in the context of information such as the orientation of the lander in a landing site coordinate frame and Instrument Deployment Camera (IDC) images of the surface spots measured by the radiometer.

5.1.2.1 RAD-RAW

Table 16: HP³ RAD Raw Data Columns

Col	Signal
1	Spacecraft Clock Time
2	Sol
3	Thermopile1A_TC
4	Thermopile2A_TC
5	Thermopile1B_TC
6	Thermopile2B_TC
7	Thermopile1C_TC
8	Thermopile2C_TC

Col	Signal
9	Thermopile1A_PT
10	Thermopile2A_PT
11	Thermopile1B_PT
12	Thermopile2B_PT
13	Thermopile1C_PT
14	Thermopile2C_PT
15	ADC1_Rref
16	ADC2_Rref
17	PT Cal Target
18	PT Sensor Head
19	Offset Thermopile1A_PT
20	Offset Thermopile2A_PT
21	Offset Thermopile1B_PT
22	Offset Thermopile2B_PT
23	Offset Thermopile1C_PT
24	Offset Thermopile2C_PT
25	Offset ADC1_Rref
26	Offset ADC2_Rref
27	Offset PT Cal Target
28	Offset PT Sensor Head
29	HK Space Craft Clock
30	Radiometer Operation Mode
31	Section of Sol
32	TRefHigh Select
33	Sensorhead Body Heater PWM
34	Cal. Target Heater PWM
35	Radiometer Test Mode

The aim of the radiometer is to constrain the annual heat wave in the underground by measuring the daily average brightness temperature over the course of the mission. The measurements of the radiometer will be coordinated with local solar time and are planned to occur at fixed local solar times. The radiometer has several modes of operation, that differ mostly in measurement duration and frequency, but not in data structure. Raw data is a table of digital numbers and Booleans.

The standard measurement mode is four measurements at four fixed local solar times (2 and 5 am; 2 and 5 pm) intermittently every sol. Each measurement in this mode acquires data for 5 min with the dust cover closed and 5 min with the dust cover open, at a sampling rate of one vector every 15 sec and thus 40 vectors per measurement. At least once per 15° of solar longitude (depending on the availability of power and data budget) the frequency of measurements is increased to 24 measurements per sol (detailed or hourly mode), again with 40 vectors per measurement. In calibration mode, the radiometer acquires data with the dust cover closed and heated to different temperatures.

The binary size of a data vector is 1x Timestamp 48 bit + 27 x 24 bit ADC readings + 3 x 16 bit HK + 7 bit Misc. = 751bit. Storing the vector as ASCII decimal number is expected to increase the size by a factor of 3, thus to 2.2 kbit. The maximum size of the raw archive is expected to be 1497 Mbit (or 187 Mbyte) if all measurements are taken in the hourly mode.

5.1.2.2 RAD-CAL

Calibrated RAD data will be archived as surface brightness temperatures T_B as measured by the 6 different sensors, and the estimated uncertainty. Additional calibrated measurements of the instruments state that affect the uncertainty estimate will be archived, these are the sensor temperatures, the calibration target and sensorhead temperatures and the heater power. (

In addition to the radiometer data, ancillary data about the FOV in relation to the sun and lander shadow will be archived. For this purpose each FOV (with three co-aligned sensors) is modelled with raytracing of 100 beams. The shadow of a lander model is projected on the DEM of the landing site.

The average of the FOV beam intersects with the DEM for the parameters emission angle, sun phase angle, sun incidence angle, surface emission angle, and the percentage of the FOV in shadow will be archived for each sensor, together with variance over the FOV if applicable.

Table 17: HP³ RAD Calibrated Data Columns

Col.	Signal
1	Universal Coordinated Time
2	Sol
3	Mars True Local Solar Time
4	Solar Longitude LS
5	Sun Azimuth
6	Sun Phase Angle FOV 1
7	Incidence Angle FOV 1
8	Sigma Sun Phase Angle FOV 1
9	Sigma Incidence Angle FOV 1
10	Shadow FOV 1
11	Sun Phase Angle FOV 2
12	Incidence Angle FOV 2
13	Sigma Sun Phase Angle FOV 2
14	Sigma Incidence Angle FOV 2

Col.	Signal
15	Shadow FOV 2
16	T_B Sensor 1A
17	T_B Sensor 1B
18	T_B Sensor 1C
19	T_B Sensor 2A
20	T_B Sensor 2B
21	T_B Sensor 2C
22	ΔT_B Sensor 1A
23	ΔT_B Sensor 1B
24	ΔT_B Sensor 1C
25	ΔT_B Sensor 2A
26	ΔT_B Sensor 2B
27	ΔT_B Sensor 2C
28	T_{ref} Sensor 1A
29	T_{ref} Sensor 1B
30	T_{ref} Sensor 1C
31	T_{ref} Sensor 2A
32	T_{ref} Sensor 2B
33	T_{ref} Sensor 2C
34	RAD Operation Mode
35	Cal. Target Heater Power
36	Cal. Target Temperature
37	Sensorhead Heater Power
38	Sensorhead Temperature
39	Lander BUS Voltage

5.1.2.3 RAD-DER

The derived data product of the radiometer is the surface temperature in each of the two fields of view of the RAD as a function of time. In addition, the temperature uncertainty resulting from calibration and emissivity uncertainty will be archived. The sun geometry data of the calibrated data product is also archived for context.

Table 18: HP³ RAD Derived Data Columns

Col.	Signal
1	Universal Coordinated Time
2	Sol
3	Mars True Local Solar Time

Col.	Signal
4	Solar Longitude LS
5	Sun Azimuth
6	Sun Phase Angle FOV 1
7	Incidence Angle FOV 1
8	Sigma Sun Phase Angle FOV 1
9	Sigma Incidence Angle FOV 1
10	Shadow FOV 1
11	Sun Phase Angle FOV 2
12	Incidence Angle FOV 2
13	Sigma Sun Phase Angle FOV 2
14	Sigma Incidence Angle FOV 2
15	Shadow FOV 2
16	T_S FoV 1
17	T_S FoV 2
18	ΔT_S FoV 1
19	ΔT_S FoV 2

5.2 Document Product Formats

Documents in InSight archives are provided as PDF/A (www.pdfa.org/download/pdfa-in-a-nutshell) or as plain ASCII text if no special formatting is required. Figures that accompany documents may be provided as TIFF, GIF, JPEG, or PNG files.

5.3 PDS Labels

Each HP3/RAD product is accompanied by a PDS4 label. PDS4 labels are ASCII text files written in the eXtensible Markup Language (XML). Product labels are detached from the files they describe (with the exception of the Product_Bundle label). There is one label for every product. A PDS4 label file usually has the same name as the data product it describes, but always with the extension ".xml".

For the InSight mission, the structure and content of PDS labels will conform to the PDS master schema and schematron based upon the PDS Information Model [3]. By use of an XML editor the schema and schematron may be used to validate the structure and content of the product labels. In brief, the schema is the XML model that PDS4 labels must follow, and the schematron is a set of validation rules that are applied to PDS4 labels.

The PDS master schema and schematron are produced, managed, and supplied to InSight by the PDS. In addition to the master schema, the InSight mission has produced additional XML schemas and schematrons which govern the products in this archive. These files contain attribute and parameter definitions specific to the InSight mission. A list of the XML schema files associated with this archive is provided at http://pds.nasa.gov/pds4/schema/released/.

Examples of PDS labels for the HP3/RAD archive are given in Appendix B.

Appendix A   Support Staff and Cognizant Persons

Table 19: Archive Support Staff and Cognizant Persons

HP3/RAD Team		
Name	**Affiliation**	**Email**
Matthias Grott, HP^3 Science Manager	DLR	matthias.grott@dlr.de
Troy Hudson, HP^3 Co-I	JPL	troy.l.hudson@jpl.nasa.gov
Christian Krause, STATIL Manager	DLR	christian.krause@dlr.de
Nils Mueller, Radiometer Scientist	DLR	nils.mueller@dlr.de
Tilman Spohn, HP^3 P.I.	DLR	tilman.spohn@dlr.de
PDS Geosciences Node		
Name	**Affiliation**	**Email**
Raymond Arvidson, director	Washington University	arvidson@wunder.wustl.edu
Edward Guinness	Washington University	guinness@wustl.edu
Susan Slavney	Washington University	susan.slavney@wustl.edu

Appendix B   Example Data Product Labels

This section provides examples of product labels for the various data types described in this document. The content of actual HP[3] and RAD labels may vary from these examples.

B.1   HP[3] TEM Raw Data

```xml
<?xml version="1.0" encoding="utf-8"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<Product_Observational
    xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:insight="http://pds.nasa.gov/pds4/mission/insight/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1
    https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.xsd

    http://pds.nasa.gov/pds4/mission/insight/v1
    https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.xsd">
    <Identification_Area>
        <logical_identifier>
            urn:nasa:pds:insight_hp3_tem:data_tem_raw:hp3_tem_raw_00653_20171101_120129
        </logical_identifier>
        <version_id>1.0</version_id>
        <title>InSight HP3 Thermal Excitation and Measurement Raw Product:hp3_tem_raw_00653_20171101_120129</title>
        <information_model_version>1.10.1.0</information_model_version>
        <product_class>Product_Observational</product_class>
        <Modification_History>
            <Modification_Detail>
                <modification_date>2018-02-14</modification_date>
                <version_id>1.0</version_id>
                <description>Peer review approved version</description>
            </Modification_Detail>
        </Modification_History>
    </Identification_Area>
    <Observation_Area>
        <Time_Coordinates>
            <start_date_time>2017-10-31T23:01:29.403Z</start_date_time>
            <stop_date_time>2017-11-01T14:10:03.145Z</stop_date_time>
        </Time_Coordinates>
```

```xml
<Investigation_Area>
    <name>InSight</name>
    <type>Mission</type>
    <Internal_Reference>
        <lid_reference>urn:nasa:pds:context:investigation:mission.insight</lid_reference>
        <reference_type>data_to_investigation</reference_type>
    </Internal_Reference>
</Investigation_Area>
<Observing_System>
    <Observing_System_Component>
        <name>InSight</name>
        <type>Spacecraft</type>
        <Internal_Reference>
            <lid_reference>urn:nasa:pds:context:instrument_host:spacecraft.insight</lid_reference>
            <reference_type>is_instrument_host</reference_type>
        </Internal_Reference>
    </Observing_System_Component>
    <Observing_System_Component>
        <name>Heat Flow and Physical Properties Probe</name>
        <type>Instrument</type>
        <Internal_Reference>
            <lid_reference>urn:nasa:pds:context:instrument:hp3.insight</lid_reference>
            <reference_type>is_instrument</reference_type>
        </Internal_Reference>
    </Observing_System_Component>
</Observing_System>
<Target_Identification>
    <name>Mars</name>
    <type>Planet</type>
    <Internal_Reference>
        <lid_reference>urn:nasa:pds:context:target:planet.mars</lid_reference>
        <reference_type>data_to_target</reference_type>
    </Internal_Reference>
</Target_Identification>
<Mission_Area>
    <insight:Observation_Information>
        <insight:release_number>0001</insight:release_number>
        <insight:mission_phase_name>SURFACE MISSION</insight:mission_phase_name>
        <insight:product_type>TEM-raw</insight:product_type>
        <insight:spacecraft_clock_start_count>1509490889-26411</insight:spacecraft_clock_start_count>
        <insight:spacecraft_clock_stop_count>1509545403-09503</insight:spacecraft_clock_stop_count>
        <insight:spacecraft_clock_count_partition>1</insight:spacecraft_clock_count_partition>
        <insight:start_sol_number>00653</insight:start_sol_number>
        <insight:stop_sol_number>00653</insight:stop_sol_number>
        <insight:start_local_mean_solar_time>Sol-00653M07:58:02</insight:start_local_mean_solar_time>
```

```
            <insight:stop_local_mean_solar_time>Sol-00653M08:53:35</insight:stop_local_mean_solar_time>
            <insight:start_solar_longitude unit="deg">7.967</insight:start_solar_longitude>
            <insight:stop_solar_longitude unit="deg">8.893</insight:stop_solar_longitude>
            <insight:software_name>XML Archiv Tool</insight:software_name>
            <insight:software_version_id>1.0</insight:software_version_id>
        </insight:Observation_Information>
    </Mission_Area>
</Observation_Area>
<Reference_List>
    <Internal_Reference>
        <lid_reference>urn:nasa:pds:insight_documents:document_mission</lid_reference>
        <reference_type>data_to_document</reference_type>
    </Internal_Reference>
    <Internal_Reference>
        <lid_reference>urn:nasa:pds:insight_documents:document_hp3rad:hp3_rad_sis</lid_reference>
        <reference_type>data_to_document</reference_type>
    </Internal_Reference>
</Reference_List>
<File_Area_Observational>
    <File>
        <file_name>hp3_tem_raw_00653_20171101_120129.tab</file_name>
        <creation_date_time>2018-10-11T15:54:00.491Z</creation_date_time>
    </File>
    <Table_Character>
        <name>HP3 TEM RAW</name>
        <offset unit="byte">0</offset>
        <records>756</records>
        <description>One row of this table contains raw Thermal Excitation and Measurement data.</description>
        <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
        <Record_Character>
            <fields>38</fields>
            <groups>0</groups>
            <record_length unit="byte">349</record_length>
            <Field_Character>
                <name>Spacecraft clock time</name>
                <field_number>1</field_number>
                <field_location unit="byte">1</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">17</field_length>
                <unit>sec</unit>
                <description>Spacecraft clock count at which measurement occurred, represented as a real number.
Note that spacecraft_clock_start_count and spacecraft_clock_stop_count in the Mission Area of this label are
represented not as a real number but as a whole number followed by  a fractional clock tick, where the fraction is in
units of 1/65536 of a tick.</description>
            </Field_Character>
```

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```xml
<Field_Character>
    <name>Sol</name>
    <field_number>2</field_number>
    <field_location unit="byte">19</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">5</field_length>
    <unit>DN</unit>
    <description>Sol number for this set of measurements</description>
</Field_Character>
<Field_Character>
    <name>PT1</name>
    <field_number>3</field_number>
    <field_location unit="byte">25</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT1</description>
</Field_Character>
<Field_Character>
    <name>PT2</name>
    <field_number>4</field_number>
    <field_location unit="byte">34</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT2</description>
</Field_Character>
<Field_Character>
    <name>Offset PT1</name>
    <field_number>5</field_number>
    <field_location unit="byte">43</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT1</description>
</Field_Character>
<Field_Character>
    <name>Offset PT2</name>
    <field_number>6</field_number>
    <field_location unit="byte">52</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT2</description>
</Field_Character>
```

```
<Field_Character>
    <name>PT3</name>
    <field_number>7</field_number>
    <field_location unit="byte">61</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT3</description>
</Field_Character>
<Field_Character>
    <name>PT4</name>
    <field_number>8</field_number>
    <field_location unit="byte">70</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT4</description>
</Field_Character>
<Field_Character>
    <name>Offset PT3</name>
    <field_number>9</field_number>
    <field_location unit="byte">79</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT3</description>
</Field_Character>
<Field_Character>
    <name>Offset PT4</name>
    <field_number>10</field_number>
    <field_location unit="byte">88</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT4</description>
</Field_Character>
<Field_Character>
    <name>PT5</name>
    <field_number>11</field_number>
    <field_location unit="byte">97</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT5</description>
</Field_Character>
```

```
<Field_Character>
    <name>PT6</name>
    <field_number>12</field_number>
    <field_location unit="byte">106</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT6</description>
</Field_Character>
<Field_Character>
    <name>Offset PT5</name>
    <field_number>13</field_number>
    <field_location unit="byte">115</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT5</description>
</Field_Character>
<Field_Character>
    <name>Offset PT6</name>
    <field_number>14</field_number>
    <field_location unit="byte">124</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT6</description>
</Field_Character>
<Field_Character>
    <name>PT7</name>
    <field_number>15</field_number>
    <field_location unit="byte">133</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT7</description>
</Field_Character>
<Field_Character>
    <name>PT8</name>
    <field_number>16</field_number>
    <field_location unit="byte">142</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT8</description>
</Field_Character>
```

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```xml
<Field_Character>
    <name>Offset PT7</name>
    <field_number>17</field_number>
    <field_location unit="byte">151</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT7</description>
</Field_Character>
<Field_Character>
    <name>Offset PT8</name>
    <field_number>18</field_number>
    <field_location unit="byte">160</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT8</description>
</Field_Character>
<Field_Character>
    <name>PT9</name>
    <field_number>19</field_number>
    <field_location unit="byte">169</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT9</description>
</Field_Character>
<Field_Character>
    <name>PT10</name>
    <field_number>20</field_number>
    <field_location unit="byte">178</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT10</description>
</Field_Character>
<Field_Character>
    <name>Offset PT9</name>
    <field_number>21</field_number>
    <field_location unit="byte">187</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT9</description>
</Field_Character>
```

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```
<Field_Character>
    <name>Offset PT10</name>
    <field_number>22</field_number>
    <field_location unit="byte">196</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT10</description>
</Field_Character>
<Field_Character>
    <name>PT11</name>
    <field_number>23</field_number>
    <field_location unit="byte">205</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT11</description>
</Field_Character>
<Field_Character>
    <name>PT12</name>
    <field_number>24</field_number>
    <field_location unit="byte">214</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT12</description>
</Field_Character>
<Field_Character>
    <name>Offset PT11</name>
    <field_number>25</field_number>
    <field_location unit="byte">223</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT11</description>
</Field_Character>
<Field_Character>
    <name>Offset PT12</name>
    <field_number>26</field_number>
    <field_location unit="byte">232</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT12</description>
</Field_Character>
```

```xml
<Field_Character>
    <name>PT13</name>
    <field_number>27</field_number>
    <field_location unit="byte">241</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT13</description>
</Field_Character>
<Field_Character>
    <name>PT14</name>
    <field_number>28</field_number>
    <field_location unit="byte">250</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at sensor PT14</description>
</Field_Character>
<Field_Character>
    <name>Offset PT13</name>
    <field_number>29</field_number>
    <field_location unit="byte">259</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT13</description>
</Field_Character>
<Field_Character>
    <name>Offset PT14</name>
    <field_number>30</field_number>
    <field_location unit="byte">268</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at sensor PT14</description>
</Field_Character>
<Field_Character>
    <name>R-Ref Odd</name>
    <field_number>31</field_number>
    <field_location unit="byte">277</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at R-Reference Odd</description>
</Field_Character>
```

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```xml
<Field_Character>
    <name>R-Ref Even</name>
    <field_number>32</field_number>
    <field_location unit="byte">286</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Temperature reading at R-Reference Even</description>
</Field_Character>
<Field_Character>
    <name>Offset R-Ref Odd</name>
    <field_number>33</field_number>
    <field_location unit="byte">295</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at R-Reference Odd</description>
</Field_Character>
<Field_Character>
    <name>Offset R-Ref Even</name>
    <field_number>34</field_number>
    <field_location unit="byte">304</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset at R-Reference Even</description>
</Field_Character>
<Field_Character>
    <name>TEM-A Current Odd</name>
    <field_number>35</field_number>
    <field_location unit="byte">313</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Reading at TEM-A Current Odd</description>
</Field_Character>
<Field_Character>
    <name>TEM-A Current Even</name>
    <field_number>36</field_number>
    <field_location unit="byte">322</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Reading at TEM-A Current Even</description>
</Field_Character>
```

```xml
                    <Field_Character>
                        <name>R-Temp Odd TEM-A</name>
                        <field_number>37</field_number>
                        <field_location unit="byte">331</field_location>
                        <data_type>ASCII_Integer</data_type>
                        <field_length unit="byte">8</field_length>
                        <unit>DN</unit>
                        <description>Reading at R-Temp-Odd-TEM-A</description>
                    </Field_Character>
                    <Field_Character>
                        <name>R-Temp Even TEM-A</name>
                        <field_number>38</field_number>
                        <field_location unit="byte">340</field_location>
                        <data_type>ASCII_Integer</data_type>
                        <field_length unit="byte">8</field_length>
                        <unit>DN</unit>
                        <description>Reading at R-Temp-Even-TEM-A</description>
                    </Field_Character>
                </Record_Character>
            </Table_Character>
        </File_Area_Observational>
</Product_Observational>
```

B.2 HP³ TEM Calibrated Data

```xml
<?xml version="1.0" encoding="utf-8"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<Product_Observational
    xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:insight="http://pds.nasa.gov/pds4/mission/insight/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1
    https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.xsd

    http://pds.nasa.gov/pds4/mission/insight/v1
    https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.xsd">
    <Identification_Area>
        <logical_identifier>
            urn:nasa:pds:insight_hp3_tem:data_tem_calibrated:hp3_tem_cal_00653_20171101_120129
        </logical_identifier>
        <version_id>1.0</version_id>
        <title>
            InSight HP3 Thermal Excitation and Measurement Calibrated
            Product:hp3_tem_cal_00653_20171101_120129
        </title>
        <information_model_version>1.10.1.0</information_model_version>
        <product_class>Product_Observational</product_class>
        <Modification_History>
            <Modification_Detail>
                <modification_date>2018-02-14</modification_date>
                <version_id>1.0</version_id>
                <description>Peer review approved version</description>
            </Modification_Detail>
        </Modification_History>
    </Identification_Area>
    <Observation_Area>
        <Time_Coordinates>
            <start_date_time>2017-10-31T23:01:29.403Z</start_date_time>
            <stop_date_time>2017-11-01T14:10:03.145Z</stop_date_time>
        </Time_Coordinates>
        <Investigation_Area>
            <name>InSight</name>
```

```xml
                <type>Mission</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:investigation:mission.insight</lid_reference>
                    <reference_type>data_to_investigation</reference_type>
                </Internal_Reference>
            </Investigation_Area>
            <Observing_System>
                <Observing_System_Component>
                    <name>InSight</name>
                    <type>Spacecraft</type>
                    <Internal_Reference>
                        <lid_reference>urn:nasa:pds:context:instrument_host:spacecraft.insight</lid_reference>
                        <reference_type>is_instrument_host</reference_type>
                    </Internal_Reference>
                </Observing_System_Component>
                <Observing_System_Component>
                    <name>Heat Flow and Physical Properties Probe</name>
                    <type>Instrument</type>
                    <Internal_Reference>
                        <lid_reference>urn:nasa:pds:context:instrument:hp3.insight</lid_reference>
                        <reference_type>is_instrument</reference_type>
                    </Internal_Reference>
                </Observing_System_Component>
            </Observing_System>
            <Target_Identification>
                <name>Mars</name>
                <type>Planet</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:target:planet.mars</lid_reference>
                    <reference_type>data_to_target</reference_type>
                </Internal_Reference>
            </Target_Identification>
            <Mission_Area>
                <insight:Observation_Information>
                    <insight:release_number>0001</insight:release_number>
                    <insight:mission_phase_name>SURFACE MISSION</insight:mission_phase_name>
                    <insight:product_type>TEM-calibrated</insight:product_type>
                    <insight:spacecraft_clock_start_count>1509490889-26411</insight:spacecraft_clock_start_count>
                    <insight:spacecraft_clock_stop_count>1509545403-09503</insight:spacecraft_clock_stop_count>
                    <insight:spacecraft_clock_count_partition>1</insight:spacecraft_clock_count_partition>
                    <insight:start_sol_number>00653</insight:start_sol_number>
                    <insight:stop_sol_number>00653</insight:stop_sol_number>
                    <insight:start_local_mean_solar_time>Sol-00653M07:58:02</insight:start_local_mean_solar_time>
                    <insight:stop_local_mean_solar_time>Sol-00653M08:53:35</insight:stop_local_mean_solar_time>
                    <insight:start_solar_longitude unit="deg">7.967</insight:start_solar_longitude>
```

```xml
                        <insight:stop_solar_longitude unit="deg">8.893</insight:stop_solar_longitude>
                        <insight:software_name>XML Archiv Tool</insight:software_name>
                        <insight:software_version_id>1.0</insight:software_version_id>
                    </insight:Observation_Information>
                </Mission_Area>
            </Observation_Area>
            <Reference_List>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:insight_documents:document_mission</lid_reference>
                    <reference_type>data_to_document</reference_type>
                </Internal_Reference>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:insight_documents:document_hp3rad:hp3_rad_sis</lid_reference>
                    <reference_type>data_to_document</reference_type>
                </Internal_Reference>
            </Reference_List>
            <File_Area_Observational>
                <File>
                    <file_name>hp3_tem_cal_00653_20171101_120129.tab</file_name>
                    <creation_date_time>2018-10-11T15:54:01.301Z</creation_date_time>
                </File>
                <Table_Character>
                    <name>HP3 TEM CAL</name>
                    <offset unit="byte">0</offset>
                    <records>756</records>
                    <description>
                        One row of this table contains calibrated Thermal Excitation and Measurement data.
                    </description>
                    <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
                    <Record_Character>
                        <fields>75</fields>
                        <groups>0</groups>
                        <record_length unit="byte">690</record_length>
                        <Field_Character>
                            <name>Universal coordinated time</name>
                            <field_number>1</field_number>
                            <field_location unit="byte">1</field_location>
                            <data_type>ASCII_Date_Time_YMD_UTC</data_type>
                            <field_length unit="byte">25</field_length>
                            <unit>Date</unit>
                            <description>Date and time at which measurement occurred</description>
                        </Field_Character>
                        <Field_Character>
                            <name>Sol</name>
                            <field_number>2</field_number>
```

```
    <field_location unit="byte">27</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">5</field_length>
    <unit>DN</unit>
    <description>Sol number for this set of measurements</description>
</Field_Character>
<Field_Character>
    <name>Mars True Local Solar Time</name>
    <field_number>3</field_number>
    <field_location unit="byte">33</field_location>
    <data_type>ASCII_String</data_type>
    <field_length unit="byte">8</field_length>
    <unit>1/24 sol</unit>
    <description>Mars Date and time at which measurement occurred</description>
</Field_Character>
<Field_Character>
    <name>Solar longitude LS </name>
    <field_number>4</field_number>
    <field_location unit="byte">42</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>Degree</unit>
    <description>Mars sun angle from northern hemisphere spring equinox</description>
</Field_Character>
<Field_Character>
    <name>Sun Azimuth</name>
    <field_number>5</field_number>
    <field_location unit="byte">51</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>Degree</unit>
    <description>Sun Azimuth</description>
</Field_Character>
<Field_Character>
    <name>Lander shadow</name>
    <field_number>6</field_number>
    <field_location unit="byte">60</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>%</unit>
    <description>Shadow at mole location</description>
</Field_Character>
<Field_Character>
    <name>Temp T1</name>
    <field_number>7</field_number>
```

```
        <field_location unit="byte">69</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature reading sensor T1</description>
    </Field_Character>
    <Field_Character>
        <name>Temp Error T1</name>
        <field_number>8</field_number>
        <field_location unit="byte">78</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature error of sensor T1</description>
    </Field_Character>
    <Field_Character>
        <name>Depth T1</name>
        <field_number>9</field_number>
        <field_location unit="byte">87</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth of sensor T1</description>
    </Field_Character>
    <Field_Character>
        <name>Depth Error T1</name>
        <field_number>10</field_number>
        <field_location unit="byte">96</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth Error of Sensor T1</description>
    </Field_Character>
    <Field_Character>
        <name>Temp T2</name>
        <field_number>11</field_number>
        <field_location unit="byte">105</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature reading sensor T2</description>
    </Field_Character>
    <Field_Character>
        <name>Temp Error T2</name>
        <field_number>12</field_number>
```

```xml
        <field_location unit="byte">114</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature error of sensor T2</description>
    </Field_Character>
    <Field_Character>
        <name>Depth T2</name>
        <field_number>13</field_number>
        <field_location unit="byte">123</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth of sensor T2</description>
    </Field_Character>
    <Field_Character>
        <name>Depth Error T2</name>
        <field_number>14</field_number>
        <field_location unit="byte">132</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth Error of Sensor T2</description>
    </Field_Character>
    <Field_Character>
        <name>Temp T3</name>
        <field_number>15</field_number>
        <field_location unit="byte">141</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature reading sensor T3</description>
    </Field_Character>
    <Field_Character>
        <name>Temp Error T3</name>
        <field_number>16</field_number>
        <field_location unit="byte">150</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature error of sensor T3</description>
    </Field_Character>
    <Field_Character>
        <name>Depth T3</name>
        <field_number>17</field_number>
```

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```xml
            <field_location unit="byte">159</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>Meter</unit>
            <description>Depth of sensor T3</description>
        </Field_Character>
        <Field_Character>
            <name>Depth Error T3</name>
            <field_number>18</field_number>
            <field_location unit="byte">168</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>Meter</unit>
            <description>Depth Error of Sensor T3</description>
        </Field_Character>
        <Field_Character>
            <name>Temp T4</name>
            <field_number>19</field_number>
            <field_location unit="byte">177</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature reading sensor T4</description>
        </Field_Character>
        <Field_Character>
            <name>Temp Error T4</name>
            <field_number>20</field_number>
            <field_location unit="byte">186</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature error of sensor T4</description>
        </Field_Character>
        <Field_Character>
            <name>Depth T4</name>
            <field_number>21</field_number>
            <field_location unit="byte">195</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>Meter</unit>
            <description>Depth of sensor T4</description>
        </Field_Character>
        <Field_Character>
            <name>Depth Error T4</name>
            <field_number>22</field_number>
```

70

```xml
            <field_location unit="byte">204</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>Meter</unit>
            <description>Depth Error of Sensor T4</description>
        </Field_Character>
        <Field_Character>
            <name>Temp T5</name>
            <field_number>23</field_number>
            <field_location unit="byte">213</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature reading sensor T5</description>
        </Field_Character>
        <Field_Character>
            <name>Temp Error T5</name>
            <field_number>24</field_number>
            <field_location unit="byte">222</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature error of sensor T5</description>
        </Field_Character>
        <Field_Character>
            <name>Depth T5</name>
            <field_number>25</field_number>
            <field_location unit="byte">231</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>Meter</unit>
            <description>Depth of sensor T5</description>
        </Field_Character>
        <Field_Character>
            <name>Depth Error T5</name>
            <field_number>26</field_number>
            <field_location unit="byte">240</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>Meter</unit>
            <description>Depth Error of Sensor T5</description>
        </Field_Character>
        <Field_Character>
            <name>Temp T6</name>
            <field_number>27</field_number>
```

71

```xml
            <field_location unit="byte">249</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature reading sensor T6</description>
        </Field_Character>
        <Field_Character>
            <name>Temp Error T6</name>
            <field_number>28</field_number>
            <field_location unit="byte">258</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature error of sensor T6</description>
        </Field_Character>
        <Field_Character>
            <name>Depth T6</name>
            <field_number>29</field_number>
            <field_location unit="byte">267</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>Meter</unit>
            <description>Depth of sensor T6</description>
        </Field_Character>
        <Field_Character>
            <name>Depth Error T6</name>
            <field_number>30</field_number>
            <field_location unit="byte">276</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>Meter</unit>
            <description>Depth Error of Sensor T6</description>
        </Field_Character>
        <Field_Character>
            <name>Temp T 7</name>
            <field_number>31</field_number>
            <field_location unit="byte">285</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature reading sensor T7</description>
        </Field_Character>
        <Field_Character>
            <name>Temp Error T7</name>
            <field_number>32</field_number>
```

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```
    <field_location unit="byte">294</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>K</unit>
    <description>Temperature error of sensor T7</description>
</Field_Character>
<Field_Character>
    <name>Depth T7</name>
    <field_number>33</field_number>
    <field_location unit="byte">303</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>Meter</unit>
    <description>Depth of sensor T7</description>
</Field_Character>
<Field_Character>
    <name>Depth Error T7</name>
    <field_number>34</field_number>
    <field_location unit="byte">312</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>Meter</unit>
    <description>Depth Error of Sensor T7</description>
</Field_Character>
<Field_Character>
    <name>Temp T 8</name>
    <field_number>35</field_number>
    <field_location unit="byte">321</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>K</unit>
    <description>Temperature reading sensor T8</description>
</Field_Character>
<Field_Character>
    <name>Temp Error T8</name>
    <field_number>36</field_number>
    <field_location unit="byte">330</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>K</unit>
    <description>Temperature error of sensor T8</description>
</Field_Character>
<Field_Character>
    <name>Depth T8</name>
    <field_number>37</field_number>
```

73

```xml
        <field_location unit="byte">339</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth of sensor T8</description>
    </Field_Character>
    <Field_Character>
        <name>Depth Error T8</name>
        <field_number>38</field_number>
        <field_location unit="byte">348</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth Error of Sensor T8</description>
    </Field_Character>
    <Field_Character>
        <name>Temp T9</name>
        <field_number>39</field_number>
        <field_location unit="byte">357</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature reading sensor T9</description>
    </Field_Character>
    <Field_Character>
        <name>Temp Error T9</name>
        <field_number>40</field_number>
        <field_location unit="byte">366</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature error of sensor T9</description>
    </Field_Character>
    <Field_Character>
        <name>Depth T9</name>
        <field_number>41</field_number>
        <field_location unit="byte">375</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth of sensor T9</description>
    </Field_Character>
    <Field_Character>
        <name>Depth Error T9</name>
        <field_number>42</field_number>
```

74

```
        <field_location unit="byte">384</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth Error of Sensor T9</description>
    </Field_Character>
    <Field_Character>
        <name>Temp T10</name>
        <field_number>43</field_number>
        <field_location unit="byte">393</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature reading sensor T10</description>
    </Field_Character>
    <Field_Character>
        <name>Temp Error T10</name>
        <field_number>44</field_number>
        <field_location unit="byte">402</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature error of sensor T10</description>
    </Field_Character>
    <Field_Character>
        <name>Depth T10</name>
        <field_number>45</field_number>
        <field_location unit="byte">411</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth of sensor T10</description>
    </Field_Character>
    <Field_Character>
        <name>Depth Error T10</name>
        <field_number>46</field_number>
        <field_location unit="byte">420</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth Error of Sensor T10</description>
    </Field_Character>
    <Field_Character>
        <name>Temp T11</name>
        <field_number>47</field_number>
```

```xml
        <field_location unit="byte">429</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature reading sensor T11</description>
    </Field_Character>
    <Field_Character>
        <name>Temp Error T11</name>
        <field_number>48</field_number>
        <field_location unit="byte">438</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature error of sensor T11</description>
    </Field_Character>
    <Field_Character>
        <name>Depth T11</name>
        <field_number>49</field_number>
        <field_location unit="byte">447</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth of sensor T11</description>
    </Field_Character>
    <Field_Character>
        <name>Depth Error T11</name>
        <field_number>50</field_number>
        <field_location unit="byte">456</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth Error of Sensor T11</description>
    </Field_Character>
    <Field_Character>
        <name>Temp T12</name>
        <field_number>51</field_number>
        <field_location unit="byte">465</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature reading sensor T12</description>
    </Field_Character>
    <Field_Character>
        <name>Temp Error T12</name>
        <field_number>52</field_number>
```

```
                    <field_location unit="byte">474</field_location>
                    <data_type>ASCII_Real</data_type>
                    <field_length unit="byte">8</field_length>
                    <unit>K</unit>
                    <description>Temperature error of sensor T12</description>
                </Field_Character>
                <Field_Character>
                    <name>Depth T12</name>
                    <field_number>53</field_number>
                    <field_location unit="byte">483</field_location>
                    <data_type>ASCII_Real</data_type>
                    <field_length unit="byte">8</field_length>
                    <unit>Meter</unit>
                    <description>Depth of sensor T12</description>
                </Field_Character>
                <Field_Character>
                    <name>Depth Error T12</name>
                    <field_number>54</field_number>
                    <field_location unit="byte">492</field_location>
                    <data_type>ASCII_Real</data_type>
                    <field_length unit="byte">8</field_length>
                    <unit>Meter</unit>
                    <description>Depth Error of Sensor T12</description>
                </Field_Character>
                <Field_Character>
                    <name>Temp T13</name>
                    <field_number>55</field_number>
                    <field_location unit="byte">501</field_location>
                    <data_type>ASCII_Real</data_type>
                    <field_length unit="byte">8</field_length>
                    <unit>K</unit>
                    <description>Temperature reading sensor T13</description>
                </Field_Character>
                <Field_Character>
                    <name>Temp Error T13</name>
                    <field_number>56</field_number>
                    <field_location unit="byte">510</field_location>
                    <data_type>ASCII_Real</data_type>
                    <field_length unit="byte">8</field_length>
                    <unit>K</unit>
                    <description>Temperature error of sensor T13</description>
                </Field_Character>
                <Field_Character>
                    <name>Depth T13</name>
                    <field_number>57</field_number>
```

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```xml
        <field_location unit="byte">519</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth of sensor T13</description>
    </Field_Character>
    <Field_Character>
        <name>Depth Error T13</name>
        <field_number>58</field_number>
        <field_location unit="byte">528</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth Error of Sensor T13</description>
    </Field_Character>
    <Field_Character>
        <name>Temp T14</name>
        <field_number>59</field_number>
        <field_location unit="byte">537</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature reading sensor T14</description>
    </Field_Character>
    <Field_Character>
        <name>Temp Error T14</name>
        <field_number>60</field_number>
        <field_location unit="byte">546</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature error of sensor T14</description>
    </Field_Character>
    <Field_Character>
        <name>Depth T14</name>
        <field_number>61</field_number>
        <field_location unit="byte">555</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth of sensor T14</description>
    </Field_Character>
    <Field_Character>
        <name>Depth Error T14</name>
        <field_number>62</field_number>
```

```
        <field_location unit="byte">564</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth Error of Sensor T14</description>
</Field_Character>
<Field_Character>
        <name>Temp T15</name>
        <field_number>63</field_number>
        <field_location unit="byte">573</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature reading sensor T15</description>
</Field_Character>
<Field_Character>
        <name>Temp Error T15</name>
        <field_number>64</field_number>
        <field_location unit="byte">582</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>K</unit>
        <description>Temperature error of sensor T15</description>
</Field_Character>
<Field_Character>
        <name>Depth T15</name>
        <field_number>65</field_number>
        <field_location unit="byte">591</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth of sensor T15</description>
</Field_Character>
<Field_Character>
        <name>Depth Error T15</name>
        <field_number>66</field_number>
        <field_location unit="byte">600</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>Meter</unit>
        <description>Depth Error of Sensor T15</description>
</Field_Character>
<Field_Character>
        <name>Temp T16</name>
        <field_number>67</field_number>
```

```
            <field_location unit="byte">609</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature reading sensor T16</description>
        </Field_Character>
        <Field_Character>
            <name>Temp Error T16</name>
            <field_number>68</field_number>
            <field_location unit="byte">618</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature error of sensor T16</description>
        </Field_Character>
        <Field_Character>
            <name>Depth T16</name>
            <field_number>69</field_number>
            <field_location unit="byte">627</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>Meter</unit>
            <description>Depth of sensor T16</description>
        </Field_Character>
        <Field_Character>
            <name>Depth Error T16</name>
            <field_number>70</field_number>
            <field_location unit="byte">636</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>Meter</unit>
            <description>Depth Error of Sensor T16</description>
        </Field_Character>
        <Field_Character>
            <name>R1</name>
            <field_number>71</field_number>
            <field_location unit="byte">645</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>Ohm</unit>
            <description>Resistance reading at TEM-A odd</description>
        </Field_Character>
        <Field_Character>
            <name>R2</name>
            <field_number>72</field_number>
```

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```
                <field_location unit="byte">654</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">8</field_length>
                <unit>Ohm</unit>
                <description>Resistance reading at TEM-A even</description>
            </Field_Character>
            <Field_Character>
                <name>I1</name>
                <field_number>73</field_number>
                <field_location unit="byte">663</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">8</field_length>
                <unit>Ampere</unit>
                <description>Current reading at TEM-A odd</description>
            </Field_Character>
            <Field_Character>
                <name>I2</name>
                <field_number>74</field_number>
                <field_location unit="byte">672</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">8</field_length>
                <unit>Ampere</unit>
                <description>Current reading at TEM-A even</description>
            </Field_Character>
            <Field_Character>
                <name>Heater</name>
                <field_number>75</field_number>
                <field_location unit="byte">681</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">8</field_length>
                <description>Heater current-on flag</description>
            </Field_Character>
        </Record_Character>
      </Table_Character>
    </File_Area_Observational>
</Product_Observational>
```

B.3 HP³ STATIL Raw Data

```xml
<?xml version="1.0" encoding="utf-8"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<Product_Observational
    xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:insight="http://pds.nasa.gov/pds4/mission/insight/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1
    https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.xsd

    http://pds.nasa.gov/pds4/mission/insight/v1
    https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.xsd">
    <Identification_Area>
        <logical_identifier>
            urn:nasa:pds:insight_hp3_tem:data_statil_raw:hp3_statil_raw_00353_20181127_020232
        </logical_identifier>
        <version_id>1.0</version_id>
        <title>InSight HP3 Static Tiltmeter Raw Product:hp3_statil_raw_00353_20181127_020232</title>
        <information_model_version>1.10.1.0</information_model_version>
        <product_class>Product_Observational</product_class>
        <Modification_History>
            <Modification_Detail>
                <modification_date>2018-02-14</modification_date>
                <version_id>1.0</version_id>
                <description>Peer review approved version</description>
            </Modification_Detail>
        </Modification_History>
    </Identification_Area>
    <Observation_Area>
        <Time_Coordinates>
            <start_date_time>2018-11-27T01:02:32.842Z</start_date_time>
            <stop_date_time>2018-11-27T20:40:28.137Z</stop_date_time>
        </Time_Coordinates>
        <Investigation_Area>
            <name>InSight</name>
            <type>Mission</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:mission.insight</lid_reference>
```

```xml
            <reference_type>data_to_investigation</reference_type>
        </Internal_Reference>
    </Investigation_Area>
    <Observing_System>
        <Observing_System_Component>
            <name>InSight</name>
            <type>Spacecraft</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:instrument_host:spacecraft.insight</lid_reference>
                <reference_type>is_instrument_host</reference_type>
            </Internal_Reference>
        </Observing_System_Component>
        <Observing_System_Component>
            <name>Heat Flow and Physical Properties Probe</name>
            <type>Instrument</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:instrument:hp3.insight</lid_reference>
                <reference_type>is_instrument</reference_type>
            </Internal_Reference>
        </Observing_System_Component>
    </Observing_System>
    <Target_Identification>
        <name>Mars</name>
        <type>Planet</type>
        <Internal_Reference>
            <lid_reference>urn:nasa:pds:context:target:planet.mars</lid_reference>
            <reference_type>data_to_target</reference_type>
        </Internal_Reference>
    </Target_Identification>
    <Mission_Area>
        <insight:Observation_Information>
            <insight:release_number>0001</insight:release_number>
            <insight:mission_phase_name>SURFACE MISSION</insight:mission_phase_name>
            <insight:product_type>STATIL-raw</insight:product_type>
            <insight:spacecraft_clock_start_count>1543280540-26214</insight:spacecraft_clock_start_count>
            <insight:spacecraft_clock_stop_count>1543351215-45548</insight:spacecraft_clock_stop_count>
            <insight:spacecraft_clock_count_partition>1</insight:spacecraft_clock_count_partition>
            <insight:start_sol_number>00353</insight:start_sol_number>
            <insight:stop_sol_number>00354</insight:stop_sol_number>
            <insight:start_local_mean_solar_time>Sol-00353M07:58:02</insight:start_local_mean_solar_time>
            <insight:stop_local_mean_solar_time>Sol-00354M08:53:35</insight:stop_local_mean_solar_time>
            <insight:start_solar_longitude unit="deg">7.967</insight:start_solar_longitude>
            <insight:stop_solar_longitude unit="deg">8.893</insight:stop_solar_longitude>
            <insight:software_name>XML Archiv Tool</insight:software_name>
            <insight:software_version_id>1.0</insight:software_version_id>
```

```xml
                </insight:Observation_Information>
            </Mission_Area>
        </Observation_Area>
        <Reference_List>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:insight_documents:document_mission</lid_reference>
                <reference_type>data_to_document</reference_type>
            </Internal_Reference>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:insight_documents:document_hp3rad:hp3_rad_sis</lid_reference>
                <reference_type>data_to_document</reference_type>
            </Internal_Reference>
        </Reference_List>
        <File_Area_Observational>
            <File>
                <file_name>hp3_statil_raw_00353_20181127_020232.tab</file_name>
                <creation_date_time>2018-10-11T15:34:45.601Z</creation_date_time>
            </File>
            <Table_Character>
                <name>HP3 STATIL RAW</name>
                <offset unit="byte">0</offset>
                <records>643</records>
                <description>One row of this table contains raw Static Tiltmeter data.</description>
                <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
                <Record_Character>
                    <fields>6</fields>
                    <groups>0</groups>
                    <record_length unit="byte">61</record_length>
                    <Field_Character>
                        <name>Spacecraft clock time</name>
                        <field_number>1</field_number>
                        <field_location unit="byte">1</field_location>
                        <data_type>ASCII_Real</data_type>
                        <field_length unit="byte">17</field_length>
                        <unit>sec</unit>
                        <description>
                            Spacecraft clock count at which measurement occurred, represented as a real number. Note that
                            spacecraft_clock_start_count and spacecraft_clock_stop_count in the Mission Area of this label
                            are represented not as a real number but as a whole number followed by  a fractional clock
                            tick, where the fraction is in units of 1/65536 of a tick.
                        </description>
                    </Field_Character>
                    <Field_Character>
                        <name>Sol</name>
                        <field_number>2</field_number>
```

```
        <field_location unit="byte">19</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">5</field_length>
        <unit>DN</unit>
        <description>Sol number for this set of measurements</description>
    </Field_Character>
    <Field_Character>
        <name>X-Axis Sensor A</name>
        <field_number>3</field_number>
        <field_location unit="byte">25</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>Instrument reading for channel 1A</description>
    </Field_Character>
    <Field_Character>
        <name>Y-Axis Sensor A</name>
        <field_number>4</field_number>
        <field_location unit="byte">34</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>Instrument reading for channel 2A</description>
    </Field_Character>
    <Field_Character>
        <name>X-Axis Sensor B</name>
        <field_number>5</field_number>
        <field_location unit="byte">43</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>Instrument reading for channel 1B</description>
    </Field_Character>
    <Field_Character>
        <name>Y-Axis Sensor B</name>
        <field_number>6</field_number>
        <field_location unit="byte">52</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>Instrument reading for channel 2B</description>
    </Field_Character>
  </Record_Character>
</Table_Character>
```

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```
        </File_Area_Observational>
</Product_Observational>
```

B.4 HP³ TLM Raw Data

```xml
<?xml version="1.0" encoding="utf-8"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<Product_Observational
    xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:insight="http://pds.nasa.gov/pds4/mission/insight/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1
    https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.xsd

    http://pds.nasa.gov/pds4/mission/insight/v1
    https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.xsd">
    <Identification_Area>
        <logical_identifier>
            urn:nasa:pds:insight_hp3_tem:data_statil_raw:hp3_tlm_raw_00353_20181127_020232
        </logical_identifier>
        <version_id>1.0</version_id>
        <title>InSight HP3 Tether Length Monitor Raw Product:hp3_tlm_raw_00353_20181127_020232</title>
        <information_model_version>1.10.1.0</information_model_version>
        <product_class>Product_Observational</product_class>
        <Modification_History>
            <Modification_Detail>
                <modification_date>2018-02-14</modification_date>
                <version_id>1.0</version_id>
                <description>Peer review approved version</description>
            </Modification_Detail>
        </Modification_History>
    </Identification_Area>
    <Observation_Area>
        <Time_Coordinates>
            <start_date_time>2018-11-27T01:02:32.842Z</start_date_time>
            <stop_date_time>2018-11-27T20:44:26.587Z</stop_date_time>
        </Time_Coordinates>
        <Investigation_Area>
            <name>InSight</name>
            <type>Mission</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:mission.insight</lid_reference>
```

```xml
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>InSight</name>
                <type>Spacecraft</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:instrument_host:spacecraft.insight</lid_reference>
                    <reference_type>is_instrument_host</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
            <Observing_System_Component>
                <name>Heat Flow and Physical Properties Probe</name>
                <type>Instrument</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:instrument:hp3.insight</lid_reference>
                    <reference_type>is_instrument</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>Mars</name>
            <type>Planet</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:target:planet.mars</lid_reference>
                <reference_type>data_to_target</reference_type>
            </Internal_Reference>
        </Target_Identification>
        <Mission_Area>
            <insight:Observation_Information>
                <insight:release_number>0001</insight:release_number>
                <insight:mission_phase_name>SURFACE MISSION</insight:mission_phase_name>
                <insight:product_type>TLM-raw</insight:product_type>
                <insight:spacecraft_clock_start_count>1543280540-26214</insight:spacecraft_clock_start_count>
                <insight:spacecraft_clock_stop_count>1543351454-09503</insight:spacecraft_clock_stop_count>
                <insight:spacecraft_clock_count_partition>1</insight:spacecraft_clock_count_partition>
                <insight:start_sol_number>00353</insight:start_sol_number>
                <insight:stop_sol_number>00354</insight:stop_sol_number>
                <insight:start_local_mean_solar_time>Sol-00353M07:58:02</insight:start_local_mean_solar_time>
                <insight:stop_local_mean_solar_time>Sol-00354M08:53:35</insight:stop_local_mean_solar_time>
                <insight:start_solar_longitude unit="deg">7.967</insight:start_solar_longitude>
                <insight:stop_solar_longitude unit="deg">8.893</insight:stop_solar_longitude>
                <insight:software_name>XML Archiv Tool</insight:software_name>
                <insight:software_version_id>1.0</insight:software_version_id>
```

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```xml
                    </insight:Observation_Information>
                </Mission_Area>
            </Observation_Area>
            <Reference_List>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:insight_documents:document_mission</lid_reference>
                    <reference_type>data_to_document</reference_type>
                </Internal_Reference>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:insight_documents:document_hp3rad:hp3_rad_sis</lid_reference>
                    <reference_type>data_to_document</reference_type>
                </Internal_Reference>
            </Reference_List>
            <File_Area_Observational>
                <File>
                    <file_name>hp3_tlm_raw_00353_20181127_020232.tab</file_name>
                    <creation_date_time>2018-10-11T15:34:55.981Z</creation_date_time>
                </File>
                <Table_Character>
                    <name>HP3 TLM RAW</name>
                    <offset unit="byte">0</offset>
                    <records>757</records>
                    <description>One row of this table contains raw Tether Length Monitor data.</description>
                    <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
                    <Record_Character>
                        <fields>7</fields>
                        <groups>0</groups>
                        <record_length unit="byte">70</record_length>
                        <Field_Character>
                            <name>Spacecraft clock time</name>
                            <field_number>1</field_number>
                            <field_location unit="byte">1</field_location>
                            <data_type>ASCII_Real</data_type>
                            <field_length unit="byte">17</field_length>
                            <unit>sec</unit>
                            <description>
                                Spacecraft clock count at which measurement occurred, represented as a real number. Note that
                                spacecraft_clock_start_count and spacecraft_clock_stop_count in the Mission Area of this label
                                are represented not as a real number but as a whole number followed by  a fractional clock
                                tick, where the fraction is in units of 1/65536 of a tick.
                            </description>
                        </Field_Character>
                        <Field_Character>
                            <name>Sol</name>
                            <field_number>2</field_number>
```

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```
            <field_location unit="byte">19</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">5</field_length>
            <unit>DN</unit>
            <description>Sol number for this set of measurements</description>
        </Field_Character>
        <Field_Character>
            <name>Relative length</name>
            <field_number>3</field_number>
            <field_location unit="byte">25</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <unit>DN</unit>
            <description>Number of relative length markers read</description>
        </Field_Character>
        <Field_Character>
            <name>Absolute length</name>
            <field_number>4</field_number>
            <field_location unit="byte">34</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <unit>DN</unit>
            <description>Number of absolute length markers read</description>
        </Field_Character>
        <Field_Character>
            <name>New Abs</name>
            <field_number>5</field_number>
            <field_location unit="byte">43</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <description>Flag indicating if a new absolute marker was read</description>
        </Field_Character>
        <Field_Character>
            <name>1bit Error</name>
            <field_number>6</field_number>
            <field_location unit="byte">52</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <description>Flag indicating if a 1bit Error occurred</description>
        </Field_Character>
        <Field_Character>
            <name>2bit Error</name>
            <field_number>7</field_number>
            <field_location unit="byte">61</field_location>
            <data_type>ASCII_Integer</data_type>
```

```
                    <field_length unit="byte">8</field_length>
                    <description>Flag indicating if a 2bit Error occurred</description>
                </Field_Character>
            </Record_Character>
        </Table_Character>
    </File_Area_Observational>
</Product_Observational>
```

B.5 STATIL Calibrated Data

```xml
<?xml version="1.0" encoding="utf-8"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<Product_Observational
    xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:insight="http://pds.nasa.gov/pds4/mission/insight/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1
    https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.xsd

    http://pds.nasa.gov/pds4/mission/insight/v1
    https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.xsd">
    <Identification_Area>
        <logical_identifier>
            urn:nasa:pds:insight_hp3_tem:data_statil_calibrated:hp3_statil_cal_00353_20170924_050217
        </logical_identifier>
        <version_id>1.0</version_id>
        <title>InSight HP3 Static Tiltmeter Calibrated Product:hp3_statil_cal_00353_20170924_050217</title>
        <information_model_version>1.10.1.0</information_model_version>
        <product_class>Product_Observational</product_class>
        <Modification_History>
            <Modification_Detail>
                <modification_date>2018-02-14</modification_date>
                <version_id>1.0</version_id>
                <description>Peer review approved version</description>
            </Modification_Detail>
        </Modification_History>
    </Identification_Area>
    <Observation_Area>
        <Time_Coordinates>
            <start_date_time>2017-09-24T15:02:17.860Z</start_date_time>
            <stop_date_time>2017-09-25T07:56:44.137Z</stop_date_time>
        </Time_Coordinates>
        <Investigation_Area>
            <name>InSight</name>
            <type>Mission</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:mission.insight</lid_reference>
```

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```xml
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>InSight</name>
                <type>Spacecraft</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:instrument_host:spacecraft.insight</lid_reference>
                    <reference_type>is_instrument_host</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
            <Observing_System_Component>
                <name>Heat Flow and Physical Properties Probe</name>
                <type>Instrument</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:instrument:hp3.insight</lid_reference>
                    <reference_type>is_instrument</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>Mars</name>
            <type>Planet</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:target:planet.mars</lid_reference>
                <reference_type>data_to_target</reference_type>
            </Internal_Reference>
        </Target_Identification>
        <Mission_Area>
            <insight:Observation_Information>
                <insight:release_number>0001</insight:release_number>
                <insight:mission_phase_name>SURFACE MISSION</insight:mission_phase_name>
                <insight:product_type>STATIL-calibrated</insight:product_type>
                <insight:spacecraft_clock_start_count>1543280540-26214</insight:spacecraft_clock_start_count>
                <insight:spacecraft_clock_stop_count>1543351215-45548</insight:spacecraft_clock_stop_count>
                <insight:spacecraft_clock_count_partition>1</insight:spacecraft_clock_count_partition>
                <insight:start_sol_number>00353</insight:start_sol_number>
                <insight:stop_sol_number>00354</insight:stop_sol_number>
                <insight:start_local_mean_solar_time>Sol-00353M07:58:02</insight:start_local_mean_solar_time>
                <insight:stop_local_mean_solar_time>Sol-00354M08:53:35</insight:stop_local_mean_solar_time>
                <insight:start_solar_longitude unit="deg">7.967</insight:start_solar_longitude>
                <insight:stop_solar_longitude unit="deg">8.893</insight:stop_solar_longitude>
                <insight:software_name>XML Archiv Tool</insight:software_name>
                <insight:software_version_id>1.0</insight:software_version_id>
```

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```
                </insight:Observation_Information>
            </Mission_Area>
        </Observation_Area>
        <Reference_List>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:insight_documents:document_mission</lid_reference>
                <reference_type>data_to_document</reference_type>
            </Internal_Reference>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:insight_documents:document_hp3rad:hp3_rad_sis</lid_reference>
                <reference_type>data_to_document</reference_type>
            </Internal_Reference>
        </Reference_List>
        <File_Area_Observational>
            <File>
                <file_name>hp3_statil_cal_00353_20170924_050217.tab</file_name>
                <creation_date_time>2018-10-11T15:35:05.981Z</creation_date_time>
            </File>
            <Table_Character>
                <name>HP3 STATIL CAL</name>
                <offset unit="byte">0</offset>
                <records>643</records>
                <description>One row of this table contains calibrated Static Tiltmeter data.</description>
                <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
                <Record_Character>
                    <fields>8</fields>
                    <groups>0</groups>
                    <record_length unit="byte">87</record_length>
                    <Field_Character>
                        <name>Universal coordinated time</name>
                        <field_number>1</field_number>
                        <field_location unit="byte">1</field_location>
                        <data_type>ASCII_Date_Time_YMD_UTC</data_type>
                        <field_length unit="byte">25</field_length>
                        <unit>Date</unit>
                        <description>Date and time at which measurement occurred</description>
                    </Field_Character>
                    <Field_Character>
                        <name>Sol</name>
                        <field_number>2</field_number>
                        <field_location unit="byte">27</field_location>
                        <data_type>ASCII_Integer</data_type>
                        <field_length unit="byte">5</field_length>
                        <unit>DN</unit>
                        <description>Sol number for this set of measurements</description>
```

```xml
                    </Field_Character>
                    <Field_Character>
                        <name>X-Axis Sensor A, angle</name>
                        <field_number>3</field_number>
                        <field_location unit="byte">33</field_location>
                        <data_type>ASCII_Real</data_type>
                        <field_length unit="byte">8</field_length>
                        <unit>Degree</unit>
                        <description>Angle X-Axis Sensor A</description>
                    </Field_Character>
                    <Field_Character>
                        <name>Y-Axis Sensor A, angle</name>
                        <field_number>4</field_number>
                        <field_location unit="byte">42</field_location>
                        <data_type>ASCII_Real</data_type>
                        <field_length unit="byte">8</field_length>
                        <unit>Degree</unit>
                        <description>Angle Y-Axis Sensor A</description>
                    </Field_Character>
                    <Field_Character>
                        <name>X-Axis Sensor B, angle</name>
                        <field_number>5</field_number>
                        <field_location unit="byte">51</field_location>
                        <data_type>ASCII_Real</data_type>
                        <field_length unit="byte">8</field_length>
                        <unit>Degree</unit>
                        <description>Angle X-Axis Sensor B</description>
                    </Field_Character>
                    <Field_Character>
                        <name>Y-Axis Sensor B, angle</name>
                        <field_number>6</field_number>
                        <field_location unit="byte">60</field_location>
                        <data_type>ASCII_Real</data_type>
                        <field_length unit="byte">8</field_length>
                        <unit>Degree</unit>
                        <description>Angle Y-Axis Sensor B</description>
                    </Field_Character>
                    <Field_Character>
                        <name>Absolute length, mm</name>
                        <field_number>7</field_number>
                        <field_location unit="byte">69</field_location>
                        <data_type>ASCII_Real</data_type>
                        <field_length unit="byte">8</field_length>
                        <unit>mm</unit>
                        <description>Absolute length of deployed tether</description>
```

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```
                    </Field_Character>
                    <Field_Character>
                        <name>Relative length, mm</name>
                        <field_number>8</field_number>
                        <field_location unit="byte">78</field_location>
                        <data_type>ASCII_Real</data_type>
                        <field_length unit="byte">8</field_length>
                        <unit>mm</unit>
                        <description>Relative length of deployed tether</description>
                    </Field_Character>
                </Record_Character>
            </Table_Character>
        </File_Area_Observational>
</Product_Observational>
```

B.6 HP³ RAD Raw Data

```xml
<?xml version="1.0" encoding="utf-8"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<Product_Observational
    xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:insight="http://pds.nasa.gov/pds4/mission/insight/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1
    https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.xsd

    http://pds.nasa.gov/pds4/mission/insight/v1
    https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.xsd">
    <Identification_Area>
        <logical_identifier>urn:nasa:pds:insight_rad:data_raw:hp3_rad_raw_09999_20181127_020232</logical_identifier>
        <version_id>1.0</version_id>
        <title>InSight HP3 Radiometer Experiment Raw Product:hp3_rad_raw_09999_20181127_020232</title>
        <information_model_version>1.10.1.0</information_model_version>
        <product_class>Product_Observational</product_class>
        <Modification_History>
            <Modification_Detail>
                <modification_date>2018-02-14</modification_date>
                <version_id>1.0</version_id>
                <description>Peer review approved version</description>
            </Modification_Detail>
        </Modification_History>
    </Identification_Area>
    <Observation_Area>
        <Time_Coordinates>
            <start_date_time>2018-11-27T01:02:32.842Z</start_date_time>
            <stop_date_time>2018-11-27T20:44:26.587Z</stop_date_time>
        </Time_Coordinates>
        <Investigation_Area>
            <name>InSight</name>
            <type>Mission</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:mission.insight</lid_reference>
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
```

```
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>InSight</name>
                <type>Spacecraft</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:instrument_host:spacecraft.insight</lid_reference>
                    <reference_type>is_instrument_host</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
            <Observing_System_Component>
                <name>Radiometer</name>
                <type>Instrument</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:instrument:radiometer.insight</lid_reference>
                    <reference_type>is_instrument</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>Mars</name>
            <type>Planet</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:target:planet.mars</lid_reference>
                <reference_type>data_to_target</reference_type>
            </Internal_Reference>
        </Target_Identification>
        <Mission_Area>
            <insight:Observation_Information>
                <insight:release_number>0001</insight:release_number>
                <insight:mission_phase_name>SURFACE MISSION</insight:mission_phase_name>
                <insight:product_type>RAD-raw</insight:product_type>
                <insight:spacecraft_clock_start_count>1543280540-26214</insight:spacecraft_clock_start_count>
                <insight:spacecraft_clock_stop_count>1543351454-09503</insight:spacecraft_clock_stop_count>
                <insight:spacecraft_clock_count_partition>1</insight:spacecraft_clock_count_partition>
                <insight:start_sol_number>09999</insight:start_sol_number>
                <insight:stop_sol_number>09999</insight:stop_sol_number>
                <insight:start_local_mean_solar_time>Sol-09999M07:58:02</insight:start_local_mean_solar_time>
                <insight:stop_local_mean_solar_time>Sol-09999M08:53:35</insight:stop_local_mean_solar_time>
                <insight:start_solar_longitude unit="deg">7.967</insight:start_solar_longitude>
                <insight:stop_solar_longitude unit="deg">8.893</insight:stop_solar_longitude>
                <insight:software_name>XML Archiv Tool</insight:software_name>
                <insight:software_version_id>1.0</insight:software_version_id>
            </insight:Observation_Information>
        </Mission_Area>
```

```xml
            </Observation_Area>
            <Reference_List>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:insight_documents:document_mission</lid_reference>
                    <reference_type>data_to_document</reference_type>
                </Internal_Reference>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:insight_documents:document_hp3rad:hp3_rad_sis</lid_reference>
                    <reference_type>data_to_document</reference_type>
                </Internal_Reference>
            </Reference_List>
            <File_Area_Observational>
                <File>
                    <file_name>hp3_rad_raw_09999_20181127_020232.tab</file_name>
                    <creation_date_time>2018-10-11T15:34:42.501Z</creation_date_time>
                </File>
                <Table_Character>
                    <name>RAD RAW</name>
                    <offset unit="byte">0</offset>
                    <records>757</records>
                    <description>One row of this table contains raw Radiometer data.</description>
                    <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
                    <Record_Character>
                        <fields>35</fields>
                        <groups>0</groups>
                        <record_length unit="byte">331</record_length>
                        <Field_Character>
                            <name>Spacecraft clock time</name>
                            <field_number>1</field_number>
                            <field_location unit="byte">1</field_location>
                            <data_type>ASCII_Real</data_type>
                            <field_length unit="byte">17</field_length>
                            <unit>sec</unit>
                            <description>
                                Spacecraft clock count at which measurement occurred, represented as a real number. Note that
                                spacecraft_clock_start_count and spacecraft_clock_stop_count in the Mission Area of this label
                                are represented not as a real number but as a whole number followed by  a fractional clock
                                tick, where the fraction is in units of 1/65536 of a tick.
                            </description>
                        </Field_Character>
                        <Field_Character>
                            <name>Sol</name>
                            <field_number>2</field_number>
                            <field_location unit="byte">19</field_location>
                            <data_type>ASCII_Integer</data_type>
```

```
            <field_length unit="byte">5</field_length>
            <unit>DN</unit>
            <description>Sol number for this set of measurements</description>
        </Field_Character>
        <Field_Character>
            <name>Thermopile1A_TC</name>
            <field_number>3</field_number>
            <field_location unit="byte">25</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <unit>DN</unit>
            <description>Instrument reading for channel 1A</description>
        </Field_Character>
        <Field_Character>
            <name>Thermopile2A_TC</name>
            <field_number>4</field_number>
            <field_location unit="byte">34</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <unit>DN</unit>
            <description>Instrument reading for channel 2A</description>
        </Field_Character>
        <Field_Character>
            <name>Thermopile1B_TC</name>
            <field_number>5</field_number>
            <field_location unit="byte">43</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <unit>DN</unit>
            <description>Instrument reading for channel 1B</description>
        </Field_Character>
        <Field_Character>
            <name>Thermopile2B_TC</name>
            <field_number>6</field_number>
            <field_location unit="byte">52</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <unit>DN</unit>
            <description>Instrument reading for channel 2B</description>
        </Field_Character>
        <Field_Character>
            <name>Thermopile1C_TC</name>
            <field_number>7</field_number>
            <field_location unit="byte">61</field_location>
            <data_type>ASCII_Integer</data_type>
```

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```
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>Instrument reading for channel 1C</description>
    </Field_Character>
    <Field_Character>
        <name>Thermopile2C_TC</name>
        <field_number>8</field_number>
        <field_location unit="byte">70</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>Instrument reading for channel 2C</description>
    </Field_Character>
    <Field_Character>
        <name>Thermopile1A_PT</name>
        <field_number>9</field_number>
        <field_location unit="byte">79</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>Instrument reading for channel 1A</description>
    </Field_Character>
    <Field_Character>
        <name>Thermopile2A_PT</name>
        <field_number>10</field_number>
        <field_location unit="byte">88</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>Instrument reading for channel 2A</description>
    </Field_Character>
    <Field_Character>
        <name>Thermopile1B_PT</name>
        <field_number>11</field_number>
        <field_location unit="byte">97</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>Instrument reading for channel 1B</description>
    </Field_Character>
    <Field_Character>
        <name>Thermopile2B_PT</name>
        <field_number>12</field_number>
        <field_location unit="byte">106</field_location>
        <data_type>ASCII_Integer</data_type>
```

101

```xml
            <field_length unit="byte">8</field_length>
            <unit>DN</unit>
            <description>Instrument reading for channel 2B</description>
        </Field_Character>
        <Field_Character>
            <name>Thermopile1C_PT</name>
            <field_number>13</field_number>
            <field_location unit="byte">115</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <unit>DN</unit>
            <description>Instrument reading for channel 1C</description>
        </Field_Character>
        <Field_Character>
            <name>Thermopile2C_PT</name>
            <field_number>14</field_number>
            <field_location unit="byte">124</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <unit>DN</unit>
            <description>Instrument reading for channel 2C</description>
        </Field_Character>
        <Field_Character>
            <name>ADC1_Rref</name>
            <field_number>15</field_number>
            <field_location unit="byte">133</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <unit>DN</unit>
            <description>ADC 1 reference 100 Ohm resistor reading</description>
        </Field_Character>
        <Field_Character>
            <name>ADC2_Rref</name>
            <field_number>16</field_number>
            <field_location unit="byte">142</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <unit>DN</unit>
            <description>ADC 2 reference 100 Ohm resistor reading</description>
        </Field_Character>
        <Field_Character>
            <name>PT Cal Target</name>
            <field_number>17</field_number>
            <field_location unit="byte">151</field_location>
            <data_type>ASCII_Integer</data_type>
```

102

```
                <field_length unit="byte">8</field_length>
                <unit>DN</unit>
                <description>Reading of calibration target PT 100 temperature sensor</description>
            </Field_Character>
            <Field_Character>
                <name>PT Sensor Head</name>
                <field_number>18</field_number>
                <field_location unit="byte">160</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">8</field_length>
                <unit>DN</unit>
                <description>Reading of calibration target PT 100 temperature sensor</description>
            </Field_Character>
            <Field_Character>
                <name>Offset Thermopile1A_PT</name>
                <field_number>19</field_number>
                <field_location unit="byte">169</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">8</field_length>
                <unit>DN</unit>
                <description>Offset reading for channel 1A</description>
            </Field_Character>
            <Field_Character>
                <name>Offset Thermopile2A_PT</name>
                <field_number>20</field_number>
                <field_location unit="byte">178</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">8</field_length>
                <unit>DN</unit>
                <description>Offset reading for channel 2A</description>
            </Field_Character>
            <Field_Character>
                <name>Offset Thermopile1B_PT</name>
                <field_number>21</field_number>
                <field_location unit="byte">187</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">8</field_length>
                <unit>DN</unit>
                <description>Offset reading for channel 1B</description>
            </Field_Character>
            <Field_Character>
                <name>Offset Thermopile2B_PT</name>
                <field_number>22</field_number>
                <field_location unit="byte">196</field_location>
                <data_type>ASCII_Integer</data_type>
```

103

```
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset reading for channel 2B</description>
</Field_Character>
<Field_Character>
    <name>Offset Thermopile1C_PT</name>
    <field_number>23</field_number>
    <field_location unit="byte">205</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset reading for channel 1C</description>
</Field_Character>
<Field_Character>
    <name>Offset Thermopile2C_PT</name>
    <field_number>24</field_number>
    <field_location unit="byte">214</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>Offset reading for channel 2C</description>
</Field_Character>
<Field_Character>
    <name>Offset ADC1_Rref</name>
    <field_number>25</field_number>
    <field_location unit="byte">223</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>ADC 1 reference 100 Ohm resistor offset reading</description>
</Field_Character>
<Field_Character>
    <name>Offset ADC2_Rref</name>
    <field_number>26</field_number>
    <field_location unit="byte">232</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">8</field_length>
    <unit>DN</unit>
    <description>ADC 2 reference 100 Ohm resistor offset reading</description>
</Field_Character>
<Field_Character>
    <name>Offset PT Cal Target</name>
    <field_number>27</field_number>
    <field_location unit="byte">241</field_location>
    <data_type>ASCII_Integer</data_type>
```

```xml
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>Offset reading of calibration target PT 100 temperature sensor</description>
    </Field_Character>
    <Field_Character>
        <name>Offset PT Sensor Head</name>
        <field_number>28</field_number>
        <field_location unit="byte">250</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>Offset reading of calibration target PT 100 temperature sensor</description>
    </Field_Character>
    <Field_Character>
        <name>HK Space craft clock</name>
        <field_number>29</field_number>
        <field_location unit="byte">259</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">17</field_length>
        <unit>DN</unit>
        <description>Time of closest HK vector used to for columns 30 to 35 (labelled as HK)</description>
    </Field_Character>
    <Field_Character>
        <name>Radiometer operation mode</name>
        <field_number>30</field_number>
        <field_location unit="byte">277</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>HK of currently active radiometer operation mode </description>
    </Field_Character>
    <Field_Character>
        <name>Section of sol</name>
        <field_number>31</field_number>
        <field_location unit="byte">286</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">8</field_length>
        <unit>DN</unit>
        <description>
            HK Software counter governing the switching of operating temperature in order to coordinate
            with local time
        </description>
    </Field_Character>
    <Field_Character>
        <name>TRefHigh Select</name>
```

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```xml
                    <field_number>32</field_number>
                    <field_location unit="byte">295</field_location>
                    <data_type>ASCII_Integer</data_type>
                    <field_length unit="byte">8</field_length>
                    <unit>DN</unit>
                    <description>
                        HK Flag indicating that the higher of the two daytime operating temperatures is
                        selected
                    </description>
                </Field_Character>
                <Field_Character>
                    <name>Sensorhead body heater PWM</name>
                    <field_number>33</field_number>
                    <field_location unit="byte">304</field_location>
                    <data_type>ASCII_Integer</data_type>
                    <field_length unit="byte">8</field_length>
                    <unit>DN</unit>
                    <description>HK of currently commanded value of the sensorhead heater current source</description>
                </Field_Character>
                <Field_Character>
                    <name>Cal. Target heater PWM</name>
                    <field_number>34</field_number>
                    <field_location unit="byte">313</field_location>
                    <data_type>ASCII_Integer</data_type>
                    <field_length unit="byte">8</field_length>
                    <unit>DN</unit>
                    <description>HK of currently commanded value of the calibration heater current source</description>
                </Field_Character>
                <Field_Character>
                    <name>Radiometer test mode</name>
                    <field_number>35</field_number>
                    <field_location unit="byte">322</field_location>
                    <data_type>ASCII_Integer</data_type>
                    <field_length unit="byte">8</field_length>
                    <description>HK flag that is true the radiometer test mode is on</description>
                </Field_Character>
            </Record_Character>
        </Table_Character>
    </File_Area_Observational>
</Product_Observational>
```

B.7 HP³ RAD Calibrated Data

```xml
<?xml version="1.0" encoding="utf-8"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<Product_Observational
    xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:insight="http://pds.nasa.gov/pds4/mission/insight/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1
    https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.xsd

    http://pds.nasa.gov/pds4/mission/insight/v1
    https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.xsd">
    <Identification_Area>
        <logical_identifier>
            urn:nasa:pds:insight_rad:data_calibrated:hp3_rad_cal_09999_20181127_020232
        </logical_identifier>
        <version_id>1.0</version_id>
        <title>InSight HP3 Radiometer Experiment Calibrated Product:hp3_rad_cal_09999_20181127_020232</title>
        <information_model_version>1.10.1.0</information_model_version>
        <product_class>Product_Observational</product_class>
        <Modification_History>
            <Modification_Detail>
                <modification_date>2018-02-14</modification_date>
                <version_id>1.0</version_id>
                <description>Peer review approved version</description>
            </Modification_Detail>
        </Modification_History>
    </Identification_Area>
    <Observation_Area>
        <Time_Coordinates>
            <start_date_time>2018-11-27T01:02:32.842Z</start_date_time>
            <stop_date_time>2018-11-27T20:44:26.587Z</stop_date_time>
        </Time_Coordinates>
        <Investigation_Area>
            <name>InSight</name>
            <type>Mission</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:mission.insight</lid_reference>
```

```xml
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>InSight</name>
                <type>Spacecraft</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:instrument_host:spacecraft.insight</lid_reference>
                    <reference_type>is_instrument_host</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
            <Observing_System_Component>
                <name>Radiometer</name>
                <type>Instrument</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:instrument:radiometer.insight</lid_reference>
                    <reference_type>is_instrument</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>Mars</name>
            <type>Planet</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:target:planet.mars</lid_reference>
                <reference_type>data_to_target</reference_type>
            </Internal_Reference>
        </Target_Identification>
        <Mission_Area>
            <insight:Observation_Information>
                <insight:release_number>0001</insight:release_number>
                <insight:mission_phase_name>SURFACE MISSION</insight:mission_phase_name>
                <insight:product_type>RAD-calibrated</insight:product_type>
                <insight:spacecraft_clock_start_count>1543280540-26214</insight:spacecraft_clock_start_count>
                <insight:spacecraft_clock_stop_count>1543351454-09503</insight:spacecraft_clock_stop_count>
                <insight:spacecraft_clock_count_partition>1</insight:spacecraft_clock_count_partition>
                <insight:start_sol_number>09999</insight:start_sol_number>
                <insight:stop_sol_number>09999</insight:stop_sol_number>
                <insight:start_local_mean_solar_time>Sol-09999M07:58:02</insight:start_local_mean_solar_time>
                <insight:stop_local_mean_solar_time>Sol-09999M08:53:35</insight:stop_local_mean_solar_time>
                <insight:start_solar_longitude unit="deg">7.967</insight:start_solar_longitude>
                <insight:stop_solar_longitude unit="deg">8.893</insight:stop_solar_longitude>
                <insight:software_name>XML Archiv Tool</insight:software_name>
                <insight:software_version_id>1.0</insight:software_version_id>
```

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```xml
                </insight:Observation_Information>
            </Mission_Area>
        </Observation_Area>
        <Reference_List>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:insight_documents:document_mission</lid_reference>
                <reference_type>data_to_document</reference_type>
            </Internal_Reference>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:insight_documents:document_hp3rad:hp3_rad_sis</lid_reference>
                <reference_type>data_to_document</reference_type>
            </Internal_Reference>
        </Reference_List>
        <File_Area_Observational>
            <File>
                <file_name>hp3_rad_cal_09999_20181127_020232.tab</file_name>
                <creation_date_time>2018-10-11T15:35:01.761Z</creation_date_time>
            </File>
            <Table_Character>
                <name>RAD CAL</name>
                <offset unit="byte">0</offset>
                <records>757</records>
                <description>One row of this table contains calibrated Radiometer data.</description>
                <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
                <Record_Character>
                    <fields>39</fields>
                    <groups>0</groups>
                    <record_length unit="byte">366</record_length>
                    <Field_Character>
                        <name>Universal coordinated time</name>
                        <field_number>1</field_number>
                        <field_location unit="byte">1</field_location>
                        <data_type>ASCII_Date_Time_YMD_UTC</data_type>
                        <field_length unit="byte">25</field_length>
                        <unit>Date</unit>
                        <description>Date and time</description>
                    </Field_Character>
                    <Field_Character>
                        <name>Sol</name>
                        <field_number>2</field_number>
                        <field_location unit="byte">27</field_location>
                        <data_type>ASCII_Integer</data_type>
                        <field_length unit="byte">5</field_length>
                        <unit>DN</unit>
                        <description>Sol number for this set of measurements</description>
```

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```
            </Field_Character>
            <Field_Character>
                <name>Mars True Local Solar Time</name>
                <field_number>3</field_number>
                <field_location unit="byte">33</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">8</field_length>
                <unit>1/24 sol</unit>
                <description>Local true solar time in Mars hours of 3699 seconds</description>
            </Field_Character>
            <Field_Character>
                <name>Solar longitude LS </name>
                <field_number>4</field_number>
                <field_location unit="byte">42</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">8</field_length>
                <unit>degree</unit>
                <description>Mars sun angle from northern hemisphere spring equinox</description>
            </Field_Character>
            <Field_Character>
                <name>Sun Azimuth</name>
                <field_number>5</field_number>
                <field_location unit="byte">51</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">8</field_length>
                <unit>degree</unit>
                <description>Azimuth angle of the sun</description>
            </Field_Character>
            <Field_Character>
                <name>Sun Phase angle FOV 1</name>
                <field_number>6</field_number>
                <field_location unit="byte">60</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">8</field_length>
                <unit>degree</unit>
                <description>Sun to FoV 1 line of sight (LOS) center </description>
            </Field_Character>
            <Field_Character>
                <name>Incidence angle FOV 1</name>
                <field_number>7</field_number>
                <field_location unit="byte">69</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">8</field_length>
                <unit>degree</unit>
                <description>Sun to surface normal at FOV 1</description>
```

```
        </Field_Character>
        <Field_Character>
            <name>Sigma Sun Phase angle FOV 1</name>
            <field_number>8</field_number>
            <field_location unit="byte">78</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>degree</unit>
            <description>Standard deviation over FOV 1 of Sun phase angle FOV 1</description>
        </Field_Character>
        <Field_Character>
            <name>Sigma Incidence angle FOV 1</name>
            <field_number>9</field_number>
            <field_location unit="byte">87</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>degree</unit>
            <description>Standard deviation over FOV 1 of incidence angle FOV 1</description>
        </Field_Character>
        <Field_Character>
            <name>Shadow FOV 1</name>
            <field_number>10</field_number>
            <field_location unit="byte">96</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>%</unit>
            <description>Fraction of lander shadow in FOV 1</description>
        </Field_Character>
        <Field_Character>
            <name>Sun Phase angle FOV 2</name>
            <field_number>11</field_number>
            <field_location unit="byte">105</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>degree</unit>
            <description>Sun to FoV 2 line of sight (LOS) center </description>
        </Field_Character>
        <Field_Character>
            <name>Incidence angle FOV 2</name>
            <field_number>12</field_number>
            <field_location unit="byte">114</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>degree</unit>
            <description>Sun to surface normal at FOV 2</description>
```

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```
        </Field_Character>
        <Field_Character>
            <name>Sigma Sun Phase angle FOV 2</name>
            <field_number>13</field_number>
            <field_location unit="byte">123</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>degree</unit>
            <description>Standard deviation over FOV 1 of Sun phase angle FOV 2</description>
        </Field_Character>
        <Field_Character>
            <name>Sigma Incidence angle FOV 2</name>
            <field_number>14</field_number>
            <field_location unit="byte">132</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>degree</unit>
            <description>Standard deviation over FOV 1 of incidence angle FOV 2</description>
        </Field_Character>
        <Field_Character>
            <name>Shadow FOV 2</name>
            <field_number>15</field_number>
            <field_location unit="byte">141</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>%</unit>
            <description>Fraction of lander shadow in FOV 2</description>
        </Field_Character>
        <Field_Character>
            <name>TB Sensor 1A</name>
            <field_number>16</field_number>
            <field_location unit="byte">150</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Brightness temperature for sensor 1A</description>
        </Field_Character>
        <Field_Character>
            <name>TB Sensor 1B</name>
            <field_number>17</field_number>
            <field_location unit="byte">159</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Brightness temperature for sensor 1B</description>
```

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```xml
        </Field_Character>
        <Field_Character>
            <name>TB Sensor 1C</name>
            <field_number>18</field_number>
            <field_location unit="byte">168</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Brightness temperature for sensor 1C</description>
        </Field_Character>
        <Field_Character>
            <name>TB Sensor 2A</name>
            <field_number>19</field_number>
            <field_location unit="byte">177</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Brightness temperature for sensor 2A</description>
        </Field_Character>
        <Field_Character>
            <name>TB Sensor 2B</name>
            <field_number>20</field_number>
            <field_location unit="byte">186</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Brightness temperature for sensor 2B</description>
        </Field_Character>
        <Field_Character>
            <name>TB Sensor 2C</name>
            <field_number>21</field_number>
            <field_location unit="byte">195</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Brightness temperature for sensor 2C</description>
        </Field_Character>
        <Field_Character>
            <name>?TB Sensor 1A</name>
            <field_number>22</field_number>
            <field_location unit="byte">204</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Error Brightness temperature sensor 1A</description>
```

```
</Field_Character>
<Field_Character>
    <name>?TB Sensor 1B</name>
    <field_number>23</field_number>
    <field_location unit="byte">213</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>K</unit>
    <description>Error Brightness temperature sensor 1B</description>
</Field_Character>
<Field_Character>
    <name>?TB Sensor 1C</name>
    <field_number>24</field_number>
    <field_location unit="byte">222</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>K</unit>
    <description>Error Brightness temperature sensor 1C</description>
</Field_Character>
<Field_Character>
    <name>?TB Sensor 2A</name>
    <field_number>25</field_number>
    <field_location unit="byte">231</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>K</unit>
    <description>Error Brightness temperature sensor 2A</description>
</Field_Character>
<Field_Character>
    <name>?TB Sensor 2B</name>
    <field_number>26</field_number>
    <field_location unit="byte">240</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>K</unit>
    <description>Error Brightness temperature sensor 2B</description>
</Field_Character>
<Field_Character>
    <name>?TB Sensor 2C</name>
    <field_number>27</field_number>
    <field_location unit="byte">249</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">8</field_length>
    <unit>K</unit>
    <description>Error Brightness temperature sensor 2C</description>
```

```xml
        </Field_Character>
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            <field_number>28</field_number>
            <field_location unit="byte">258</field_location>
            <data_type>ASCII_Real</data_type>
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            <unit>K</unit>
            <description>Temperature of sensor 1A</description>
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            <name>Tref Sensor 1B</name>
            <field_number>29</field_number>
            <field_location unit="byte">267</field_location>
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            <unit>K</unit>
            <description>Temperature of sensor 1B</description>
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            <name>Tref Sensor 1C</name>
            <field_number>30</field_number>
            <field_location unit="byte">276</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature of sensor 1C</description>
        </Field_Character>
        <Field_Character>
            <name>Tref Sensor 2A</name>
            <field_number>31</field_number>
            <field_location unit="byte">285</field_location>
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            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature of sensor 2A</description>
        </Field_Character>
        <Field_Character>
            <name>Tref Sensor 2B</name>
            <field_number>32</field_number>
            <field_location unit="byte">294</field_location>
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            <unit>K</unit>
            <description>Temperature of sensor 2B</description>
```

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```xml
        </Field_Character>
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            <name>Tref Sensor 2C</name>
            <field_number>33</field_number>
            <field_location unit="byte">303</field_location>
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            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature of sensor 2C</description>
        </Field_Character>
        <Field_Character>
            <name>RAD operation mode</name>
            <field_number>34</field_number>
            <field_location unit="byte">312</field_location>
            <data_type>ASCII_Integer</data_type>
            <field_length unit="byte">8</field_length>
            <description>Operation mode identifier</description>
        </Field_Character>
        <Field_Character>
            <name>Cal. Target heater power</name>
            <field_number>35</field_number>
            <field_location unit="byte">321</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>W</unit>
            <description>Power of calibration target heater</description>
        </Field_Character>
        <Field_Character>
            <name>Cal. Target temperature</name>
            <field_number>36</field_number>
            <field_location unit="byte">330</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Temperature of calibration target</description>
        </Field_Character>
        <Field_Character>
            <name>Sensorhead heater power</name>
            <field_number>37</field_number>
            <field_location unit="byte">339</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>W</unit>
            <description>Power of sensorhead heater</description>
        </Field_Character>
```

```xml
                    <Field_Character>
                        <name>Sensorhead temperature</name>
                        <field_number>38</field_number>
                        <field_location unit="byte">348</field_location>
                        <data_type>ASCII_Real</data_type>
                        <field_length unit="byte">8</field_length>
                        <unit>K</unit>
                        <description>Sensorhead body temperature</description>
                    </Field_Character>
                    <Field_Character>
                        <name>Lander BUS voltage</name>
                        <field_number>39</field_number>
                        <field_location unit="byte">357</field_location>
                        <data_type>ASCII_Real</data_type>
                        <field_length unit="byte">8</field_length>
                        <unit>V</unit>
                        <description>Bus voltage used in heater power calibration</description>
                    </Field_Character>
                </Record_Character>
            </Table_Character>
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</Product_Observational>
```

B.8 HP³ RAD Derived Data

```xml
<?xml version="1.0" encoding="utf-8"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<?xml-model
      href="https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.sch"
      schematypens="http://purl.oclc.org/dsdl/schematron"?>
<Product_Observational
    xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:insight="http://pds.nasa.gov/pds4/mission/insight/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1
    https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1A10.xsd

    http://pds.nasa.gov/pds4/mission/insight/v1
    https://pds.nasa.gov/pds4/mission/insight/v1/PDS4_INSIGHT_1A10_1830.xsd">
    <Identification_Area>
        <logical_identifier>
            urn:nasa:pds:insight_rad:data_derived:hp3_rad_der_09999_20181127_020232
        </logical_identifier>
        <version_id>1.0</version_id>
        <title>InSight HP3 Radiometer Experiment Derived Product:hp3_rad_der_09999_20181127_020232</title>
        <information_model_version>1.10.1.0</information_model_version>
        <product_class>Product_Observational</product_class>
        <Modification_History>
            <Modification_Detail>
                <modification_date>2018-02-14</modification_date>
                <version_id>1.0</version_id>
                <description>Peer review approved version</description>
            </Modification_Detail>
        </Modification_History>
    </Identification_Area>
    <Observation_Area>
        <Time_Coordinates>
            <start_date_time>2018-11-27T01:02:32.842Z</start_date_time>
            <stop_date_time>2018-11-27T20:44:26.587Z</stop_date_time>
        </Time_Coordinates>
        <Investigation_Area>
            <name>InSight</name>
            <type>Mission</type>
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                <lid_reference>urn:nasa:pds:context:investigation:mission.insight</lid_reference>
```

```xml
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
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                <type>Spacecraft</type>
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                    <reference_type>is_instrument_host</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
            <Observing_System_Component>
                <name>Radiometer</name>
                <type>Instrument</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:instrument:radiometer.insight</lid_reference>
                    <reference_type>is_instrument</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
        </Observing_System>
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            <type>Planet</type>
            <Internal_Reference>
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                <reference_type>data_to_target</reference_type>
            </Internal_Reference>
        </Target_Identification>
        <Mission_Area>
            <insight:Observation_Information>
                <insight:release_number>0001</insight:release_number>
                <insight:mission_phase_name>SURFACE MISSION</insight:mission_phase_name>
                <insight:product_type>RAD-derived</insight:product_type>
                <insight:spacecraft_clock_start_count>1543280540-26214</insight:spacecraft_clock_start_count>
                <insight:spacecraft_clock_stop_count>1543351454-09503</insight:spacecraft_clock_stop_count>
                <insight:spacecraft_clock_count_partition>1</insight:spacecraft_clock_count_partition>
                <insight:start_sol_number>09999</insight:start_sol_number>
                <insight:stop_sol_number>09999</insight:stop_sol_number>
                <insight:start_local_mean_solar_time>Sol-09999M07:58:02</insight:start_local_mean_solar_time>
                <insight:stop_local_mean_solar_time>Sol-09999M08:53:35</insight:stop_local_mean_solar_time>
                <insight:start_solar_longitude unit="deg">7.967</insight:start_solar_longitude>
                <insight:stop_solar_longitude unit="deg">8.893</insight:stop_solar_longitude>
                <insight:software_name>XML Archiv Tool</insight:software_name>
                <insight:software_version_id>1.0</insight:software_version_id>
```

```xml
            </insight:Observation_Information>
        </Mission_Area>
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            <reference_type>data_to_document</reference_type>
        </Internal_Reference>
        <Internal_Reference>
            <lid_reference>urn:nasa:pds:insight_documents:document_hp3rad:hp3_rad_sis</lid_reference>
            <reference_type>data_to_document</reference_type>
        </Internal_Reference>
    </Reference_List>
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        <File>
            <file_name>hp3_rad_der_09999_20181127_020232.tab</file_name>
            <creation_date_time>2018-10-11T15:35:09.981Z</creation_date_time>
        </File>
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            <offset unit="byte">0</offset>
            <records>757</records>
            <description>One row of this table contains derived Radiometer data.</description>
            <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
            <Record_Character>
                <fields>19</fields>
                <groups>0</groups>
                <record_length unit="byte">186</record_length>
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                    <field_location unit="byte">1</field_location>
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                    <field_length unit="byte">25</field_length>
                    <unit>Date</unit>
                    <description>Date and time</description>
                </Field_Character>
                <Field_Character>
                    <name>Sol</name>
                    <field_number>2</field_number>
                    <field_location unit="byte">27</field_location>
                    <data_type>ASCII_Integer</data_type>
                    <field_length unit="byte">5</field_length>
                    <unit>DN</unit>
                    <description>Sol number for this set of measurements</description>
```

```xml
        </Field_Character>
        <Field_Character>
            <name>Mars True Local Solar Time</name>
            <field_number>3</field_number>
            <field_location unit="byte">33</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>1/24 sol</unit>
            <description>Local true solar time in Mars hours of 3699 seconds</description>
        </Field_Character>
        <Field_Character>
            <name>Solar longitude LS</name>
            <field_number>4</field_number>
            <field_location unit="byte">42</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>degree</unit>
            <description>Mars sun angle from northern hemisphere spring equinox</description>
        </Field_Character>
        <Field_Character>
            <name>Sun Azimuth</name>
            <field_number>5</field_number>
            <field_location unit="byte">51</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>degree</unit>
            <description>Local sun azimuth relative to north</description>
        </Field_Character>
        <Field_Character>
            <name>Sun Phase angle FOV 1</name>
            <field_number>6</field_number>
            <field_location unit="byte">60</field_location>
            <data_type>ASCII_Real</data_type>
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            <unit>degree</unit>
            <description>Sun to FoV 1 line of sight (LOS) center </description>
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        <Field_Character>
            <name>Incidence angle FOV 1</name>
            <field_number>7</field_number>
            <field_location unit="byte">69</field_location>
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            <unit>degree</unit>
            <description>Sun to surface normal at FOV 1</description>
```

```xml
    </Field_Character>
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        <name>Sigma Sun Phase angle FOV 1</name>
        <field_number>8</field_number>
        <field_location unit="byte">78</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>degree</unit>
        <description>Standard deviation over FOV 1 of Sun phase angle FOV 1</description>
    </Field_Character>
    <Field_Character>
        <name>Sigma Incidence angle FOV 1</name>
        <field_number>9</field_number>
        <field_location unit="byte">87</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>degree</unit>
        <description>Standard deviation over FOV 1 of incidence angle FOV 1</description>
    </Field_Character>
    <Field_Character>
        <name>Shadow FOV 1</name>
        <field_number>10</field_number>
        <field_location unit="byte">96</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>%</unit>
        <description>Fraction of lander shadow in FOV 1</description>
    </Field_Character>
    <Field_Character>
        <name>Sun Phase angle FOV 2</name>
        <field_number>11</field_number>
        <field_location unit="byte">105</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>degree</unit>
        <description>Sun to FoV 2 line of sight (LOS) center </description>
    </Field_Character>
    <Field_Character>
        <name>Incidence angle FOV 2</name>
        <field_number>12</field_number>
        <field_location unit="byte">114</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">8</field_length>
        <unit>degree</unit>
        <description>Sun to surface normal at FOV 2</description>
```

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```
        </Field_Character>
        <Field_Character>
            <name>Sigma Sun Phase angle FOV 2</name>
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            <field_location unit="byte">123</field_location>
            <data_type>ASCII_Real</data_type>
            <field_length unit="byte">8</field_length>
            <unit>degree</unit>
            <description>Standard deviation over FOV 1 of Sun phase angle FOV 2</description>
        </Field_Character>
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            <name>Sigma Incidence angle FOV 2</name>
            <field_number>14</field_number>
            <field_location unit="byte">132</field_location>
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            <unit>degree</unit>
            <description>Standard deviation over FOV 1 of incidence angle FOV 2</description>
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            <name>Shadow FOV 2</name>
            <field_number>15</field_number>
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            <unit>%</unit>
            <description>Fraction of lander shadow in FOV 2</description>
        </Field_Character>
        <Field_Character>
            <name>TS FoV 1</name>
            <field_number>16</field_number>
            <field_location unit="byte">150</field_location>
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            <field_length unit="byte">8</field_length>
            <unit>K</unit>
            <description>Surface temperature for FoV 1</description>
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            <name>TS FoV 2</name>
            <field_number>17</field_number>
            <field_location unit="byte">159</field_location>
            <data_type>ASCII_Real</data_type>
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            <unit>K</unit>
            <description>Surface temperature for FoV 2</description>
```

```
            </Field_Character>
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                <name>DTS FoV 1</name>
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                <field_location unit="byte">168</field_location>
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            <Field_Character>
                <name>DTS FoV 2</name>
                <field_number>19</field_number>
                <field_location unit="byte">177</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">8</field_length>
                <unit>K</unit>
                <description>Temperature error for FoV 2</description>
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        </Record_Character>
    </Table_Character>
  </File_Area_Observational>
</Product_Observational>
```