HASI PPI Data Processing and Calibration Report

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1. Acronyms

C	Constant
DPU	Data Processing Unit
HC	Health-Check
N	Normal
P	Pressure
PPI	Pressure Profile Instrument
R	Reference
T	Temperature

2. Scope of the document

Scope of the document is to report on the procedure and results of the calibration of the HASI PPI (Pressure Profile Instrument) subsystem and to present guidelines for data processing and the reconstruction of the pressure measurement.

3. Applicable and Reference documents

[AD1] Cassini Mission Huygens Probe Huygens Atmospheric Structure Instrument – HASI PPI Flight Model Acceptance Data Package (PPI FM ADP) E.I.D.P. HASI-FMI-FM-DOC-009 30/03/1995 1 (II/210.B.6)

[AD2] HASI Experiment Flight User Manual Document HASI-MA-OG-002 Issue 3, 1 December 1998 (II/196.B.6)

[AD3] HASI DPU Software User Requirements Document HASI-SP-OG-004, Issue 7, 7 Sep 1995 (II/179.B.1)

[RD1] Mäkinen, T. **Processing the HASI measurements,** *Advances in Space Research,* **17**, Issue 11, 219-222, 1996

[RD2] Harri, A. M., B. Fagerström, A. Lehto, G. W. Leppelmeier, T. Mäkinen, R. Pirjola, T. Siikonen and T. Siili, **Scientific objectives and implementation of the Pressure Profile Instrument (PPI\HASI) for the Huygens spacecraft,** *Planetary and Space Science,* **46**, Issues 9-10, 1383-1392,1998.

4. PPI description

The *Pressure Profile Instrument* (**PPI**) 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 stem 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), constant (C) and reference (R) sensors (high stability capacitor, respectively 7C used for housekeeping and 6R 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).

Table 1. PPI characteristics and performance
(pressure profile with altitude).

Range: 0- 400 hPa	low pressure
0-1200 hPa	medium pressure
0-1600 hPa	high pressure

Resolution: <0.04% or +/- 0.005 hPa
Absolute accuracy: 1%

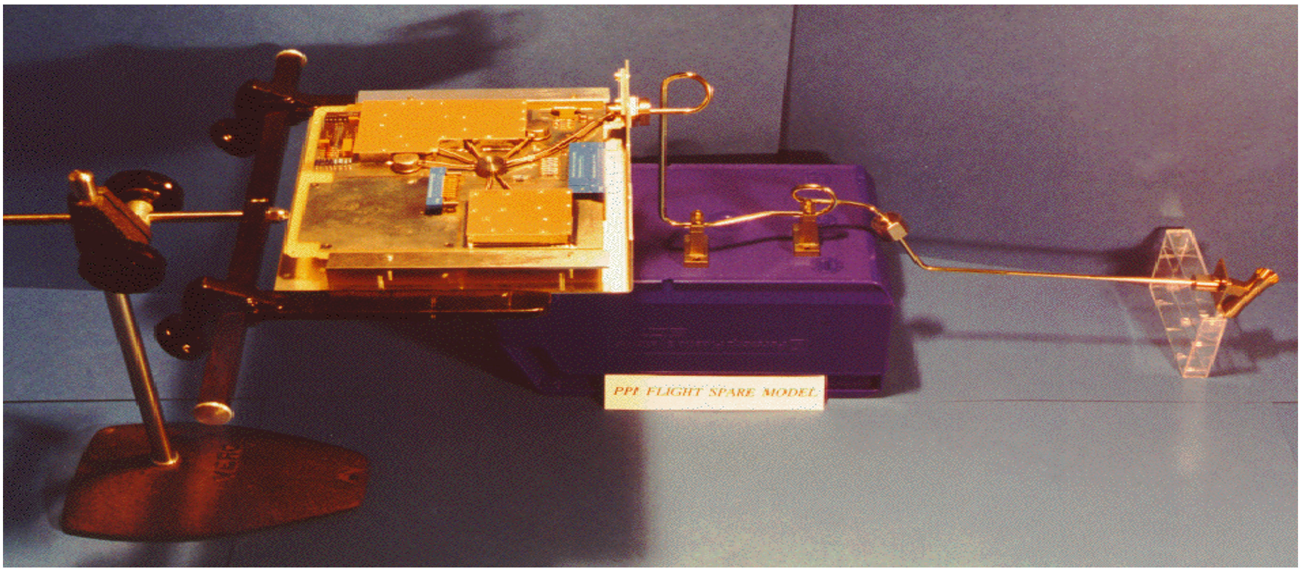

Fig. 1 The PPI subsystem

4.1. PPI location and accommodation

The PPI sensor heads and related electronics are located on the PPI board inside HASI DPU. The Kiel-type total pressure Pitot tube inlet (Kiel probe) is mounted at the tip of the STUB stem and a sectioned tube conveys the external pressure to the sensor heads inside Huygens.

4.2. Measurement principle and data sampling

The PPI pressure transducer is a variant of the silicon capacitive absolute pressure sensor (**Barocap**) produced by the Vaisala Co, Helsinki, Finland, for radiosondes flown on stratospheric balloons up to 40 km. The Barocap consists of a very small sensor head with associated transducer electronics. The varying ambient pressure bends a thin silicon diaphragm in the sensor head, causing changes in the head capacitance. That variation is converted into frequency in the PPI electronics. Two types of Barocap, characterised by different thickness of silicon diaphragm, are used. The thinner diaphragm is suitable for 10^{-3}-10^{2} hPa. The thicker diaphragm of the other Barocap completes the required range. In total there are 8 Barocaps.
The temperature is measured by Thermocap sensor for compensation. Thermocap technology is similar to that one of Barocap. There are 3 Thermocaps (one for each block)
Each Constant sensor is a high stability capacitor (7 constant capacitor in PPI). They are mainly used to check stability and performance of the PPI measurement system.
The Reference sensor heads are high stability capacitors (6 Reference in PPI). They provide a fixed capacitance to be used in the pressure measurement in combination with other sensors (ref. Eq. 1).
The sensors are grouped in three blocks (Multicap) each composed of eight frequency output channels.

Table 1 Pressure sensor layout

Block	channel	sensor type	name
1	1	Medium pressure	1.1P
	2	Reference	1.2R
	3	Temperature	1.3T
	4	Constant	1.4C
	5	Reference	1.5R
	6	Medium pressure	1.6P
	7	Constant	1.7C
	8	Medium pressure	1.8P
2	1	High pressure	2.1P
	2	Reference	2.2R
	3	Temperature	2.3T
	4	Constant	2.4C
	5	Reference	2.5R
	6	Constant	2.6C
	7	High pressure	2.7P
	8	High pressure	2.8P
3	1	Constant	3.1C
	2	Reference	3.2R
	3	Temperature	3.3T
	4	Constant	3.4C

5	Reference	3.5R
6	Constant	3.6C
7	Low pressure	3.7P
8	Low pressure	3.8P

High pressure sensors are capable to measure in the range 0..2000 hPa (e.g. whole pressure profile of Titan) and they are more sensitive and stable in the high part of the range. Low pressure sensors are more sensitive and stable in the low pressure range (e.g. 0..400 hPa). The Medium pressure heads behave as the high pressure heads except that their working range is limited to approximately 1400 hPa. They are mainly used to check the long term stability of the PPI.

The variable capacitance (P, T) and the constant capacitance (C, R) are transformed into a frequency variation by means of a stable oscillator (each block has a dedicated oscillator).
The pressure and temperature measurements consist of three samplings/measurements:
the frequency period of the selected sensor head and the frequency periods of the two Reference channels relevant to the sensor. Then the three samplings/measurements are combined together to provide the Yvalue:

$$Y=(S-R1(S))/(R2(S)-R1(S)) \qquad \text{Eq 1}$$

where:

- S is the period measurement of the sensor output frequency
- R1(S) is the period measurement of the 1st Reference channel of the block containing the sensor S. R1 is the reference channel of low frequency (high capacitance)
- R2(S) is the measurement of the 2nd Reference channel of highest frequency (lowest capacitance)
- Y is the compressed pressure data in the range [-1,+1]

The two PPI housekeeping voltages correspond respectively to the monitoring of the oscillators and multiplexer supply voltage (PPI HKV0) and PPI power supply voltage (PPI HKV1).

Pressure measurement is organized in a sequence of NORMAL and HEALTH-CHECK session as in the following 7-session basic cycle: [HC+N+N+N+HC+NN].

NORMAL session includes three different type (session A = LOW, session B = MEDIUM, session C = HIGH). Each is defined as a sequence {YSh} of 36 YSi statistical pressure data at a regular rate of 2 each 2.4s (2 items at 0.42 Hz). Two YSi data are obtained from 16 raw frequency measurements (periods). Each NORMAL session data is composed by the arithmetical average of five YSi values and their variance

HEALTH-CHECK session includes two different types (G and H). Each is defined as a sequence {Fh} of 37 frequency channel raw data (either sensor or reference) acquired every 5.17 s (7.16 Hz). Each Fi frequency raw data is the time corresponding to the measured frequency period. Each HEALTH-CHECK session data set is composed by 37 Fi values

4.3. Operational modes

HASI starts to sample PPI sensors at the beginning of the descent phase, starting from T0+10s (=Tdata) when the sensors are still under the front shield (front shield jettisoning at T0+32.5s) in order to get data during the transitional phase helping to connect entry and descent profiles.

PPI measurement is organized in sessions (ref §4.2) and divided in three phases:

Phase	session sequence	starting time (DDB time)
LOW pressure phase	G A A A H A A	Tdata=T0+10s
MEDIUM Pressure phase	G B B B H B B	Tmid=T0+75min
HIGH pressure phase	G C C C H C C	Thigh=T0+105min

The switching to different phases/modes is triggered by HASI timeline (predefined Tmid, Thigh).

PPI will keep going sampling, in high pressure mode, till the loss of the link.

The PPI channels polling tables for normal and health check session are reported in appendix A.

4.4. Telemetry output

PPI telemetry data are organized in telemetry (TM) packets per sessions plus a data format containg housekeeping voltages:

Data format	format name	content
#64	PPI session A	YSi statistical data of NORMAL session A (couples at 0.42 Hz)
#65	PPI session B	YSi statistical data of NORMAL session B (couples at 0.42 Hz)
#66	PPI session C	YSi statistical data of NORMAL session C (couples at 0.42 Hz)
#70	PPI HC session G	raw data Fi of HEALTH CHECK session G (at 6.7 Hz)
#71	PPI HC session H	raw data Fi of HEALTH CHECK session H (at 6.7 Hz)
#72	PPI HKV	housekeeping voltages 1 & 2 (HKV0 & HKV1) (averages over 64s, 32 sums at 0.5 Hz)

Each TM packet is time stamped with mission time (=native time) when the first data is written in Time relevant to each data value is derived from the packet time stamp and the PPI session sampling rate and scheme.

5. Pre-flight calibration

5.1. Static calibration

The static calibration for pressure sensors has been performed in two phases, the first one at high pressures (19 points . 0,100…1800mbar) and the second al low pressures (0, 5, 10, 15, 20, 30, 40, 65, 100, 150, 200, 300, 400, 500, 600, 700, 800, 900, atmosphere) both at temperatures between -45 and +55°C (10°C steps).
For temperature sensor calibration 13 temperature points between -45 and 75 °C (10°C steps).

For pressure sensors the primary calibration has been conducted at room temperature, furthermore long term stability has been verified and possible drifts have been observed in two pressure areas (in vacuum below 0.5 mbar and at atmospheric pressure , 970..1030 mbar).
Further tests have been conducted to verify sensitivity to acceleration, sensor hysteresis (not significant) effect, long tubing and leakage.
A discontinuity in the behaviour oh the low pressure Multicap 3 has been observed at high temperatures (above 55°C).

5.2. Dynamic calibration

The purpose is to verify PPI behaviour in dynamic conditions, with rising pressure during descent phase, and investigate possible problems as:

- High hysteresis
- Long time constant (of sensors or tubing)
- Effect of temperature gradient caused by "adiabatic process".

The results have shown that the deviation of any PPI pressure sensor does not increase more than 0,1% of the actual pressure (in the range 100-1000mbar).

6. In-flight Calibration

During the cruise phase HASI experiment and the Huygens probe have been switched on regularly for performing in-flight CheckOut (CO). These COs have been performed approximately every 6 months since launch, to test the probe and its subsystems during simulated entry, descent and surface proximity phases and also to upload SW patches.
PPI have been subjected to a test sequence during each CO, monitoring the pressure (and PPI board temperature) conditions inside Huygens. In space conditions (zero-g and vacuum) only temperature conditions varied due to the heating of the experiment platform due to CDMS working.
It is not possible to perform an in flight calibration since there is no a more accurate reference sensor. The only purpose was to check the status of the subsystem and sensors and eventually monitoring any drift and/or ageing effects.

7. Dynamic corrections on pressure measurements: Total to static pressure

Pressure measurements are relevant to total values and have to be corrected taking into account the dynamic conditions [RD2]:

Eq. 4

$$p_{stat} = p_{meas}\left(1+\frac{\gamma-1}{2}Ma^2\right)^{\frac{\gamma}{1-\gamma}}$$

Where p_{meas} are the values really measured by the sensors, $\gamma = {c_p}/{c_v}$ is the ratio of the specific heat constants, *Ma* is the Mach number.

The dynamic correction of the measured pressure profiles will be carried with an iterative method as from [RD2] and in [Fulchignoni et al 1997].

8. PPI total error budget

PPI total error budget in the pressure range 100…1000,bar *)				
Accuracy error item description	**Error (% of reading)**			**Remarks**
		RMS	**Straight SUM**	
Sensor accuracy	≤	**0,43**	**0,68**	Uncertainty caused by sensors & PPI electronics
Resolution	≤0,01			
Stability error (repeatability etc.)	≤0,1			
Uncertainty in temperature compensation	≤0,05			1°C total temperature measurement error (in temperature dependence compensation) can be partly compensated (manually)
Long term drift (without compensation)	≤0,4			
Hysteresis (without compensation)	≤0,02			
Sensor calibration error (-40≤ t ≤+50°C)	≤0,1			Reference uncertainty, modelling error
HASI DPU contributions		**0,02**	**0,02**	
Sampling error	≤0,002			Frequency meas. Accuracy 4,5Mhz, 100ms
Y-value calculation	≤0,02			Integer rounding error, 15bits
Error due to leakage	≤	**0,01**	**0,01**	
Total error (at laboratory conditions)	≤	**0,43**	**0,71**	Total pressure value
Calibration time error	≈	**0,05**	**0,05**	Uncertainty in RefP time constant & hyst.
Tubing errors		**0,01**	**0,01**	
Kiel probe effect	≤ 0			Verified to 40 deg. Attack angles
Uncompensated time lag (pressure delay)	≤ 0,01			Effect on long tubes
Total pressure → static pressure conversion	≤	**0,2**	**0,2**	Mach number determination error ≤ 1% for Mach number ≤0,3
Integration to DPU box uncompensated	≤ 0,1			Not included in sums
Effect of acceleration (uncompensated)	0,3 mbar			At 5g, not included in sums
Total pressure measurement error	≤	**0,48**	**0,97**	

Note: the errors are worst case values (usually at pressure near 400mbar) as from [AD1]

*) the complete operating range for PPI is 0…1800mbar
for pressures < 100mbar use accuracy at 100mbar
for pressures < 1000mbar use accuracy at 1000mbar

Uncertainty
The major component of the total error is systematic. The confidence limit for PPI is 1% or 1 hPa (whichever is better/smaller).

9. PPI data processing: Engineering value reconstruction

In every packet for every data format are contained:

Data Format:	Sensor	Data Field Content:
#64	Session#A	36 PPI statistics (YSI and variance) subfields of 24 bit each and two subfields of 16 bit (1 word) with reference values
#65	Session#B	36 PPI statistics (YSI and variance) subfields of 24 bit each and two subfields of 16 bit (1 word) with reference values
#66	Session#C	36 PPI statistics (YSI and variance) subfields of 24 bit each and two subfields of 16 bit (1 word) with reference values
#70	Session#G (health check)	37 PPI subfields (Fi) of 24 bit each
#71	Session#H (health check)	37 PPI subfields (Fi)of 24 bit each
#72	Housekeeping	28 PPI housekeeping voltages (HKV0, HKV1) subfields of 16 bit (1 word) each

The packet data field layout are:

For df #64,65,66

word 0	Y1a	Y0a
word 1	Y0b	Y2a
word 2	Y2b	Y1b
…	…	…
word 54	R1	
word 55	R2	

For data format #70 and #71

word 0	F1a	F0a
word 1	F0b	F2a
Word 2	F2b	F1b
…	…	…
word 55	UNUSED	F2z

For data format #72

word 0	HKV1a
word 1	HKV2a
Word 3	HKV1b
Word 4	HKV2b
…	…
word 55	HKV2z

9.1. Raw values extraction

The first step is the extraction of the sub-fields from the packet for each data format.

9.1.1. NORMAL Session (#A, #B, #C) raw data extraction

In data format #64 packets the first 54 words are divided in 36 subfields of 24 bit each.
Each datum of 24bit is obtained from the subfields Y2a,Y1a,Y0a. The first 8 bits are the variance and the other 16bits (Y value) are compressed pressure or temperature reading.
The sensor reading sequence is reported in [RD2] and in Appendix A.
Y_RawVal bit 15-0
Var_RawVal bit 23-16

The following 2 words are divided in 16 bit subfields and are reference value of R1 and R2.

R_RawVal bit 15-0

The same extraction procedure is used for data formats #65 (Session #B) and #66 (Session #C) (for sensor reading sequences Appendix A).

9.1.2. HEALTH CHECK Session (#G, #H) raw data extraction

In data format 70 packets are contained 56 words divided in 37 statistics subfields of 24 bit each. Each datum of 24bit is obtained by a sequence F2a, F1a, F0a. The sensor reading sequence (pressure, temperature and reference) is reported in Appendix A.

Y_HC_RawVal bit 23-0

the same extraction procedure is used for data formats 71 (Session #H), the sensor reading sequence is in Appendix A.

9.1.3. Housekeeping raw data extraction

In data format 72 packets are contained 56 words for raw housekeeping voltage values.

HK_RawVal bit 15-0

9.2. Raw values normalisation

Raw values for each sensor are normalised as follows.

9.2.1. NORMAL Session (#A, #B, #C) normalisation

Y_Norm_Val= RawVal
Var__Norm_Val= RawVal
R_ Norm_Val = 1/ R_RawVal

9.2.2. HEALTH CHECK Session (#G and #H) normalisation

Using Eq. 1(formula 3 page 105 HASI-MA -OG-002 issue 3 [AD2]):

Y_HC_Norm_Val= (S-R1)/(R2-R1)
in each block R1 and R2 are the reference channel readings for in each block (e.g. R1.5, R1.2 for block #1).

9.2.3. Housekeeping data normalisation

HK_Norm_Val = RawVal

9.3. Engineering conversion

For every sensor reported above the normalised value with sign is converted in engineering units.

9.3.1. NORMAL Session (#A, #B, #C) engineering conversions

Y_Eng_Val= 2^{-15} * P_Norm_Val
Var_Eng_Val= 2^{-18} * Var_Norm_Val
R_ Eng_Val = 4,5*10^{6}* R_Norm_Val

9.3.2. HEALTH CHECK Session (#G and #H) engineering conversions

Y_HC_Eng_Val= 4,5*10^{6}*2^{10}*Y_HC_Norm_Val

9.3.3. Housekeeping engineering conversion

HK_Norm_Val = 10*HK_Norm_Val/(2^{16}-1)

10. Scientific conversion of engineering values: Scientific reconstruction values for in flight CheckOuts

10.1. NORMAL Session (#A, #B, #C) conversion

T_Val =[(1/(a- Y_Eng_Val))-b]/c
T_Val_K=T_Val+ 273.16 Eq.2
P_Val= ((1/(A-Y_Eng_Val))+(K4 Y_Eng_Val^{4})+(K3* Y_Eng_Val^{3})+(K2* Y_Eng_Val^{2})-(O+TFFSET*T_Val)/(G+TGAIN*T_Val) Eq. 3
where T is expressed in Kelvin [K] and P in [hPa]

The calibration coefficients used in the above formulas are reported in Appendix B.

10.2. Health check Sessions (#G and #H) conversions

Same formulas for Nominal Sessions (#A,#B,#C)

11. Scientific conversion of engineering values: Scientific reconstruction values for Titan mission

11.1. NORMAL Session (#A, #B, #C) conversion

T_Val =[(1/(a- Y_Eng_Val))-b]/c

Y_c = Y_Eng_Val +Y_off Eq. 4

$$P\_Val = \sum_{i=1}^{3}\sum_{j=1}^{3} a_{ij} T\_Val^{(j-1)} \left(A - Y_c\right)^{-i} + \sum_{i=1}^{3}\sum_{j=1}^{4} K_{ij} T\_Val^{(i-1)} Y_c^{(j-1)} \quad \text{Eq. 5}$$

where T is expressed in Celsius [°C] and P in [hPa]

The calibration coefficients used in the above formulas are reported in Appendix C.

11.2. Health check Sessions (#G and #H) conversions

Same formulas for Nominal Sessions (#A,#B,#C)

12. Higher level products derivation

Starting from pressure measurements, **ambient pressure**, **velocity** and **altitude** profiles are retrieved through an iterative process (refer to [RD1, RD3]) using real gas equation, temperature (as measured by HASI TEM) and atmospheric mixing ratios (as provided by GCMS).

13. Appendixes

13.1. Appendix A: PPI channels polling tables

PPI Normal Session#A, #B, #C and Health Check Session #G, #H tables

Session#A	Session#B	Session#C	Session#G	Session#H
P1.1	P2.7	P1.1	R1.5	P1.1
P1.8	P2.8	P1.8	P1.1	P1.1
P3.7	P1.1	P2.7	P1.8	P1.1
P3.8	P1.8	P2.8	R1.2	P1.1
T1.3	T1.3	T1.3	P1.1	P1.1
P1.6	P1.6	P1.6	P1.8	P1.1
P3.7	P1.1	P2.7	R1.5	P1.1
P3.8	P1.8	P2.8	P1.1	P1.1
P1.1	P2.7	P1.1	R2.5	P1.1
P1.8	P2.8	P1.8	P2.7	P1.1
P3.7	P1.1	P2.7	P2.8	P1.1
P3.8	P1.8	P2.8	R2.2	P1.1
T2.3	T2.3	T2.3	P2.7	P1.1
P2.1	P2.1	P2.1	P2.8	P1.1
P3.7	P1.1	P2.7	R2.5	R1.2
P3.8	P1.8	P2.8	P2.7	T1.3

P1.1	P2.7	P1.1	P2.8	C1.4
P1.8	P2.8	P1.8	R3.5	R1.5
P3.7	P1.1	P2.7	P3.7	P1.6
P3.8	P1.8	P2.8	P3.8	C1.7
T3.3	T3.3	T3.3	R3.2	P1.8
C3.1	C3.1	C3.1	P3.7	P2.1
P3.7	P1.1	P2.7	P3.8	R2.2
P3.8	P1.8	P2.8	R3.5	T2.3
P1.1	P2.7	P1.1	P3.7	C2.4
P1.8	P2.8	P1.8	T1.3	R2.5
P3.7	P1.1	P2.7	C1.4	C2.6
P3.8	P1.8	P2.8	P1.6	P2.7
P2.7	P3.7	P3.7	C1.7	P2.8
P2.8	P3.8	P3.8	P2.1	C3.1
P3.7	P1.1	P2.7	T2.3	R3.2
P3.8	P1.8	P2.8	C2.4	T3.3
P1.1	P2.7	P1.1	C2.6	C3.4
P1.8	P2.8	P1.8	C3.1	R3.5
P3.7	P1.1	P2.7	T3.3	C3.6
P3.8	P1.8	P2.8	C3.4	P3.7
			C3.6	P3.8

Table 1 PPI session tables sensor sequences

P1.6 and P2.1 sensors measure the "housekeeping pressure" inside the DPU box.

13.2. Appendix B : Calibration for in flight CheckOuts

Scientific conversion coefficients

Block.Ch#	a	b	c
1.3	0.95520	4.34272	0.0239358
2.3	0.94665	3.35377	0.0182452
3.3	0.92365	2.52352	0.0137031

In ASCII format

[Sensor channel, a, b ,c]
1.3,0.95520,4.34272,0.0239358
2.3,0.94665,3.35377,0.0182452
3.3,0.92365,2.52352,0.0137031

Table 2 PPI temperature conversion coefficients

Block. Ch#	A	K4	K3	K2	G	O	TGAIN	TOFFSET
1.1	0.70933	0.576038	0.420474	0.222446	-0.0016989	3.11431	0.000000191	-0.000278
1.6	0.70944	0.913535	0.322299	0.243633	-0.0015446	3.20610	0.000000176	-0.000291
1.8	0.70900	0.509454	0.421665	0.227899	-0.0017922	3.11988	0.000000210	-0.000274
2.1	0.69483	0.260947	0.346241	0.207277	-0.0012719	2.91446	0.000000146	-0.000167
2.7	0.69070	0.369996	0.377318	0.211959	-0.0011483	2.88523	0.000000131	-0.000201
2.8	0.67356	0.352843	0.390846	0.222883	-0.0011488	2.87117	0.000000121	-0.000173
3.7	0.88774	-0.487971	0.080418	0.028051	0.0084094	1.16132	-0.000001127	-0.000274
3.8	0.88500	-0.130457	-0.286945	0.172239	0.0097982	1.23710	-0.000000834	-0.000392

In ASCII format

[Sensor channel, A, K4, K3, K2, G, O, TGAIN, TOFFSET]
1.1,0.70933,0.576038,0.420474,0.222446,-0.0016989,3.11431,0.000000191,-0.000278
1.6,0.70944,0.913535,0.322299,0.243633,-0.0015446,3.20610,0.000000176,-0.000291
1.8,0.70900,0.509454,0.421665,0.227899,-0.0017922,3.11988,0.000000210,-0.000274
2.1,0.69483,0.260947,0.346241,0.207277,-0.0012719,2.91446,0.000000146,-0.000167
2.7,0.69070,0.369996,0.377318,0.211959,-0.0011483,2.88523,0.000000131,-0.000201
2.8,0.67356,0.352843,0.390846,0.222883,-0.0011488,2.87117,0.000000121,-0.000173
3.7,0.88774,-0.487971,0.080418,0.028051,0.0084094,1.16132,-0.000001127,-0.000274
3.8,0.88500,-0.130457,-0.286945,0.172239,0.0097982,1.23710,-0.000000834,-0.000392

Table 3 PPI pressure conversion coefficients

Formulas:

Y_Val = (S-R1)/(R2-R1) Eq.1

T_Val =[(1/(a- Y_Eng_Val))-b]/c T_Val_K = T_Val + 273.16 Eq.2

P_Val= $((1/(A-Y\_Eng\_Val))+(K4\ Y\_Eng\_Val^4)+(K3*\ Y\_Eng\_Val^3)+(K2*\ Y\_Eng\_Val^2)-(O+TFFSET*T\_Val)/(G+TGAIN*T\_Val)$ Eq. 3

where T is expressed in Kelvin [K] and P in [hPa]

13.3. Appendix C : Calibration for Titan mission

Scientific conversion coefficients

Block.Ch#	a	b	c
1.3	0.95520	4.34272	0.0239358
2.3	0.94665	3.35377	0.0182452
3.3	0.92365	2.52352	0.0137031

In ASCII format

[Sensor channel, a, b ,c]
1.3,0.95520,4.34272,0.0239358
2.3,0.94665,3.35377,0.0182452
3.3,0.92365,2.52352,0.0137031

Table 4 PPI pressure conversion coefficients

#ch	Y_off	A	a11	a12	a13	a21	a22	a23
1.1	-0.00007	0.719	-657.4292279	-0.100342031	0.000326826	0	0	0
1.6	-0.00007	0.714	-686.2551263	-0.109695236	0.000333509	0	0	0
1.8	-0.00007	0.726	-669.4615346	-0.101388028	0.000319535	0	0	0
2.1	-0.00003	0.716	-966.4281555	-0.133100727	-0.000019593	0	0	0

2.7	-0.00016	0.712	-1080.174483	-0.155553526	0.000344837	0	0	0
2.8	-0.00016	0.695	-1079.884751	-0.155847787	-0.000062807	0	0	0
3.7	-0.0003	0.809	88.06750069	0.018178688	-0.000014784	-3.802727572	-0.001704142	0.000002594
3.8	-0.0003	0.805	73.98128576	0.010673543	0.000006087	-3.097715374	-0.001015383	0.00000088
	a31	**a32**	**a33**					
1.1	0	0	0					
1.6	0	0	0					
1.8	0	0	0					
2.1	0	0	0					
2.7	0	0	0					
2.8	0	0	0					
3.7	0.077164611	0.000059704	0					
3.8	0.059014787	0.000032967	0					

In ASCII format

[Sensor channel, Y_off,A, a11,a12,a13,a21,a22,a23,a31,a32,a33]
1.1, -0.00007, 0.719, -657.4292279, -0.100342031, 0.000326826, 0, 0, 0, 0, 0, 0
1.6, -0.00007, 0.714, -686.2551263, -0.109695236, 0.000333509, 0, 0, 0, 0, 0, 0
1.8, -0.00007, 0.726, -669.4615346, -0.101388028, 0.000319535, 0, 0, 0, 0, 0, 0
2.1, -0.00003, 0.716, -966.4281555, -0.133100727, -0.000019593, 0, 0, 0, 0, 0, 0
2.7, -0.00016, 0.712, -1080.174483, -0.155553526, 0.000344837, 0, 0, 0, 0, 0, 0
2.8, -0.00016, 0.695, -1079.884751, -0.155847787, -0.000062807, 0, 0, 0, 0, 0, 0
3.7, -0.0003, 0.809, 88.06750069, 0.018178688, -0.000014784, -3.802727572, -0.001704142, 0.000002594, 0.077164611, 0.000059704, 0
3.8, -0.0003, 0.805, 73.98128576, 0.010673543, 0.000006087, -3.097715374, -0.001015383, 0.00000088, 0.059014787, 0.000032967, 0

Table 5 PPI pressure conversion coefficients

Table 6 PPI pressure conversion coefficients

#ch	K_11	K_12	K_13	K_14	K_21	K_22	K_23	K_24
1.1	1917.589245	101.0844221	0	-190.2248322	0.085946109	0.089560648	0	0
1.6	2124.845234	45.34485761	24.09251419	-493.6641469	0.090065834	0.119673487	0	0
1.8	1875.879196	159.5436089	59.17257105	-46.5313299	0.097258901	0.081547068	0	0
2.1	2509.297639	256.2924743	132.7041323	44.98558513	0.189549766	0.122206777	0.076148017	0.001893328
2.7	2768.424329	303.534838	168.0515145	68.96209852	0.189656425	0.163047384	0.126348058	0
2.8	2760.141431	316.1517516	178.497679	71.01049135	0.203270515	0.174390885	0.162238146	0.097758547
3.7	-107.2712543	30.39331205	32.0691027	26.69205533	0.006594045	0	0	0
3.8	-98.17188197	29.34880543	31.14502493	25.26979811	0.022303389	0	0	0
	K_31	**K_32**	**K_33**	**K_34**				
1.1	-0.000389231	0	0	0				
1.6	-0.000380453	0	0	0				
1.8	-0.000380038	0	0	0				
2.1	0	0.000599493	0.001312938	0.001760405				
2.7	-0.000782556	0	0	0				
2.8	0.000040707	0.000776008	0.001218297	0.001811214				
3.7	0.000105811	0	0	0				

3.8	0.000083481	0	0	0				

In ASCII format

[Sensor channel, K11,K12,K13,K14,K21,K22,K23,K24,K31,K32,K33,K34]
1.1, 1917.589245, 101.0844221, 0, -190.2248322, 0.085946109, 0.089560648, 0, 0, -0.000389231, 0, 0, 0
1.6, 2124.845234, 45.34485761, 24.09251419, -493.6641469, 0.090065834, 0.119673487, 0, 0, -0.000380453, 0, 0, 0
1.8, 1875.879196, 159.5436089, 59.17257105, -46.5313299, 0.097258901, 0.081547068, 0, 0, -0.000380038, 0, 0, 0
2.1, 2509.297639, 256.2924743, 132.7041323, 44.98558513, 0.189549766, 0.122206777, 0.076148017, 0.001893328, 0, 0.000599493, 0.001312938, 0.001760405
2.7, 2768.424329, 303.534838, 168.0515145, 68.96209852, 0.189656425, 0.163047384, 0.126348058, 0, -0.000782556, 0, 0, 0
2.8, 2760.141431, 316.1517516, 178.497679, 71.01049135, 0.203270515, 0.174390885, 0.162238146, 0.097758547, 0.000040707, 0.000776008, 0.001218297, 0.001811214
3.7, -107.2712543, 30.39331205, 32.0691027, 26.69205533, 0.006594045, 0, 0, 0, 0.000105811, 0, 0, 0
3.8, -98.17188197, 29.34880543, 31.14502493, 25.26979811, 0.022303389, 0, 0, 0, 0.000083481, 0, 0, 0

Table 7 PPI pressure conversion coefficients

Formulas:

Y_Val = (S-R1)/(R2-R1) Eq.1

Y_c=Y_Val + Y_off Eq. 2

T_Val =[(1/(a- Y_Eng_Val))-b]/c Eq. 3

P_Val= Sum[i=1:3]Sum[j=1:3](a_{ij}*T_Val$^{(j-1)}$)*(A-Y_c)^(-i) + Sum[i=1:3]Sum[j=1:4](K_{ij}*T_Val$^{(i-1)}$)*(Y_c)^(j-1) Eq. 4

where T is expressed in Celsius [°C] and P in [hPa]

P.S. Formulas and coefficients in ASCII format as to be included in the CALIBRATION PDS directory