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| HASI<br>Huygens Atmospheric Structure Instrument | **HASI** | Ref.:HASI-ICD-UPD-001<br>Issue: 2 Rev.:2<br>Date: June 2006 |

# Huygens-HASI

To Planetary Science Archive [or NASA PDS] Interface Control Document

[Issue 2 Rev. 2]

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**Change Log**

| Date | Sections Changed | Reasons for Change |
|---|---|---|
| 18 June 2003<br>August 2003 | First draft issue<br>Revised in accordance with the Huygens Data Archiving Plan:<br>HUY-RSSD-PL-001 V. 1.0 (14 July 2003) | |
| January 2004<br>Issue 1 | Update of Applicable and Reference Documents<br>Update with data level classification as CODMAC | New document issues |
| February 2004<br>Issue 1 | Definition of directories structure and data file format.<br>Revision of proposed data products (content and format) within HASI team | |
| May 2004<br>Issue 1.1 | Data filenames convention: shortened<br>Removed LABEL directory | Too long >27.3 characters |
| December 2004<br>Issue 1.2 | Revised after EAICD reviewer's report | |
| January 2006<br>Issue 2 | Revised after [Huygens] Feedback on the HASI EAICD (mail by Olivier & Lyle on 12/10/2005) Very marginal modifications | |
| April 2006<br>Issue 2 Rev. 1 | Removed TDB ITEMS section<br>Data file naming convention changed § 3.1.4.<br>PWA products defined and confirmed.<br>Added timeline as during mission (Table 3b) and<br>T0 transition in UTC (still TBC by the Project)<br>§ 4.3 Sample Labels eliminated<br>Added in annex 3: Table 8: HASI timelines and events during Huygens mission at Titan and Table 9: HASI DPU Event description | New document revision to go with HASI DA data set |
| June 2006<br>Issue 2 Rev. 2 | Corrected PWA ACU data file format (including burst mode)<br>§2.6.1 extended in order to include:<br>- ASCII data calibration files per subsystem and/or reference for higher | New document revision after review of HASI DA data set |

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|---|---|---|
| | level product derivation<br>Added ACC L4 product (descent trajectory) | |

## Table Of Contents

# 1 Introduction

## 1.1 Purpose and Scope

The purpose of this EAICD (Experimenter to (Science) Archive Interface Control Document) is two fold. First it provides users of the HASI instrument with a detailed description of the product and a description of how it was generated, including data sources and destinations. Secondly, it is the official interface between HASI team and ESA PSA (and NASA PDS).

## 1.2 Contents

This document describes the data flow of the HASI instrument on Huygens from the S/C until insertion into the PSA [and/or PDS]. It includes information on how data were processed, formatted, labeled and uniquely identified. The document discusses general naming schemes for data volumes, data sets, data and label files. Standards used to generate the product are explained..

## 1.3 Applicable Documents

[AD1] PDS Standards Reference - Revised, October 30, 2002, Version 3.5, http://pds.jpl.nasa.gov/stdref

[AD2] Huygens Data Archive Generation, Validation and Transfer Plan HUY-RSSD-PL-001, Issue 1.0, 14 July 2003

## 1.4 Reference Documents

[RD1] HASI Experiment User Manual (Flight and Flight Spare models), HASI-MA-OG-002, Issue 3, 1 December 1998 (II/196.B.6) HASI_USER_MANUAL

[RD2] HAS DPU Software User Requirements Document HASI-SP-OG-004, Issue 7, 7 Sep 1995 (II/179.B.1) HASI_SW_URD

[RD3] Fulchignoni, Ferri et al **The characterisation of Titan's atmospheric physical properties by the Huygens Atmospheric Structure Instrument (HASI)** *Space Science Reviews,* **104**, 395-431, 2002 (scientific paper) FULCHIGNONIETAL2002

[RD4] TEM data processing and calibration report HASI-RP-UPD-104

[RD5] PPI data processing and calibration report HASI-RP-UPD-105

[RD6] ACC data processing and calibration report HASI-RP-UPD-106

[RD7] PWA data processing and report HASI-PWA-FM-DOC-041.DOC

## 1.5 Relationships to Other Interfaces

Documents that will be affected by this change will be noted on an as needed basis.

## 1.6 Intended Readership

The staff of archiving authority (Planetary Data System for NASA, Planetary Science Archive for ESA) design team and any potential user of the HASI data.

## 1.7 Acronyms and Abbreviations

ACC Accelerometer sensor subsystem
ACU Acoustic sensor
AD Applicable Document
ASI Agenzia Spaziale Italiana
C1, C2 TEM 1 (TEM 2) Coarse sensor TM packets (TM formats #98 and #102)
CDMS,U Control and Data Management System, Unit
CEPT CNRS Observatoire de Saint Maur, France
CISAS Centro Interdipartimentale Studi e Attività Spaziali (CISAS) "G. Colombo", UPD
DBS Deployable Boom Subsystem
DDB Descent Data Broadcast
DPU Data Processing Unit Subsystem
EAICD Experimenter to Archive Interface Control Document
ELF Extremely Low Frequency
EM Engineering Model
ESA European Space Agency
ESTEC European Science and Technologies Center
F1, F2 TEM 1 (TEM 2) Fine sensor TM packets (TM formats #96 and #100)
FM Flight Model
FMI Finnish Meteorological Institute
FS Flight Spare model
HASI HUYGENS Atmospheric Structure Instrument
HASI-I HASI PWA Interface boxes
H/K Housekeeping
H/W Hardware
IAA Instituto de Astrofisica Andalusia, Granada, Spain
I/F,i/f Interface
IPMO Instrument Project Manager Office
IWF Institut fur Weltraumforschung, Graz, Austria
LESIA Laboratoire d'Environnement Spatial, Obs. Paris-Meudon, France
LPCE Lab. de Phisique et Chimique de l'Environment, Orelans, FRance
MCA Magnetic Coil Actuator device
MI Mutual Impedance (experiment)
MI-Rx MI receiver sensor
MI-Tx MI transmitter sensor
N/A Not Applicable
OG Officine Galileo
PDS Planetary Data System
PI Principal Investigator
PPI Pressure Profile Instrument
PSA Planetary Science Archive
PSSRI Planetary Space Science Research Institute, The Open University, UK
PWA Permittivity, Wave and Altimetry package
RAE Radar Altimeter (Proximity sensors) Extension elec. board (DPU s/s)
RAU Radar Altimeter Unit
RD Reference Document
RP, REL RELaxation Probe sensor
S/S, s/s Subsystem
STUB STUB subsystem
S/W Software
T0 Mission Time for end of Probe Entry phase (descent device deployment begins)
Tacc Mission time when HASI starts to acquire ACC sensors
(Td1, Td1w) Mission time window for the first Boom deploy attempt
(Td2, Teoff) Mission time window for the second Boom deploy attempt
Tdata Mission time when HASI starts to acquire TEM and PRE sensors

TdataH Mission time when Probe relay link with Cassini should be set
Thigh Mission time when HASI change from MEDIUM to HIGH Normal Session
Thasi Mission time when HASI is switched-ON during Titan Descent (before T0 transition)
Tmid Mission time when HASI change from LOW to MEDIUM Normal Session
Tradar Mission time when HASI starts to acquire Proximity sensors
Tproximity Mission Time to start the Impact state when HASI in Back-up sub-mode
TBD To Be Defined
TEM TEMperature sensors (STUB s/s)
Temp 1 Temperature sensor located inside of the Xservo sensor (ACC s/s)
Temp 2 Temperature sensor located inside on the ACC mounting block (ACC s/s)
TM Telemetry
UPD Universita' Padova
VLF Very Low Frequency
Xservo axis Servo accelerometer sensor (ACC s/s)
Xpiezo X axis Piezo accelerometer sensor (ACC s/s)
Ypiezo Y axis Piezo accelerometer sensor (ACC s/s)
Zpiezo Z axis Piezo accelerometer sensor (ACC s/s)
Yvalue Data which is contained in the PPI NORMAL session TM packets

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**Interface with the PSA/PDS will be managed only by the HASI team at CISAS-UPD.**

# 2 Overview of Process and Product Generation

## 2.1 Experiment Overview

HASI is a multisensor package which has been designed to measure the physical quantities characterizing Titan's atmosphere during the Huygens probe entry, descent and at the surface.
The HASI experiment is divided into four subsystems [RD3]: the accelerometers (ACC); the deployable booms system (DBS); the stem (STUB) carrying the temperature sensors, a Kiel probe pressure sampling inlet, an acoustic sensor and the data processing unit (DPU). The HASI subsystems, their acronyms, the institutions responsible for the management (together with the providers) and the elements included are summarised in Table 1.

**Table 1.** ***HASI subsystems***

| *Subsystem* | *Responsible Institutions. (Providers)*[1] | *Elements* |
|---|---|---|
| Deployable Boom System (DBS) | RSSD (LPCE/SSD) | PWA electrodes, Boom Magnetic Actuators, PWA preamplifiers (HASI-I) |
| Fixed stem (STUB) | UPD (UPD/FMI/IWF) | Temperature sensors, PPI Kiel probe, acoustic sensor |
| Accelerometers (ACC) | OU-UK (UKC) | Four accelerometers |
| Data Processing Unit (DPU) | OG (FMI/IWF/IAA/OG) | Electronics boards |
| Electrical Ground Support Equipment | OG (UPD/OG) | EGSE |

The scientific measurements are performed by four sensor packages: the accelerometers (ACC), the temperature sensors (TEM), the Pressure Profile Instrument (PPI) and the Permittivity, Wave and Altimetry package (PWA) (see Table 2). In figure 1 the block diagram of the HASI experiment on the Huygens probe in descent configuration. The location of the different subsystems and sensors within the Huygens probe is reported in fig. 2.

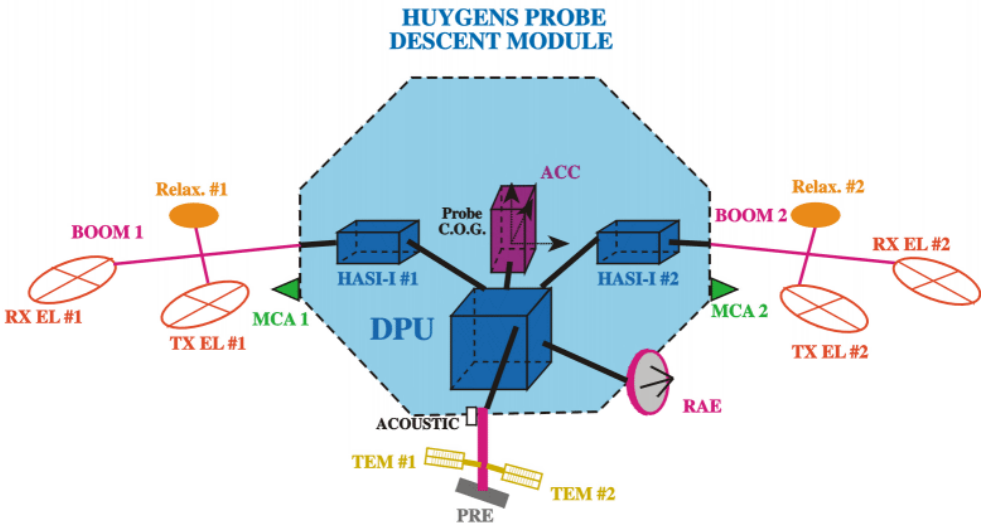


Fig. 1 HASI experiment block diagram

**Table 2.** ***HASI sensor packages***

| *Sensor package* | *Acronym* | *Sensor type* | *Accuracy* | *Resolution* | *Measured parameters* |
|---|---|---|---|---|---|
| Accelerometers* | ACC | 3-axes accelerometer (1 Xservo & 3 piezo-resistive accelerometers) | 1% | 1-10 µg (high res.)<br>0.9-9 mg (low res.) | Atmospheric deceleration<br>Descent monitoring<br>Response to impact |
| Pressure Profile Instrument | PPI | Kiel type pressure probe + capacitive transducers | 1% | 0.01 hPa | Atmospheric pressure |
| Temperature sensors | TEM | 2 dual element Pt thermometers | 0.5 K | 0.02 K | Atmospheric temperature |
| Permittivity, Wave and Altimetry | PWA | Mutual Impedance AC field measurement | 10% | $3x10^{-11}$ $(\Omega m)^{-1}$<br>2µV/m (threshold) | Atmospheric electric conductivity Wave electric fields and lightning |
| | | Relaxation probe | 10% | 1 min<br>25 ms - 2 s<br>1mV (threshold) | Ion conductivity & DC electric field |
| | | Acoustic sensor | 5% | 10 mPa (threshold) | Acoustic noise due to turbulence or storms |
| | | Radar signal processing (FFT) | 1.5 dB | 40 m @24 km | Radar echoes below 60 km |

** figures for resolution and accuracy are for the X servo accelerometer*

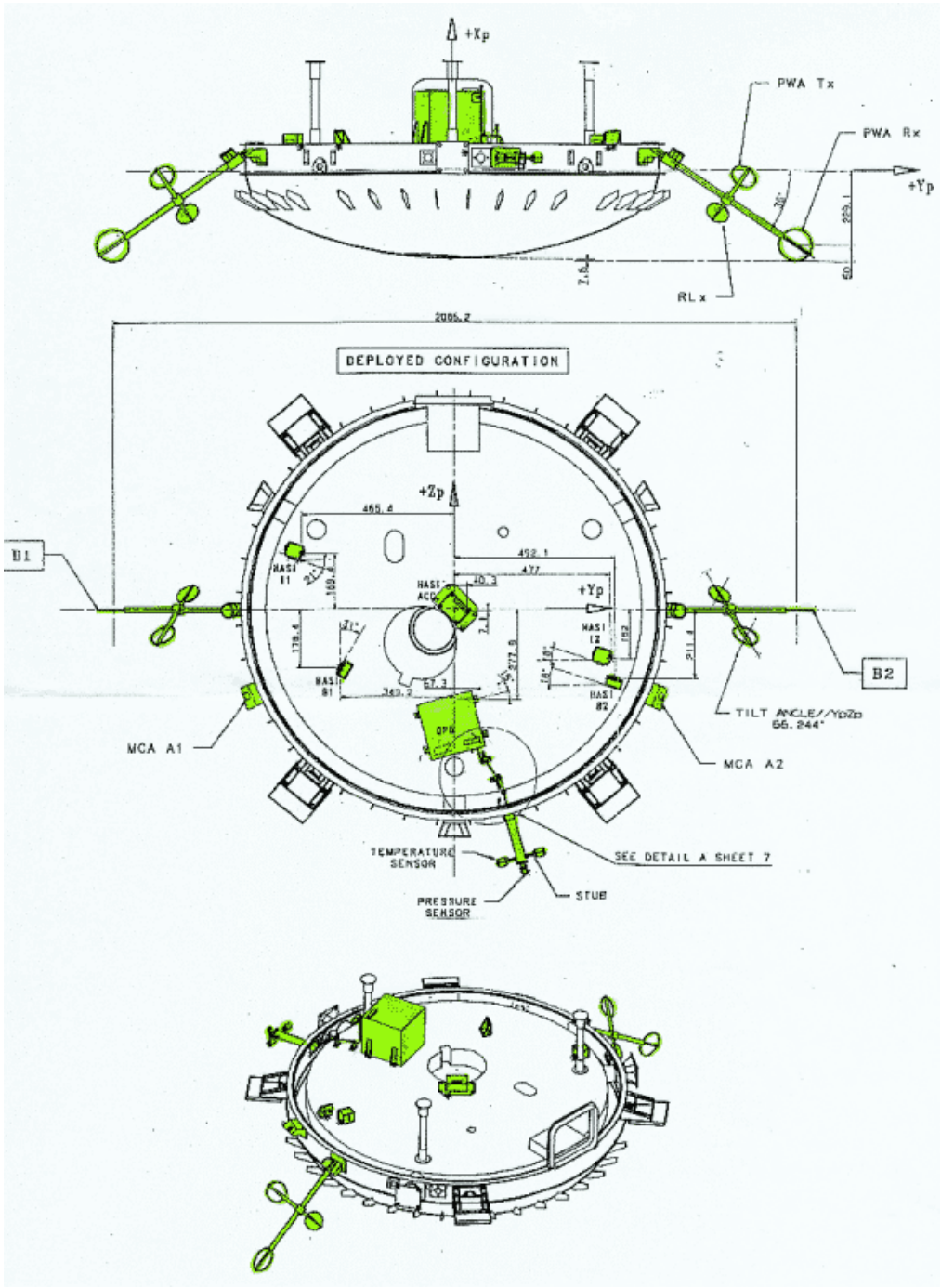


Fig. 2 HASI subsystem accommodation on the Huygens probe experiment platform

## 2.2 Sensor Overview

### 2.2.1 ACC

The Accelerometer subsystem (ACC) is placed at the centre of mass of the descent module of the Probe. It consists of one highly sensitive single axis accelerometer (Xservo) and three piezoresistive accelometer (X, Y, Z piezo), their conditioning electronics and two temperature sensors (Temp1 and Temp2) used for thermal compensation. The Xservo accelerometer output is amplified providing two channels (HIGH and LOW gain). Each channel has a switchable range (FINE and COARSE resolution) which is set autonomously (FINE range set at startup and swithched on COARSE prior saturation or anyhow after Tdata (T0+10s)). Xservo channel selection is performed autonomously by checking the measured value against a setable threshold.
7 channels and relevant sampling:
- Xservo LOW gain at 100 Hz
- Xservo HIGH gain at 100 Hz
- Xpiezo at 50 Hz
- Ypiezo at 50 Hz
- Zpiezo at 50 Hz
- Temp 1 (Tservo) at 1.5625 Hz
- Temp 2 (Tpiezo) at 1.5625 Hz

Values are arithmetically averaged by the HASI onboard S/W to produce lower sampling rates.

### 2.2.2 TEM

HASI temperature sensors are two redundant dual element platinum resistance thermometers (TEM) mounted on the STUB in order to be appropriatelly located and oriented with respect to the gas flow during the measurements.
Each TEM has a primary sensor (fine, F) directly exposed to the air flow and a secondary sensor (coarse, C) which is annealed in glass of the supporting frame and is used as spare unit in case of damage on the primary sensor. Temperature measurement is performed by monitoring the resistance of TEM sensors; the resistance of each TEM sensor is measured by a four wire configuration.
Temperature measurements can be performed in HIGH and LOW resolution range (60-110K for HIGH and 100-330K for LOW resolution ) by switching HIGH and LOW gain channel. The range selection is performed by HASI S/W calculating the rough resistor value and comparing against a setable threshold.
4 sensors:
- TEM1 fine (F1)
- TEM1 coarse (C1)
- TEM2 fine (F2)
- TEM2 coarse (C2)

### 2.2.3 PPI

The *Pressure Profile Instrument* includes sensors for measuring the atmospheric pressure during descent and surface phase. The atmospheric flow is conveyed through a Kiel probe, mounted on the STUB tip, inside the DPU where the transducers and related electronics are located. The PPI sensors are 6 reference sensors (for housekeeping) and 18 transducers. The transducers are silicon capacitive absolute pressure sensors (**Barocap**, 8 P), temperature capacitive sensors (**Thermocap**, 3 T) and Constant (C) and reference (R) sensors (high stability capacitor, respectively 7 C used for housekeeping and 6 R used in the pressure measurements) The sensors are organized in three blocks each having eight frequency output channels. The three blocks corresponds to different pressure sensibility range:

| | | |
|---|---|---|
| low pressure | 0-400 hPa | block 3, sensor 3.7P , 3.8P and 3.3T |
| medium pressure | 0-1200 hPa | block 1, sensor 1.1P, 1.6P , 1.8P and 1.3T |
| high pressure | 0-1600 hPa | block2, sensor 2.1P, 2.7P, 2.8P and 2.3T |

In total there are:
24 frequency channels:

| | | |
|---|---|---|
| 1.1P | 2.1P | 3.1C |
| 1.2R | 2.2R | 3.2R |
| 1.3T | 2.3T | 3.3T |
| 1.4C | 2.4C | 3.4C |
| 1.5R | 2.5R | 3.5R |
| 1.6P | 2.6C | 3.6C |
| 1.7C | 2.7P | 3.7P |
| 1.8P | 2.8P | 3.8P |

and 2 housekeeping voltages (HKV0 and HKV1 for housekeeping).

### 2.2.4 PWA

The PWA sensors are 6 electrodes and an acoustic transducer. The electrodes are mounted on the deployable booms system (DBS), 3 electrodes on each boom – transmitter TX (ring-shape), receiver RX (ring-shape), and relaxation probe RP (disk-shape)-, and can operate in different modes. The two RP electrodes are independent relaxation probes with different sensitivity. The two transmitters and two receivers are part of the mutual impedance probe (active mode). Furthermore, when the transmitters are off, the receivers located at the tip of the booms operate as an antenna (passive mode). The relaxation probes measure ion conductivities and the mutual impedance probe is sensitive to electron conductivity only. The passive mode operation allows the detection of electromagnetic waves in the ELF-VLF range.
The acoustic sensor (ACU) is mounted on the STUB for detecting sound waves to correlate with acoustic noise, turbulence and meteorological events.
The radar return signals of the Huygens Proximity Sensor, containing information on surface properties and altitude, are processed also by HASI. The radar signal is converted to 10KHz and filtered by the Radar Altimeter Extension (RAE) board and passed to the PWA A/D converter and signal processor. The radar input signals in HASI/PWA are the blanking signal and the analogue intermediate frequency signal (echo signal). The PWA signal processor performs FFT, digital integration and data packetising and controls the data acquisition. The spectrum and altitude information of the radar return signal are added to the HASI data stream.
*Data products:*

| | | |
|---|---|---|
| PWA-ACU | Acoustic (High and Low gain) | (Descent 2 and 3; Surface) |
| PWA-RP | Relaxation probe | (Descent 2 and 3) |
| PWA-MI | Mutual Impedance | (Descent 2 and 3; Surface) |
| PWA-AC_VLF | AC Field VLF range (High and Low gain) | (Descent 2, Descent 3; Surface) |
| PWA-AC_ELF | AC Field ELF range (High and Low gain) | (Descent 2, Descent 3; Surface) |
| PWA-LGH | Lightning | (Descent 2 and 3; Surface) |
| PWA-RAU | Radar | (Descent 3) |

## 2.3 Operational modes and measurements

***HASI mission phases***

***ENTRY***
from higher than 1270 km (~1900 km) to 170 km;
**Tacc**=Probe-ON +21min 30s to **T0** (expected at 28 min)

***DESCENT***
from **Tdata**=T0+10s to surface
***DESCENT 1st state*** from Tdata to **TdataH**=T0+2min 30s
***DESCENT 2nd state*** from TdataH to **Tradar**=T0+32min
***DESCENT 3rd state*** from Tradar to **last km** (~T0+2h12min)
***IMPACT state*** from last km to surface (~T0+2h14min)
***SURFACE state*** from ACC impact detection to link loss

Table 3a HASI timeline, probe events and related dynamic conditions during the Huygens mission as expected.
*(as from Huygens engineering profile for recommended Yelle's atmosphere model as in EIDpartC, reviewed by Alcatel in 1997)*

| | **Time (min)** | **Mission time** | **Altitude (km)** | **Vertical velocity (m/s)** | **Accele-ration (m/s^2)** | | |
|---|---|---|---|---|---|---|---|
| **COAST** | | T0-22d 5mn | | | | *Tsep* | *Probe separation from Orbiter* |
| | | T0-18 mn | | | | *Tp* | *Probe power-up and CDMS activities* |
| | | T0-10 mn | | | | *Thasi* | HASI ON (17:46 preT0) |
| | | T0-8 mn | ~1900 | | | *Tacc* | ACC sampling start |
| **ENTRY** | 0.03 | ~T0-5 mn | 1260.8 | 6145.28 | 0.61 | *Tentry* | |
| | 2.7 | | 401.082 | 6114.32 | 11.031 | | |
| | 3.37 | | 229.334 | 3404.9 | 120.78 | *max acc* | |
| | 4.13 | | 170.24 | 638.54 | 16.886 | | |
| | 4.42 | | 162.648 | 429.37 | 8.3181 | | |
| **DESCENT** | | | | | | | *end of entry phase* |
| | 0.03 | | 162.063 | 307.91 | 24.196 | *T0* | *descent device deployment begins* |
| | | T0+00.25s | | | | | *Pilot chute deployed and inflation* |
| | | T0+2.5s | | | | | *Back cover release, main chute deployment & inflation* |
| | | T0+10s | 157.3 | 192.6 | 12.363 | Tdata, | T&p sampling; |
| | 0.5 | T0+32.5s | 157.452 | 99.63 | 2.469 | | *Front shield jettison* |
| | 1 | T0+1mn | | | | | *DISR cover jettison* |
| | 1.05 | | 154.904 | 67.42 | 0.598 | Td1 | 1st BOOM release attempt start |
| | 1.55 | | 153.002 | 62.06 | 0.255 | Td1w | 1st BOOM release attempt end |
| | 2.2 | | 150.658 | 59.72 | 0.113 | Td2 | 2nd BOOM release attempt start |
| | 2.5 | | 149.775 | 59.08 | 0.086 | TdataH | PWA sampling (mode A) start |
| | | T0+15mn | 114.733 | 36.61 | 0.02 | | *Main chute jettison, stabiliser deployment & inflation* |
| | 25.78 | | 74.906 | 44.58 | 0.049 | | |
| | 32.12 | | 61.372 | 27.49 | 0.028 | Tradar | RADAR sampling, PWA mode C |
| | 48.45 | | 42.103 | 14.71 | 0.007 | tropo-pause | |
| | 75.12 | | 24.262 | 8.76 | 0.002 | Tpmed | Medium p sampling start |
| | 105.1 | | 11.034 | 6.29 | 0.001 | Tphigh | High p sampling start |
| | | | 7 | | | | PWA mode D |
| | 134.5 | | 1.025 | 5.22 | 0 | last km | IMPACT mode |
| **SURFACE** | 138.1 | | 0 | 0 | 0 | Timpact | SURFACE mode, PWA mode G |
| | | | | | | *Tloss* | *Loss of radio link* |

### 2.3.1 ACC modes

For the acceleration there are two types of data: 'raw' data and statistics data (obtained from average of 100 Hz sampling, on-board processing).

Channels readouts are summed in order to get the following sampling rate:

| | | |
|---|---|---|
| *ACC Xservo* | *3.125 Hz* | *in ENTRY; from Tacc till T0+10 s* |
| | *4.167 Hz* | *till T0+32 min* |
| | *1.754 Hz* | *last km (~132 min) Impact detection and in Surface state* |
| *ACC X, Y, Z piezo* | *1.6129 Hz* | *in ENTRY and last km and in Surface state* |
| *Statistics* | *0.1 Hz* | *always, except in impact detection* |
| *ACC Servo & piezo Temperature* | *0.097 Hz* | *always, except in impact detection* |

*Impact trace* *(0.5 s before & 5.5 s after impact)*

| | | |
|---|---|---|
| *X piezo* | *200 Hz* | |
| *Y piezo* | *200 Hz* | *transmitted after Timpact* |
| *Z piezo* | *200 Hz* | |

p.s. NO ACC data are transmitted during impact phase

### 2.3.2 TEM modes

All 4 TEM sensors are sampled every 5 s. The measurement sequence is the following:

F1,C1, F2, C2.

Sampling rate:

1 Temperature point every 1.25s (0.8 Hz)
but same sensor sampled every 5s (0.2Hz)

IMPACT STATE only F1 and F2 are sampled

1 Temperature point every 1.25s (0.8 Hz)
but same sensor sampled every 2.5s (0.4Hz)

### 2.3.3 PPI modes

Table 4 PPI modes

| DDB time | HASI time | PPI normal session | |
|---|---|---|---|
| T0+10s | Tdata | A | Low pressure |
| T0+75' | Tpmed | B | Medium p sampling start |
| T0+105' | Tphigh | C | High p sampling start |

Two pressure values every 2.3 s are produced.

PPI channels polling tables for normal and health check session are reported in PPI calibration report [RD5].

### 2.3.4 PWA modes

Table 5 PWA modes

| Phase | DDB time | HASI time | altitude range | PWA mode | measurements |
|---|---|---|---|---|---|
| Descent_2 | T0+2.5' | Tdatah | ~60 km<h<160 km | mode A | ACDC, MI, RP |
| Descent_3 | T0+32' | Tradar | 7 km<h<~60km | mode C | ACDC&ACU, MI, RAU, RP |
| Descent_3 | | | 1 km<h<7km | mode D | ACDC&ACU, MI, RAU, RP Radar polling scheme change |
| Impact | | last km | 200 m<h<1km<br>0 m<h<200 m | mode D | ACDC&ACU, MI, RAU, RP no RP relay switching |
| Surface | | Timpact | 0m | modeG | ACDC&ACU, MI |

*derived from HASI-PWA FM USER MANUAL PWA-FM-DOC-012 V. 3.0 17/11/1995

### 2.3.5 HASI modes of operation

Table 6 HASI operation modes

| Phase | ENTRY | | DESCENT | | | | IMPACT | SURFACE |
|---|---|---|---|---|---|---|---|---|
| Mode | - | | 1 | 2 | 3 | | - | - |
| | $T_{HASI}$ 17:46 | $T_{ACC}$ 21:30 | $T_{data}$ 00:10 | $T_{dataH}$ 02:30 | $T_{radar}$ 32:00 | 1 km | Impact detection | $T_{loss}$ |
| DDBL Time/ Altitude | | | T0 Reset 00:00 | | Tmid 1:15:00 | Thigh 1:45:00 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| ACC XSERVO statistics | 3.125 Hz 0.1 Hz | 4.167 Hz 0.1 Hz | 1.754 Hz 0.1 Hz | | | 1.754 Hz 0.1 Hz |
| ACC PIEZO statistics | 1.6129 Hz 0.1 Hz | 0.1 Hz | | | 200 Hz | 0.1 Hz |
| TEM | | 0.8 Hz 0.2 Hz same sensor | | 0.4 Hz (0.2 Hz) | | 0.8 Hz (0.2 Hz) |
| PPI | | A 2 pressure every 2.3s | B | C | | |
| PWA | | Mode A | Mode C | Mode D | | Mode G |

ACC statistics average on samples @400 Hz
ACC PIEZO special buffer at 200 Hz, from $T_{impact}$-0.5s to $T_{impact}$+5.5s
ACC no data transmitted during impact phase (except for impact detection trace)
TEM F1, C1, F2, C2 (F: fine, C: coarse); impact phase F1, F2 (only fine)
PPI measurement sequence provide 2 pressure point every 2.3s A: low pressure range, B: medium pressure range, C: high pressure

## 2.4 Pre-Flight Data Products

We do not currently plan to include pre-flight data products

## 2.5 Sub-System Test

We do not plan to include any subsystem tests.

## 2.6 Instrument Calibrations

Calibration and data processing will be detailed in the HASI subsystem calibration reports:

- TEM calibration report [RD4]
- PPI calibration report [RD5]
- ACC calibration report [RD6]
- PWA report [RD7]

Calibration reports will contain all the information (Transfer functions, lookup table, algorithm to convert engineering data to science products) for processing and calibrate the data derived from the different HASI sensor packages.

### *2.6.1* Other Files written during Calibration

ASCII calibration data files are also provided within the CALIB directory per subsystem containing information on data conversions and calibration parameters (e.g. formulae, coefficients). When necessary, also ASCII files containing information on higher level products derivation are provided.

In general for the description of the methods of data analysis clear reference to scientific papers or documents are indicated either in calibration reports or in references.

## 2.7 In-Flight Data Products

The following data products are processing level 2 (raw data converted into engineering units) 3 and 4 (and elaborated in scientific units), converted in ASCII.

The HASI data products are listed in table 7, the size of each product is stated just for reference and it is a minimum estimation on the base only of level 2 data.

**Table 7: HASI data products**

| Product Type | Measured parameter | Derived parameter | Estimated Minimum Data Set Size (kbyte) |
|---|---|---|---|
| HASI_HK | housekeeping data (temperature, voltage, events,) | - | *100* |
| HASI_ACCE | acceleration during entry and HK temperature | density | 300 |
| HASI_ACCD | acceleration during descent and HK temperature | density | 800 |
| HASI_ACCI | acceleration at impact and HK temperature | surface characteristics | 150 |
| HASI_TEM | resistance | temperature | 720 |
| HASI_PPI | capacitance variation (frequency) | pressure | 700 |
| HASI_PWA-ACU | acoustic recording; | sound (spectra) | *500* *only raw TM data (pck PWA ACDCAU)* |
| HASI_PWA-RP | relaxation potentials | Quasi-static electric field and ion conductivity | *30* *only raw TM data (pck PWA RP)* |
| HASI_PWA-MI | mutual impedance (amplitude and phase) | electron conductivity and e.m. wave emission | *70* *only raw TM data (pck PWA MI)* |
| HASI_PWA-ACDC & LIGHTNING | AC/DC fields | electric fields and e.m. wave emission | *150* *only raw TM data (pck PWA ACDC)* |

| | | | |
|---|---|---|---|
| HASI_PWA-RAU | echo signal and FFT; | elevation, topography and surface properties (e.g. roughness, texture, soil permittivity) | *100** *only raw TM data (pck PWA RAU)* |

*only raw TM data

## 2.8 Software

No software will be provided (data will be provided in ASCII form so as the calibration documents)

## 2.9 Documentation

Documentation will be provided to give instructions to how to use the calibration data (calibration report) and converting data from engineering units to science product. ASCII documents will be provided; in case of images and drawing WORD and/or PDF document will be provided.

## 2.10 Derived and other Data Products

Any derived data products will be completed on the best effort basis, as time and funding permit.

# 3 Archive Format and Content

## 3.1 Format and Conventions

### 3.1.1 Deliveries and Archive Volume Format

The individual logical archive volumes delivered will contain:

- Data from ALL sensors (including housekeeping)
- Raw data (e.g. data in engineering units), converted and calibrated data (namely engineering data converted into scientific data) as well calibration data

The logical archive volumes identified at the moment are:

- Titan mission

### 3.1.2 Data Set ID Formation

Data set ID complaiant with PDS standard will be indicated as follow (acronyms meaning is reported within <>):

HP-SSA-HASI-dpl-MISSION-V1.0

<Huygens Probe>-<Saturn Satellite>-<Huygens Atmospheric Structure Instrument>-<dpl=data processing level {2-3-4}*>-<Experiment Data Record>-<version 1.0>

*Level 2 is data converted in engineering units; Level 3 converted to scientific units, Level 4 is high scientific product.*

*see ANNEX I of [AD2] *should be complaint with CODMAC PROCESSING LEVELS (see chapter 6 B* [AD1]

### 3.1.3 Data Directory Naming Convention

For all the data sets, the subdirectories will be named according to the data products, in the /**data** directory with the following naming scheme:
/data/{subsystem}/filename, with

- subsystem={ACC, PPI, TEM, PWA, HK}

The calibration data will be archived in the /**calib** directory below the root directory, as:
/calib/{subsystem}/filename, with

- subsystem={ACC, PPI, TEM, PWA, HK}

### 3.1.4 Filenaming Convention

The following filename scheme is used for all the data files.

HASI_L{data processing level}_{subsystem}{mission phase}_{datatype}.{extension}

| | |
|---|---|
| data processing level | {2, 3, 4} according to CODMAC processing level [AD1, AD2] |
| subsystem | {ACC, TEM, PPI, PWA, DPU} |
| mission phase | {E = entry , D = descent, S = surface} when applicable |

| | |
|---|---|
| sensor data type | {SERVO, SERVOSTD, SERVOT, PIEZO, PIEZOSTD, PIEZOT, PIEZOIMP}; {FINE1, COARSE1,…}; {NSA,HCA, HK, NSA11P, NSA13T, …}; {RP, AC_ELF, AC_VLF, ACU, LGH, MIP, RAU} |
| extension | {LBL = label, TAB = table} |

*Max filename length 27.3*

## 3.2 Standards Used in Data Product Generation

### 3.2.1 PDS Standards

PDS Standard Reference version 3.5, http://pds.jpl.nasa.gov/stdref was used for the design of the HASI archive.

### 3.2.2 Time Standards

The time reference (Mission Time) is given by the Huygens timer provided to the instrument in the DDB by the CDMS.

HASI receives a DDB information every 2 s and is synchronized every 125 ms by the BCP (BroadCast Pulse) signal.

In preT0 (entry phase), time is referenced to Huygens probe power on (S0); after entry time is referenced to T0 (arming time of the Descent Device Deployment System pyros) [ref. to EIDA; table 3].

HASI marks each telemetry packets with a timestamp relevant to the DDB time when the first source data contained in the packet data field is created. Timestamp resolution is a BCP count (125 ms); the resolution on this time value is 1 LSB = 1ms. Time relevant to each data value contained in the telemetry packet is computed starting from the timestamp, according to their position within the packets and from the sampling rate (constant).

Conversion from DDB time (Mission Time) to UTC time will be provided by HPOC.

The format for time that HASI intends to use is

| | |
|---|---|
| UTC time | YYYY-MM-DDThh:mm:ss.xxx (e.g. 2005-01-25T12:09:09.999) and I8 (8-digit integer number) [ms] |
| DDB time | h:mm:ss.xxx or I8 (8-digit integer number) [ms] (spacecraft clock time) (DDB time starts at Probe ON and is reset to 0 at T0) signed "-" for preT0 |
| Native time | I8 (8-digit integer number) [ms] (Elapsed time from T0) signed: "–" for preT0 |

**N.B.** Conversion time from DDB to UTC time provided by HPOC (could be changed). For this data set the following value has been used:

**To transition at UTC time 9:10:20.828** (corresponds to 33020828 milliseconds starting from 2005-01-14T00:00:00.000 UTC.)

***T0 transition** happened at DDB time 4:28:47.875 (16127875 ms) corresponding to **UTC time 9:10:20.828** (information provided by HPOC and contained in the Huygens HK parameter S2013E_H3B)*

### 3.2.3 Reference Systems

The reference system for HASI is the Huygens probe system axes.

The official trajectory reconstruction is the result of a common effort, produced by the Huygens Descent Trajectory Working Group (DTWG) and archived within the Huygens DTWG data set.

Huygens reference system: Titan centric coordinates (as defined by DTWG) ([AD2]).

### 3.2.4 Other Applicable Standards

N/A

## 3.3 Data Validation

HASI data products will be validate internally within the HASI team by interactions with the HASI CoIs, responsible for the different subsystems. The final validation will be performed by the HASI PMO at CISAS – UPD under the PI supervision and endorsement by Italian Space Agency (ASI).

## 3.4 Content

### 3.4.1 Volume Set

N/A

### 3.4.2 Data Set

Data are organized in directories for each HASI subsystems (ACC, PPI, TEM, PWA, HK) within these directories data files relevant to the different measurements and derived parameters are contained. Data directory and filename conventions are stated in § 3.1.

Data set id name: **HP-SSA-HASI-2-3-4-TITAN-V1.0** *ref.§3.1.2*

HP-SSA-HASI-2-3-4-TITAN-V1.0

| Data | Calib | Catalog | Index | Label | Document |
|---|---|---|---|---|---|

Data:
- ACC
- TEM
- PPI
- PWA
- HK
- PROFILES

Calib:
- ACC
- TEM
- PPI
- PWA
- HK

See ANNEX 1.

**Table 8: HASI data products**

| Product Type | Measured parameter | Derived parameter | Data Set Size (kbyte) |
|---|---|---|---|
| HASI_HK | housekeeping data (temperature, voltage, events) | - | 61,440 |
| HASI_ACC | acceleration and HK temperature during entry, descent, impact and surface | Density, trajectory Impact instant; surface characteristics | 3.788,800 |
| HASI_TEM | resistance | temperature | 1.355,296 |
| HASI_PPI | capacitance variation (frequency) | pressure | 1.019,904 |
| HASI_PWA-ACU | acoustic recording; | sound (spectra) | 990* |
| HASI_PWA-RP | relaxation potentials | Quasi-static electric field and ion conductivity | 131* |
| HASI_PWA-MI | mutual impedance (amplitude and phase) | electron conductivity and e.m. wave emission | 605* |
| HASI_PWA-AC Field LIGHTNING | AC fields ELF and VLF range Discharges | electric fields and e.m. wave emission | 4540* |
| HASI_PWARAU | echo signal and FFT; | elevation, topography and surface properties (e.g. roughness, texture, surface matierial permitivity) | 445* |
| HIGHER LEVEL PRODUCTS | | Atmospheric profiles | 307,200 |

*only raw data (level2)

## 3.4.3 Directories

### 3.4.3.1 Root Directory

Root Directory will be / **HP-SSA-HASI-2/3/4-TITAN-V1.0/**.

### 3.4.3.2 Calibration Directory

Calibration directory will be **/CALIB/**.
Subdirectories will be divided for HASI subsystems:

/ACC
/TEM
/PPI
/PWA
/HK

These directories will contain the calibration reports and data.

### 3.4.3.3 Catalog Directory

The Catalog Directory will contain the following files:

MISSION.CAT (to be provided by the project)
INSTRUMENTHOST.CAT (to be provided by the project)
INSTRUMENT.CAT containing a description of the instrument
DATASET.CAT containg a description of the dataset and relevant information
REFERENCE.CAT containing a list of scientific papers
PERSONNEL.CAT containing list and coordinates of personnel involved
TARGET.CAT containg the name of the target
SOFT.CAT not applicable, but requested by PDS
CATINFO.TXT

### 3.4.3.4 Index Directory

### 3.4.3.4.1 Dataset Index File, index.lbl and index.tab

### 3.4.3.4.2 Geometric Index File, geoindex.lbl and geoindex.tab

N/A

### 3.4.3.5 Browse Directory and Browse Files

N/A

### 3.4.3.6 Geometry Directory

N/A

### 3.4.3.7 Software Directory

N/A
We do not foresee any software to be archived.

### 3.4.3.8 Gazetter Directory

N/A

### 3.4.3.9 Label Directory

N/A

### 3.4.3.10 Document Directory

Within this directory will be contained documents useful and relevant to data processing and analysis.
Documents are provided in PDF format.
Documents are divided into directory:

- EAICD
- USER_MANUAL: containing HASI technical documents:
  - HASI_USER_MANUAL HASI Experiment User Manual (Flight and Flight Spare models), HASI-MA-OG-002, Issue 3, 1 December 1998 (II/196.B.6) [RD1]
  - HASI_SW_URD HAS DPU Software User Requirements Document HASI-SP-OG-004, Issue 7, 7 Sep 1995 (II/179.B.1) [RD2]
- PUBLICATIONS: containing HASI general description papers and publication of the preliminary results and reference for HASI subsystems:

### 3.4.3.11 Extras Directory

N/A

HASI home page at CISAS-UPD http://cisas.unipd.it/hasi/
IWF HASI-PWA web site http://saturn.iwf.oeaw.ac.at/iwfmag/cassini/index.htm

### 3.4.3.12 Data Directory

This directory contains all the data products of HASI (at different processing level) organized in subdirectories containing different data files.
Subdirectories are divided for HASI subsystems plus a directory for higher level products (PROFILES):

/ACC
/TEM
/PPI
/PWA
/HK
/PROFILES

Within these directories data files relevant to different sensors, mission phase, measured parameters etc. will be contained. The filename (as from § 3.1.4) will help for understanding the content of the file.

# 4. Detailed Interface Specifications

## 4.1 Structure and Organization Overview

**/HP-SSA-HASI-2/3/4-TITAN-V1.0/data** directory will be organized in subdirectories.
Subdirectories will be divided for HASI subsystems plus a directory for higher level products (PROFILES):

/ACC
/TEM
/PPI
/PWA
/HK
/PROFILES

Filename convention as from §3.1.4:
HASI_L{data processing level}_{subsystem}{mission phase}_{datatype}.{extension}

| | |
|---|---|
| data processing level | {2, 3, 4} according to CODMAC processing level [AD1, AD2] |
| subsystem | {ACC, TEM, PPI, PWA, DPU} |
| mission phase | {E = entry , D = descent, S = surface} when applicable |
| sensor data type | {SERVO, SERVOSTD, SERVOT, PIEZO, PIEZOSTD, PIEZOT, PIEZOIMP}; {FINE1, COARSE1,…}; {NSA,HCA, HK, NSA11P, NSA13T, …}; {RP, AC_ELF, AC_VLF, ACU, LGH, MIP, RAU} |
| extension | {LBL = label, TAB = table} |

### 4.1.1 ACC subdirectory

The following files are inserted in this subdirectory (naming convention as from §3.1.4). In what follow it is reported the file name and a schematic structure of the content of the table:
ref. to [RD6]

***ENTRY PHASE ENGINEERING DATA (level 2)**:*

HASI_L2_ACCE_SERVO.TAB/LBL

| Time [ms] | voltages [V] | gain [high/low] | range [fine/coarse] |
|---|---|---|---|

HASI_L2_ACCE_SERVOSTD.TAB/LBL

| Time [ms] | voltages [V] | gain [high/low] | range [fine/coarse] |
|---|---|---|---|

HASI_L2_ACCE_SERVOT.TAB/LBL

| Time [ms] | temperature [V] |
|---|---|

HASI_L2_ACCE_PIEZO.TAB/LBL

| Time [ms] | Xpiezo [V] | Ypiezo [V] | Zpiezo [V] |
|---|---|---|---|

HASI_L2_ACCE_PIEZOSTD.TAB/LBL

| Time [ms] | Xpiezo [V] | Ypiezo [V] | Zpiezo [V] |
|---|---|---|---|

HASI_L2_ACCE_PIEZOT.TAB/LBL

| Time [ms] | temperature [V] |
|---|---|

***ENTRY PHASE SCIENTIFIC DATA (level3)**:*

HASI_L3_ACCE_SERVO.TAB/LBL

| Time [ms] | acceleration [m/s2] |
|---|---|

HASI_L3_ACCE_SERVOSTD.TAB/LBL

| Time [ms] | acceleration [m/s2] |
|---|---|

HASI_L3_ACCE_SERVOT.TAB/LBL

| Time [ms] | temperature [K] |
|---|---|

HASI_L3_ACCE_PIEZO.TAB/LBL

| Time [ms] | Xpiezo [m/s2] | Ypiezo [m/s2] | Zpiezo [m/s2] |
|---|---|---|---|

HASI_L3_ACCE_PIEZOSTD.TAB/LBL

| Time [ms] | Xpiezo [m/s2] | Ypiezo [m/s2] | Zpiezo [m/s2] |
|---|---|---|---|

HASI_L3_ACCE_PIEZOT.TAB/LBL

| Time [ms] | temperature [K] |
|---|---|

***DESCENT PHASE:***
*(same structure that in ENTRY, for Piezo only statistic data will be measured)*

HASI_LX_ACCD_SERVO.TAB/LBL
HASI_LX_ACCD_SERVOSTD.TAB/LBL
HASI_LX_ACCD_SERVOT.TAB/LBL
HASI_LX_ACCD_PIEZOSTD.TAB/LBL
HASI_LX_ACCD_PIEZOT.TAB/LBL

LEVELX with X=2 & 3

***SURFACE PHASE:***
*(during impact Piezo sensors acquired at 100 Hz frequency)*

HASI_LX_ACCS_PIEZOIMP.TAB/LBL

*(same structure that DESCENT, for Piezo only statistic data will be measured)*

HASI_LX_ACCS_SERVO.TAB
HASI_LX_ACCS_SERVOSTD.TAB
HASI_LX_ACCS_SERVOTEM.TAB
HASI_LX_ACCS_PIEZOSTD.TAB
HASI_LX_ACCS_PIEZOT.TAB

LEVELX with X=2 & 3

Higher level products (***LEVEL4***)

- **Acceleration** profile of the Huygens probe relevant to entry phase
  **Velocity** of the Huygens probe expressed in Titan centric coordinates (ref §3.2.3) or vertical velocity as derived from trajectory reconstruction
  **Altitude** as derived from trajectory reconstruction
- **Density** profile relevant to entry phase as derived from acceleration profile [RD3, RD6] using Huygens probe characteristics and aerodynamic database.

HASI_L4_ACCE_ACC_VEL.TAB

| *Time [ms]* | Altitude [m] | acceleration [m/s2] | VX [m/s] | VY [m/s] | VZ [m/s] |
|---|---|---|---|---|---|

HASI_L4_ACCE_DENSITY.TAB

| *Time [ms]* | Altitude [m] | density [kg/m3] |
|---|---|---|

HASI_L4_ACCD_ALT_VEL.TAB

| *Time [ms]* | Altitude [m] | 1sigma altitude [m] | Vertical velocity [m/s] | 1sigma velocity [m/s] |
|---|---|---|---|---|

### 4.1.2 TEM subdirectory

The following files are expected to be inserted in this subdirectory (naming convention as from §3.1.4). In what follow it is reported the file name and a schematic structure of the content of the table:
ref to [RD4]

HASI_L2_TEMX_Y.TAB/LBL

| Time [ms] | VF[V] | 0VF[V] | VR [V] | 0VR [V] | gain[high/low] | 0VRMEAN [V] | 0VFMEAN [V] |
|---|---|---|---|---|---|---|---|

HASI_L3_TEMX_Y.TAB/LBL

| Time [ms] | Resistance [ohm] | temperature [K] |
|---|---|---|

with X = D, S
with Y = FINE1, COARSE1, FINE2, COARSE2

Higher level products (***LEVEL4***) refer to [RD4]
Corresponding to **temperature** values corrected for instrumental response effects and dynamical effects.

HASI_L4_TEM_TEMPERATURE.TAB

| Time [ms] | Altitude [h] | temperature [K] | ± uncertainty [K] | *Ref sensor* |
|---|---|---|---|---|

Including also temperature data recorded at surface after landing for almost half an hour.

### 4.1.3 PPI subdirectory

The following files are inserted in this subdirectory (naming convention as from §3.1.4). In what follow it is reported the file name and a schematic structure of the content of the table:
ref to [RD5]

***ENGINEERING DATA (level2):***

HASI_L2_PPI_X.TAB/LBL

| Time [ms] | Channel type | Counter |
|---|---|---|

with X = NSA, NSB, NSC, HCA, HCB
NS = normal session
HC = health check

HASI_L2_PPID_HK.TAB/LBL

| Time [ms] | HK voltage 1 [Volt] | HK voltage2 [Volt] |
|---|---|---|

***SCIENTIFIC DATA (level 3):***
Scientific data for normal session will divided with respect to measurement channel.

HASI_L3_PPI_*XY*P.TAB/LBL

| Time [ms] | Pressure [Pa] |
|---|---|

with X = NSA, NSB, NSC
with Y = 11, 16, 18, 21, 27, 28, 37, 38 (corresponding to PPI channel ref § 2.2.3)

HASI_L3_PPID_XYT.TAB/LBL

| Time [ms] | Temperature [K] |
|---|---|

with X = NSA, NSB, NSC
with Y = 13, 23, 33 (corresponding to temperature channel)

Higher level products (***LEVEL4***)
corresponding to **total** and **ambient pressure**, **descent velocity**, and **altitude** profiles has reconstructed by PPI team starting from total pressure measurements (using real gas and hydrostatic equilibrium) [RD5]

HASI_L4_PPI_PRESSURE_VEL.TAB

| Time [ms] | *Ref sensor* | total pressure [Pa] | ambient pressure [Pa] | Altitude [m] | velocity [m/s2] |
|---|---|---|---|---|---|

Including also pressure data recorded at surface after landing for almost half an hour.

### 4.1.4 PWA subdirectory

The following files are inserted in this subdirectory (naming convention as from §3.1.4). In what follow it is reported the file name and a schematic structure of the content of the table:

| Data Type / Sensor Name | Description | File Name |
|---|---|---|
| Relaxation Probe | RP –5V, Descent | HASI_Lx_PWAD23_RP.TAB |
| | RP 0V, Descent | |
| | RP +5V, Descent | |
| AC Field VLF range | VLF, Descent H | HASI_Lx_PWAD2_AC_VLF.TAB |
| | VLF, Descent L | HASI_Lx_PWAD3_AC_VLF.TAB |
| | VLF, Surface | HASI_Lx_PWAS_AC_VLF_.TAB |
| Lightning, | Lightning, descent | HASI_Lx_PWAD23_LGH.TAB |
| | Lightning, surface | HASI_Lx_PWAS_LGH_ |
| Mutual Impedance | MI Descent | HASI_Lx_PWAD23_MIP.TAB |
| | MI Surface | HASI_Lx_PWAS_MIP.TAB |
| AC Field ELF range | ELF, Descent H | HASI_Lx_PWAD2_AC_ELF.TAB |
| | ELF, Descent L | HASI_Lx_PWAD3_AC_ELF.TAB |
| | ELF, Surface | HASI_Lx_PWAS_AC_ELF.TAB |
| Acoustic | ACU, Descent | HASI_Lx_PWAD3_ACU.TAB |
| | ACU, Surface | HASI_Lx_PWAS_ACU.TAB |
| Radar | RAU, Descent | HASI_Lx_PWAD3_Fyy_RAU.TAB/LBL |

Legend:
x - is 2 or 3. Level 2 tables will be delivered in LSB (Least Significant Bit), as converted from Telemetry Data File. Level 3 tables will be delivered in SI units.

**NOTE:** As calibration data is model dependent, PWA team will not be able to provide level 4 data at the present stage, not only electron and ion density but also conductivity profiles.

RelaxationProbe

HASI_L2_PWAD23_RP.TAB/LBL

| Time[ms] | InitialVoltage<br>0=>0V<br>1=>+5V<br>2=>-5V | RelaxationValue1 | ... | RelaxationValue97 |
|---|---|---|---|---|

VLF Field

HASI_L2_PWAD2_AC_VLF.TAB/LBL

| Time[ms] | GainMode<br>0=>Low<br>1=>High | SpectralLineL1<br>180Hz | ... | SpectralLineL32<br>11340Hz |
|---|---|---|---|---|

HASI_L2_PWAD3_AC_VLF.TAB/LBL

| Time[ms] | GainMode<br>0=>Low<br>1=>High | SpectralLineL1<br>720Hz | ... | SpectralLineL14<br>10080Hz |
|---|---|---|---|---|

HASI_L2_PWAS_AC_VLF.TAB/LBL

| Time[ms] | GainMode<br>0=>Low<br>1=>High | SpectralLineL1<br>720Hz | ... | SpectralLineL14<br>10080Hz |
|---|---|---|---|---|

Mutual Impedance Probe

HASI_L2_PWAD23_MIP.TAB/LBL

| Time[ms] | OperatingMode<br>1=>45HzTxHRxH<br>2=>45HzTxMRxH<br>3=>45HzTxLRxH<br>4=>45HzTxHRxL<br>5=>45HzTxMRxL | Amplitude RealPart [LSB] | Amplitude ImagPart [LSB] | Amplitude Standard Deviation RealPart [LSB] | Amplitude Standard Deviation ImagPart [LSB] | Spectral Line L1 90Hz | … | Spectral Line L102 9180Hz |
|---|---|---|---|---|---|---|---|---|

HASI_L2_PWAS_MIP.TAB/LBL

| Time[ms] | OperatingMode<br>1=>45HzTxHRxH<br>6=>90HzTxHRxH<br>7=>360HzTxHRxH<br>8=>1440HzTxHRxH<br>9=>5760HzTxHRxH | Amplitude RealPart [LSB] | Amplitude ImagPart [LSB] | Amplitude Standard Deviation RealPart [LSB] | Amplitude Standard Deviation ImagPart [LSB] | Spectral Line L1 90Hz | … | Spectral Line L102 9180Hz |
|---|---|---|---|---|---|---|---|---|

Lightning

HASI_L2_PWAD23_LGH.TAB/LBL

| Time [ms] | Freq-L [Hz] | Bw-L[Hz] | L1 | ... | L40 | Freq-M [Hz] | Bw-M[Hz] | L1 | ... | L40 | Freq-H [Hz] | Bw-H[Hz] | L1 | ... | L40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

HASI_L2_PWAS_LGH.TAB/LBL

| Time [ms] | Freq-L [Hz] | Bw-L[Hz] | L1 | ... | L40 | Freq-M [Hz] | Bw-M[Hz] | L1 | ... | L40 | Freq-H [Hz] | Bw-H[Hz] | L1 | ... | L40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

Freq–x=>FrequencyLow,Medium,High

Bw–x=>BandwidthLow,Medium,High

L1-L40=>SpectralLineL1-L40

ELF Field

HASI_L2_PWAD2_AC_ELF.TAB/LBL

| Time[ms] | SpectralLineL1 6Hz | ... | SpectralLineL16 96Hz |
|---|---|---|---|

HASI_L2_PWAD3_AC_ELF.TAB/LBL

| Time[ms] | SpectralLineL1 10.5Hz | ... | SpectralLineL8 94.5Hz |
|---|---|---|---|

HASI_L2_PWAS_AC_ELF.TAB/LBL

| Time[ms] | SpectralLineL1 10.5Hz | ... | SpectralLineL8 94.5Hz |
|---|---|---|---|

Acoustic

HASI_L2_PWAD3_ACU.TAB/LBL

| Time [ms] | L1 | … | L14 | burst f Low | burst wd Low | L1 | … | L10 | Burst f High | Burst wd High | L1 | … | L10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

HASI_L2_PWAS_ACU.TAB/LBL

| Time [ms] | L1 | … | L14 | burst f Low | burst wd Low | L1 | … | L10 | Burst f High | Burst wd high | L1 | … | L10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

Burst f => Burst frequency Low and High

Burst bd => Burst Bandwidth Low, High

L1-L10 and L1-L14 => Spectral Line L1-L10 and L1-L14

Radar

HASI_L2_PWAD3_F52_RAU.TAB /LBL

| Time [ms] | L1 [Hz] | … | L52 [Hz] |
|---|---|---|---|

1 + 2 x 52 columns

1x

| L1 [Hz] | … | L52 [Hz] |
|---|---|---|

HASI_L2_PWAD3_F26_RAU.TAB /LBL

| Time [ms] | L1 [Hz] | … | L26 [Hz] |
|---|---|---|---|

1 + 4 x 26 columns

2x

| L1 [Hz] | … | L26 [Hz] |
|---|---|---|

HASI_L2_PWAD3_F13_RAU.TAB /LBL

| Time [ms] | L1 [Hz] | … | L13 [Hz] |
|---|---|---|---|

1 + 8 x 13 columns

4x

| L1 [Hz] | … | L13 [Hz] |
|---|---|---|

HASI_L2_PWAD3_F0_RAU.TAB /LBL

| Time [ms] | T1 [ms] | … | T104 [ms] |
|---|---|---|---|

1 + 104 columns

*LEVEL 3 To be defined (TBD)*

### 4.1.5 HK subdirectory

The following files will be inserted in this subdirectory (naming convention as from §3.1.4). In what follow it is reported the file name and a schematic structure of the content of the table:

HASI_L2_DPU_TEMP.TAB/LBL

| Time [ms] | Voltage [V] |
|---|---|

HASI_L3_DPU_TEMP.TAB/LBL

| Time [ms] | Temperature [K] |
|---|---|

HASI_L2_DPU_EVENT.TAB/LBL

| Time [ms] | Event |
|---|---|

### 4.1.6 PROFILES (higher level products)

The following files are expected to be inserted in this subdirectory (naming convention as from §3.1.4). In what follow it is reported the file name and a schematic structure of the content of the table:
These data files are relevant to higher level products deduced from HASI direct and/or derived measurements.
The **atmospheric vertical profile** in terms of **pressure**, **temperature**, and **density** as derived from accelerometric data during entry and direct pressure and temperature during the descent.

HASI_L4_ATMO_PROFILE_ENTRY.TAB

| Time [ms] | Altitude [m] | pressure [Pa] | temperature [K] | density [kg/m3] |
|---|---|---|---|---|

HASI_L4_ATMO_PROFILE_DESCEN.TAB

| Time [ms] | Altitude [m] | pressure [Pa] | temperature [K] | density [kg/m3] |
|---|---|---|---|---|

**Trajectory** in terms of **vertical velocity** and **altitude** profiles

HASI_L4_VELOCITY_PROFILE.TAB

| Time [ms] | Altitude [m] | velocity [m/s] | *Ref sensor* |
|---|---|---|---|

HASI_L4_ALTITUDE_PROFILE.TAB

| Time [ms] | Altitude [m] | *Ref sensor* |
|---|---|---|

**N.B.** The **TIME** reported in the first column is the **mission time** (DDB time) expressed in milliseconds [ms] starting from Probe switch on, reset to 0 at T0.

## 4.2 Data Product Design

Data files as included in the different subdirectories of the DATA directory are listed as for the data products defined in table 7.
For each file it is reported numbering, filename, type, no of columns, a brief description of the content and the relevant mission phase.

**ACC engineering and scientific data**

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 1 | HASI_L2_ACCE_SERVO.TAB/LBL | TAB/LBL | 4 | ACC XServo acceleration engineering data | ENTRY |
| 2 | HASI_L2_ACCE_SERVOSTD.TAB/LBL | TAB/LBL | 4 | ACC Xservo acceleration engineering statistic data | ENTRY |
| 3 | HASI_L2_ACCE_SERVOTEM.TAB/LBL | TAB/LBL | 2 | ACC Xservo temperature engineering data | ENTRY |
| 4 | HASI_L2_ACCE_PIEZO.TAB/LBL | TAB/LBL | 4 | ACC X, Y, Z Piezo acceleration engineering data | ENTRY |
| 5 | HASI_L2_ACCE_PIEZOSTD.TAB/LBL | TAB/LBL | 4 | ACC X, Y, Z Piezo acceleration engineering statistic data | ENTRY |
| 6 | HASI_L2_ACCE_PIEZOTEM.TAB/LBL | TAB/LBL | 2 | ACC Piezos temperature engineering data | ENTRY |
| 7 | HASI_L3_ACCE_SERVO.TAB/LBL | TAB/LBL | 2 | ACC XServo acceleration scientific data | ENTRY |
| 8 | HASI_L3_ACCE_SERVOSTD.TAB/LBL | TAB/LBL | 2 | ACC Xservo acceleration scientific statistic data | ENTRY |
| 9 | HASI_L3_ACCE_SERVOTEM.TAB/LBL | TAB/LBL | 2 | ACC Xservo temperature scientific data | ENTRY |
| 10 | HASI_L3_ACCE_PIEZO.TAB/LBL | TAB/LBL | 4 | ACC X, Y, Z Piezo acceleration scientific data | ENTRY |
| 11 | HASI_L3_ACCE_PIEZOSTD.TAB/LBL | TAB/LBL | 4 | ACC X, Y, Z Piezo acceleration scientific statistic data | ENTRY |
| 12 | HASI_L3_ACCE_PIEZOTEM.TAB/LBL | TAB/LBL | 2 | ACC Piezos temperature scientific data | ENTRY |

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 13 | HASI_L2_ACCD_SERVO.TAB/LBL | TAB/LBL | 4 | ACC XServo acceleration engineering data | DESCENT |
| 14 | HASI_L2_ACCD_SERVOSTD.TAB/LBL | TAB/LBL | 4 | ACC Xservo acceleration engineering statistic data | DESCENT |
| 15 | HASI_L2_ACCD_SERVOTEM.TAB/LBL | TAB/LBL | 2 | ACC Xservo temperature engineering data | DESCENT |
| 16 | HASI_L2_ACCD_PIEZOSTD.TAB/LBL | TAB/LBL | 4 | ACC X, Y, Z Piezo acceleration engineering statistic data | DESCENT |
| 17 | HASI_L2_ACCD_PIEZOTEM.TAB/LBL | TAB/LBL | 2 | ACC Piezos temperature engineering data | DESCENT |
| 18 | HASI_L3_ACCD_SERVO.TAB/LBL | TAB/LBL | 2 | ACC XServo acceleration scientific data | DESCENT |
| 19 | HASI_L3_ACCD_SERVOSTD.TAB/LBL | TAB/LBL | 2 | ACC Xservo acceleration scientific statistic data | DESCENT |
| 20 | HASI_L3_ACCD_SERVOTEM.TAB/LBL | TAB/LBL | 2 | ACC Xservo temperature scientific data | DESCENT |
| 21 | HASI_L3_ACCD_PIEZOSTD.TAB/LBL | TAB/LBL | 4 | ACC X, Y, Z Piezo acceleration scientific statistic data | DESCENT |
| 22 | HASI_L3_ACCD_PIEZOTEM.TAB/LBL | TAB/LBL | 2 | ACC Piezos temperature scientific data | DESCENT |

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 23 | HASI_L2_ACCS_PIEZOIMP.TAB/LBL | TAB/LBL | 4 | ACC X, Y, Z Piezo acceleration engineering data | SURFACE |
| 24 | HASI_L3_ACCS_PIEZOIMP.TAB/LBL | TAB/LBL | 4 | ACC X, Y, Z Piezo acceleration data | SURFACE |

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 25 | HASI_L2_ACCS_SERVO.TAB/LBL | TAB/LBL | 4 | ACC XServo acceleration engineering data | SURFACE |
| 26 | HASI_L2_ACCS_SERVOSTD.TAB/LBL | TAB/LBL | 4 | ACC Xservo acceleration engineering statistic data | SURFACE |
| 27 | HASI_L2_ACCS_SERVOTEM.TAB/LBL | TAB/LBL | 2 | ACC Xservo temperature engineering data | SURFACE |
| 28 | HASI_L2_ACCS_PIEZOSTD.TAB/LBL | TAB/LBL | 4 | ACC X, Y, Z Piezo acceleration engineering statistic data | SURFACE |
| 29 | HASI_L2_ACCS_PIEZOTEM.TAB/LBL | TAB/LBL | 2 | ACC Piezos temperature engineering data | SURFACE |
| 30 | HASI_L3_ACCS_SERVO.TAB/LBL | TAB/LBL | 2 | ACC XServo acceleration scientific data | SURFACE |
| 31 | HASI_L3_ACCS_SERVOSTD.TAB/LBL | TAB/LBL | 2 | ACC Xservo acceleration scientific statistic data | SURFACE |
| 32 | HASI_L3_ACCS_SERVOTEM.TAB/LBL | TAB/LBL | 2 | ACC Xservo temperature scientific data | SURFACE |
| 33 | HASI_L3_ACCS_PIEZOSTD.TAB/LBL | TAB/LBL | 4 | ACC X, Y, Z Piezo acceleration scientific statistic data | SURFACE |
| 34 | HASI_L3_ACCS_PIEZOTEM.TAB/LBL | TAB/LBL | 2 | ACC Piezos temperature scientific data | SURFACE |

**ACC higher level products**

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 35 | HASI_L4_ACCE_ACC_VEL.TAB | TAB/LBL | 6 | **Acceleration** profile of the Huygens probe; **Velocity** expressed in Titan centric coordinates and **Altitude** as derived from trajectory reconstruction | ENTRY |
| 36 | HASI_L4_ACCE_DENSITY.TAB | TAB/LBL | 3 | **Density** profile as derived from acceleration profile | ENTRY |
| 37 | HASI_L4_ACCD_ALT_VEL.TAB | TAB/LBL | 5 | **Altitude** and vertical **Velocity** profiles as derived from trajectory reconstruction during descent | DESCENT |

**TEM engineering and scientific data**

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 1 | HASI_L2_TEMD_FINE1.TAB/LBL | TAB/LBL | 8 | TEM 1 fine sensor engineering data | DESCENT |
| 2 | HASI_L2_TEMD_COARSE1.TAB/LBL | TAB/LBL | 8 | TEM 1 coarse sensor engineering data | DESCENT |
| 3 | HASI_L2_TEMD_FINE2.TAB/LBL | TAB/LBL | 8 | TEM 2 fine sensor engineering data | DESCENT |
| 4 | HASI_L2_TEMD_COARSE2.TAB/LBL | TAB/LBL | 8 | TEM 2 coarse sensor engineering data | DESCENT |
| 5 | HASI_L3_TEMD_FINE1.TAB/LBL | TAB/LBL | 3 | TEM 1 fine sensor scientific data | DESCENT |
| 6 | HASI_L3_TEMD_COARSE1.TAB/LBL | TAB/LBL | 3 | TEM 1 coarse sensor scientific data | DESCENT |
| 7 | HASI_L3_TEMD_FINE2.TAB/LBL | TAB/LBL | 3 | TEM 2 fine sensor scientific data | DESCENT |
| 8 | HASI_L3_TEMD_COARSE2.TAB/LBL | TAB/LBL | 3 | TEM 2 coarse sensor scientific data | DESCENT |

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 9 | HASI_L2_TEMS_FINE1.TAB/LBL | TAB/LBL | 8 | TEM 1 fine sensor engineering data | SURFACE |
| 10 | HASI_L2_TEMS_COARSE1.TAB/LBL | TAB/LBL | 8 | TEM 1 coarse sensor engineering data | SURFACE |
| 11 | HASI_L2_TEMS_FINE2.TAB/LBL | TAB/LBL | 8 | TEM 2 fine sensor engineering data | SURFACE |
| 12 | HASI_L2_TEMS_COARSE2.TAB/LBL | TAB/LBL | 8 | TEM 2 coarse sensor engineering data | SURFACE |
| 13 | HASI_L3_TEMS_FINE1.TAB/LBL | TAB/LBL | 3 | TEM 1 fine sensor scientific data | SURFACE |
| 14 | HASI_L3_TEMS_COARSE1.TAB/LBL | TAB/LBL | 3 | TEM 1 coarse sensor scientific data | SURFACE |
| 15 | HASI_L3_TEMS_FINE2.TAB/LBL | TAB/LBL | 3 | TEM 2 fine sensor scientific data | SURFACE |
| 16 | HASI_L3_TEMS_COARSE2.TAB/LBL | TAB/LBL | 3 | TEM 2 coarse sensor scientific data | SURFACE |

**TEM higher level products**

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 17 | HASI_L4_TEM_TEMPERATURE_D.TAB/LBL | TAB/LBL | 5 | **TEM temperature** profile; values corrected for instrumental response effects and dynamical effects | DESCENT & SURFACE |

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**PPI engineering and scientific data**

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 1 | HASI_L2_PPID_NSA.TAB/LBL | TAB/LBL | 3 | PPI Normal Session A engineering data | DESCENT |
| 2 | HASI_L2_PPID_NSB.TAB/LBL | TAB/LBL | 3 | PPI Normal Session B engineering data | DESCENT |
| 3 | HASI_L2_PPID_NSC.TAB/LBL | TAB/LBL | 3 | PPI Normal Session C engineering data | DESCENT |
| 4 | HASI_L2_PPID_HCA.TAB/LBL | TAB/LBL | 3 | PPI Health Check A engineering data | DESCENT |
| 5 | HASI_L2_PPID_HCB.TAB/LBL | TAB/LBL | 3 | PPI Health Check B engineering data | DESCENT |
| 6 | HASI_L2_PPID_HK.TAB/LBL | TAB/LBL | 4 | PPI Housekeeping engineering data | DESCENT |

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 7 | HASI_L3_PPID_NSA11P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session A channel 11 pressure | DESCENT |
| 8 | HASI_L3_PPID_NSA13P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session A channel 13 temperature | DESCENT |
| 9 | HASI_L3_PPID_NSA16P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session A channel 16 pressure | DESCENT |
| 10 | HASI_L3_PPID_NSA18P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session A channel 18 pressure | DESCENT |
| 11 | HASI_L3_PPID_NSA21P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session A channel 21 pressure | DESCENT |
| 12 | HASI_L3_PPID_NSA23P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session A channel 23 temperature | DESCENT |
| 13 | HASI_L3_PPID_NSA27P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session A channel 27 pressure | DESCENT |
| 14 | HASI_L3_PPID_NSA28P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session A channel 28 pressure | DESCENT |
| 15 | HASI_L3_PPID_NSA33P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session A channel 33 temperature | DESCENT |
| 16 | HASI_L3_PPID_NSA37P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session A channel 37 pressure | DESCENT |
| 17 | HASI_L3_PPID_NSA38P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session A channel 38 pressure | DESCENT |

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 18 | HASI_L3_PPID_NSB11P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session B channel 11 pressure | DESCENT |
| 19 | HASI_L3_PPID_NSB13P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session B channel 13 temperature | DESCENT |
| 20 | HASI_L3_PPID_NSB16P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session B channel 16 pressure | DESCENT |
| 21 | HASI_L3_PPID_NSB18P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session B channel 18 pressure | DESCENT |
| 22 | HASI_L3_PPID_NSB21P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session B channel 21 pressure | DESCENT |
| 23 | HASI_L3_PPID_NSB23P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session B channel 23 temperature | DESCENT |
| 24 | HASI_L3_PPID_NSB27P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session B channel 27 pressure | DESCENT |
| 25 | HASI_L3_PPID_NSB28P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session B channel 28 pressure | DESCENT |
| 26 | HASI_L3_PPID_NSB33P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session B channel 33 temperature | DESCENT |
| 27 | HASI_L3_PPID_NSB37P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session B channel 37 pressure | DESCENT |
| 28 | HASI_L3_PPID_NSB38P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session B channel 38 pressure | DESCENT |

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 29 | HASI_L3_PPID_NSC11P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session C channel 11 pressure | DESCENT |
| 30 | HASI_L3_PPID_NSC13P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session C channel 13 temperature | DESCENT |
| 31 | HASI_L3_PPID_NSC16P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session C channel 16 pressure | DESCENT |
| 32 | HASI_L3_PPID_NSC18P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session C channel 18 pressure | DESCENT |
| 33 | HASI_L3_PPID_NSC21P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session C channel 21 pressure | DESCENT |
| 34 | HASI_L3_PPID_NSC23P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session C channel 23 temperature | DESCENT |
| 35 | HASI_L3_PPID_NSC27P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session C channel 27 pressure | DESCENT |
| 36 | HASI_L3_PPID_NSC28P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session C channel 28 pressure | DESCENT |
| 37 | HASI_L3_PPID_NSC33P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session C channel 33 temperature | DESCENT |
| 38 | HASI_L3_PPID_NSC37P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session C channel 37 pressure | DESCENT |
| 39 | HASI_L3_PPID_NSC38P.TAB/LBL | TAB/LBL | 2 | PPI Normal Session C channel 38 pressure | DESCENT |

**PPI higher level products**

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 40 | HASI_L4_PPI_PRESSURE_VEL.TAB /LBL | TAB/LBL | 6 | PPI **total** and **ambient pressure**, **descent velocity**, and **altitude** profiles | DESCENT & SURFACE |

**PWA engineering and scientific data**

| # | Filename | type | #columns | description | missionphase |
|---|---|---|---|---|---|
| 1 | HASI_L2_PWAD23_RP.TAB | TAB/LBL | 99 | PWA Relaxation Probe RP engineering data | DESCENT2-3 |
| 2 | HASI_L2_PWAD2_AC_VLF.TAB | TAB/LBL | 34 | PWA AC VLF Field engineering data | DESCENT2 |
| 3 | HASI_L2_PWAD3_AC_VLF.TAB | TAB/LBL | 16 | PWA AC VLF Field engineering data | DESCENT3 |
| 4 | HASI_L2_PWAS_AC_VLF.TAB | TAB/LBL | 16 | PWA AC VLF Field engineering data | SURFACE |
| 5 | HASI_L2_PWAD23_LGH.TAB | TAB/LBL | 127 | PWA Lightning mode engineering data | DESCENT2-3 |
| 6 | HASI_L2_PWAS_LGH.TAB | TAB/LBL | 127 | PWA Lightning mode engineering data | SURFACE |
| 7 | HASI_L2_PWAD23_MIP.TAB | TAB/LBL | 108 | PWA Mutual Impedance engineering data | DESCENT2-3 |
| 8 | HASI_L2_PWAS_MIP.TAB | TAB/LBL | 108 | PWA Mutual Impedance engineering data | SURFACE |
| 9 | HASI_L2_PWAD2_AC_ELF.TAB | TAB/LBL | 17 | PWA AC ELF Field engineering data | DESCENT2 |
| 10 | HASI_L2_PWAD3_AC_ELF.TAB | TAB/LBL | 9 | PWA AC ELF Field engineering data | DESCENT3 |
| 11 | HASI_L2_PWAS_AC_ELF.TAB | TAB/LBL | 9 | PWA AC ELF Field engineering data | SURFACE |
| 12 | HASI_L2_PWAD3_ACU.TAB | TAB/LBL | 39 | PWA Acoustic engineering data | DESCENT |
| 13 | HASI_L2_PWAS_ACU.TAB | TAB/LBL | 39 | PWA Acoustic engineering data | SURFACE |
| 14 | HASI_L2_PWAD3_F0_RAU.TAB | TAB/LBL | 105 | PWA Radar Altimeter engineering data | DESCENT3 |
| 15 | HASI_L2_PWAD3_F13_RAU.TAB | TAB/LBL | 105 | PWA Radar Altimeter engineering data | DESCENT3 |
| 16 | HASI_L2_PWAD3_F26_RAU.TAB | TAB/LBL | 105 | PWA Radar Altimeter engineering data | DESCENT3 |
| 17 | HASI_L2_PWAD3_F52_RAU.TAB | TAB/LBL | 105 | PWA Radar Altimeter engineering data | DESCENT3 |

| # | Filename | type | #columns | description | missionphase |
|---|---|---|---|---|---|
| 18 | HASI_L3_PWAD23_RP.TAB | TAB/LBL | 99 | PWA Relaxation Probe RP scientific data | DESCENT2-3 |
| 19 | HASI_L3_PWAD2_AC_VLF.TAB | TAB/LBL | 34 | PWA AC VLF Field scientific data | DESCENT2 |
| 20 | HASI_L3_PWAD3_AC_VLF.TAB | TAB/LBL | 16 | PWA AC VLF Field scientific data | DESCENT3 |
| 21 | HASI_L3_PWAS_AC_VLF.TAB | TAB/LBL | 16 | PWA AC VLF Field scientific data | SURFACE |
| 22 | HASI_L3_PWAD23_LGH.TAB | TAB/LBL | 127 | PWA Lightning mode scientific data | DESCENT2-3 |
| 23 | HASI_L3_PWAS_LGH.TAB | TAB/LBL | 127 | PWA Lightning mode scientific data | SURFACE |
| 24 | HASI_L3_PWAD23_MIP.TAB | TAB/LBL | 108 | PWA Mutual Impedance scientific data | DESCENT2-3 |
| 25 | HASI_L3_PWAS_MIP.TAB | TAB/LBL | 108 | PWA Mutual Impedance scientific data | SURFACE |
| 26 | HASI_L3_PWAD2_AC_ELF.TAB | TAB/LBL | 17 | PWA AC ELF Field scientific data | DESCENT2 |
| 27 | HASI_L3_PWAD3_AC_ELF.TAB | TAB/LBL | 9 | PWA AC ELF Field scientific data | DESCENT3 |
| 28 | HASI_L3_PWAS_AC_ELF.TAB | TAB/LBL | 9 | PWA AC ELF Field scientific data | SURFACE |
| 29 | HASI_L3_PWAD23_ACU.TAB | TAB/LBL | 39 | PWA Acoustic scientific data | DESCENT2-3 |
| 30 | HASI_L3_PWAS_ACU.TAB | TAB/LBL | 39 | PWA Acoustic scientific data | SURFACE |
|  | HASI_L3_PWAD_RAU.TAB | TAB/LBL |  | PWA Radar Altimeter scientific data | DESCENT3 |

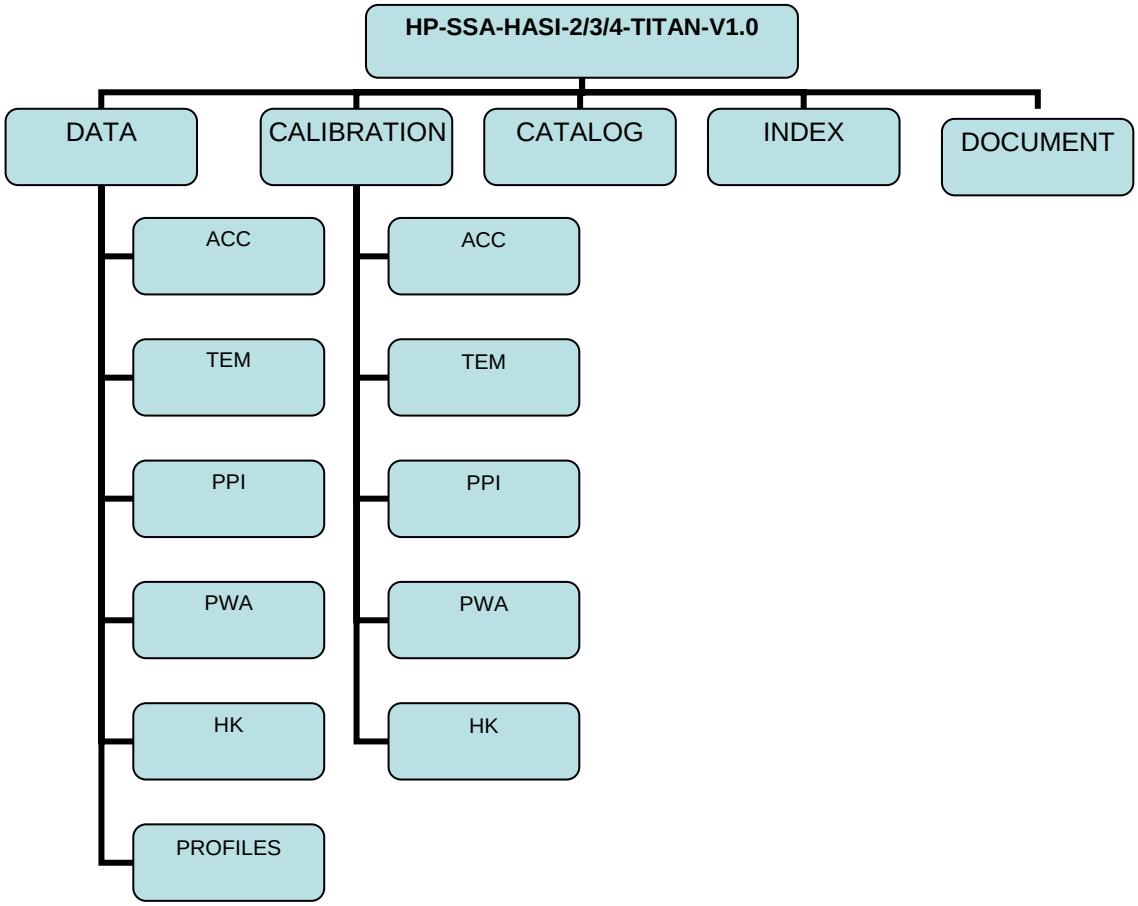
**HASI_HK**

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 1 | HASI_L2_DPU_TEMPERATURE.TAB/LBL | TAB/LBL | 2 | DPU internal temperature engineering data | ALL MISSION |
| 2 | HASI_L3_DPU_TEMPERATURE.TAB/LBL | TAB/LBL | 2 | DPU internal temperature scientific data | ALL MISSION |
| 3 | HASI_L2_DPU_EVENTS.TAB/LBL | TAB/LBL | 2 | HASI DPU events | ALL MISSION |

**PROFILES (higher level products)**

| # | Filename | type | # columns | description | mission phase |
|---|---|---|---|---|---|
| 1 | HASI_L4_ATMO_PROFILE_ENTRY.TAB/LBL | TAB/LBL | 5 | **Atmospheric vertical profile**:**pressure**, **temperature**, and **density** as function of altitude (as derived from accelerometric data) | ENTRY |
| 2 | HASI_L4_ATMO_PROFILE_DESCEN.TAB/LBL | TAB/LBL | 5 | **Atmospheric vertical profile** in terms of **pressure**, **temperature**, and **density** as function of altitude (as derived from T and p meas.) | DESCENT |
| 3 | HASI_L4_VELOCITY_PROFILE.TAB/LBL | TAB/LBL | 4 | Probe **vertical velocity** profile | ENTRY&DESCENT |
| 4 | HASI_L4_ALTITUDE_PROFILE. TAB/LBL | TAB/LBL | 4 | **Altitude** profile | ENTRY&DESCENT |

## Appendix 1: Data set organization (flow chart)



## Appendix 2: Available Software to read PDS files

N/A

## Appendix 3: Auxiliary Data Usage

Table 8 HASI timelines and events during Huygens mission at Titan

| HASI | Mission Time (SPC Time) | Mission Time [ms] | Event | |
|---|---|---|---|---|
| | | | HASI ON | |
| 9:01:17.453 | 4:19:44.500 | 15584500 | first ACC pck (after resets) | T0-9min |
| 9:05:52.523 | | | NASA Cassini NAV entry state | |
| 9:07:45.953 | 4:26:13.000 | 15973000 | ACC range coarse | |
| 9:09:07.488 | 4:27:34.535 | 16054535 | max acc | T0-73.340s |
| 9:10:14.453 | 4:28:41.500 | *16121500* | *S0 (CASU detection 10 m/s2)* | ACCXservo=9.645 m/s2 |
| **9:10:20.828** | **4:28:47.875** | **16127875** | **T0 (PDD firing)** | T0=S0+6.375s |
| 9:10:21.078 | 0:00:00.250 | 250 | *Pilot chute deployment & inflation* | T0+0.25s |
| 9:10:22.113 | 0:00:01.285 | 1285 | Pilot chute ACC peak | T0+1.285s |
| 9:10:23.328 | 0:00:02.500 | 2500 | *Back cover release, main chute deployment & inflation* | T0+2.5s |
| 9:10:25.313 | 0:00:04.485 | 4485 | Main chute deployment | T0+4.485s |
| 9:10:30.828 | 0:00:10.000 | 10000 | Tdata=T0+10s | T0+10s |
| 9:10:53.328 | 0:00:32.500 | 32500 | *frontshield jettison* | T0+32.5s |
| 9:11:20.828 | 0:01:00.000 | 60000 | 1st BOOM release attempt start | Td1 MCA sequence |
| 9:11:23.578 | 0:01:02.750 | 62750 | 1st BOOM release attempt end | Td1w |
| 9:12:40.828 | 0:02:20.000 | 140000 | 2nd BOOM release attempt start | Td2 |
| 9:12:43.578 | 0:02:22.750 | 142750 | 2nd BOOM release attempt end | |
| 9:12:50.828 | 0:02:30.000 | 150000 | PWA mode A | TdataH=T0+2.5min |
| 9:25:20.828 | 0:15:00.000 | 900000 | *Main chute jettison, stabiliser deployment & inflation* | T0+15min |
| 9:42:50.828 | | 1950000 | RADAR sampling, PWA mode C | Tradar=T0+32.5min |
| 10:25:28:028 | 1:15:07.200 | 4507200 | PPI Medium p mode (session B) | Tpmed=T0+1:15:00 |
| 10.55.26.828 | 1:45:06.000 | 6306000 | PPI High p mode (session C) | Tphigh=T0+1:45:00 |
| 11:16:18.577 | 2:05:57.749 | 7757749! | PWA mode D | DDB 7 km |
| 11:34:57.078 | 2:24:36.250 | 8676250 | last km | last km |
| **11:38:10.668** | **2:27:49.840** | **8869840** | **Impact detection** | **Timpact** |
| 12:10:20.828 | 3:00:00.000 | 10800000 | autoreset/ last HASI data | SW reset |

Table 9 HASI DPU Event description

| ***DDB EVENTS*** | ***DESCRIPTION*** |
|---|---|
| T0 | T0 transition according to the DDB line flag. |
| AUTORESET | It indicates that the HASI Instrument has been switched ON according to the automatic reset sequence. |
| DDBL Time Wrong | It indicates that the DDBLtime is not monotone (two consecutive DDB cuts have Mission time difference greater than 2 s). |
| TIMPACT | Time instant when HASI recognizes the Probe Impact by ACC Xservo data elaboration (filter). |
| DDBL nok line A | When the DDB line layout test results unsuccessfully completed on CDMU line A. |
| DDBL nok line B | When the DDB line layout test results unsuccessfully completed on CDMU line B. |
| ***TC EVENTS*** | |
| UNKNOWN TC | When a TC is correctly received, but has an unknown Command Header. |
| TC RX incorrect | Telecommand received incorrectly |
| ***SENSORS EVENTS*** | |
| PWA LINK ERROR | The PWA DB is checked against its protocol and the following Event data are hereafter reported:<br>- Invalid Packet ID - Invalid Sequence count<br>- Invalid Packet length - Invalid Packet error control<br>- Invalid Data Field Header - Time-out. |
| MCA READOUT | The message reports the Energize status, MCA1 and MCA2 activation status during Booms deployment. |
| PPI RANGE FAIL | The message is issued when the Y-value calculation is out of the expected range. |
| PPI Time-out | The message is issued when a frequency measure of a PPI channel is lower than 1khz. |
| ADC1 FAILURE | When the ACCelerometer Analog to Digital Converter does not provide the End Of Conversion. |
| ADC2 FAILURE | When the TEM and HK Analog to Digital Converter does not provide the End Of Conversion. |
| ACC range set COARSE | The ACC Xservo range changes from FINE (HIGH gain) to COARSE (LOW gain). |
| ***EEPROM EVENTS*** | |
| EEPROM LATCH-UP | It is part of the nominal switch-ON/OFF sequence of the EEPROM procedure. Nominally, it happens after the EEPROM SWITCHED OFF message. In the case it happens before, a hardware latch-up has occured when using EEPROM and its content and the next operations may result corrupted or incomplete. A severe latch-up may destroy the device itself. |
| EEPROM SWITCHED | The message has two event data: 0 (OFF) and 1 (ON). Before any read/write operation the EEPROM must be switched on (EEPROM SWITCHED-ON) and then shall be switched OFF EEPROM SWITCHED-OFF). |
| EEPROM LOCKED | It refers to the EEPROM overwrite capability. |

## Appendix 4: Example of Directory Listing of Data Set

### HP-SSA-HASI-2/3/4-MISSION-V1.0

\DATA

\ACC

HASI_L2_ACCE_SERVO.TAB/LBL
HASI_L2_ACCE_SERVOSTD.TAB/LBL
HASI_L2_ACCE_SERVOTEM.TAB/LBL
HASI_L2_ACCE_PIEZO.TAB/LBL
HASI_L2_ACCE_PIEZOSTD.TAB/LBL
HASI_L2_ACCE_PIEZOTEM.TAB/LBL
HASI_L3_ACCE_SERVO.TAB/LBL
HASI_L3_ACCE_SERVOSTD.TAB/LBL
HASI_L3_ACCE_SERVOTEM.TAB/LBL
HASI_L3_ACCE_PIEZO.TAB/LBL
HASI_L3_ACCE_PIEZOSTD.TAB/LBL
HASI_L3_ACCE_PIEZOTEM.TAB/LBL
HASI_L2_ACCD_SERVO.TAB/LBL
HASI_L2_ACCD_SERVOSTD.TAB/LBL
HASI_L2_ACCD_SERVOTEM.TAB/LBL
HASI_L2_ACCD_PIEZOSTD.TAB/LBL
HASI_L2_ACCD_PIEZOTEM.TAB/LBL
HASI_L3_ACCD_SERVO.TAB/LBL
HASI_L3_ACCD_SERVOSTD.TAB/LBL
HASI_L3_ACCD_SERVOTEM.TAB/LBL
HASI_L3_ACCD_PIEZOSTD.TAB/LBL
HASI_L3_ACCD_PIEZOTEM.TAB/LBL
HASI_L2_ACCS_PIEZOIMP.TAB/LBL
HASI_L3_ACCS_PIEZOIMP.TAB/LBL
HASI_L2_ACCS_SERVO.TAB/LBL
HASI_L2_ACCS_SERVOSTD.TAB/LBL
HASI_L2_ACCS_SERVOTEM.TAB/LBL
HASI_L2_ACCS_PIEZOSTD.TAB/LBL
HASI_L2_ACCS_PIEZOTEM.TAB/LBL
HASI_L3_ACCS_SERVO.TAB/LBL
HASI_L3_ACCS_SERVOSTD.TAB/LBL
HASI_L3_ACCS_SERVOTEM.TAB/LBL
HASI_L3_ACCS_PIEZOSTD.TAB/LBL
HASI_L3_ACCS_PIEZOTEM.TAB/LBL
HASI_L4_ACCE_ACC_VEL.TAB
HASI_L4_ACCE_DENSITY.TAB