ALCATEL

HUYGENS

TITRE : **HUYGENS FLIGHT CHECKOUT F11**
TEST REPORT

Doc n° HUY.ASPI.HIT.RE.0016

Ed. : n°01 **Date : 30/06/04**
Rév. :n°00

	FUNCTION	NAME	SIGNATURE	DATE
WRITTEN BY	TECHNICAL TEAM	P.COUZIN		30/06/04
APPROVED BY	PROGRAM MANAGER	AM.SCHIPPER		17/08/04

CLASSES DE CONFIDENTIALITE	SOCIETE	MILITAIRE	PROGRAMME
	Non Protégé : ☐	Non Protégé : ☐	Classe 1/Grand Public : ☐
	Réservé Alcatel : ☐	Diff. Restreinte : ☐	Classe 2/Industrie : ☐
	Confid.Alcatel : ☐	Confid. Défense : ☐	Classe 3/Diff. Restr. : ☐
	Secret AS : ☐	Secret Défense : ☐	Classe 4/Confidentiel : ☐

CONTRAT ou MARCHE (Note Externe)	Client	n° contrat ou marché	Programme
	ESA	12 150/96/NL/RE	HUYGENS
	Document Contractuel	**Lot**	**Poste**
	-	-	-

TITRE	Catégorie de configuration
HUYGENS FLIGHT CHECKOUT F11 TEST REPORT	Configuré : ☐ Non configuré : ☐

AUTEUR

Sigle :OSM/IE

Nom . P. Couzin

Signature

Date	Réf. interne/Ed.	Réf. Programme/Ed.	Nb pages	Nb d'annexes
30/06/04	1	HUYGENS	30	0

RESUME D'AUTEUR

Ce document présente l'évaluation technique de la sonde HUYGENS pendant le onzième " cruise check out " (F11). F11 s'est déroulé le 3 Mai 2003.

.

Références Informatiques		
Réf. du fichier :	Langue du document : Ang
Nom du logiciel : WORD 95	Langue faisant foi : Ang

ETAT DES EDITIONS

N°	DATE	RAISON DE L'EVOLUTION
1		Création -

MOTS CLES	Catégorie de diffusion	
HUYGENS CRUISE CHECK OUT	**INTERET** Court terme : ☐ Moyen et long termes : ☐	Sigle : Nom : Signature
	DIFFUSION SUPPLEMENTAIRE Autorisée : ☐ Contrôlée : ☐	Sigle : Nom : AM.SCHIPPER Signature

EXTERNAL COMPANIES		
Company	Name	Nb of Copies
ESA ESOC	C. SOLLAZZO	2
ESA ESTEC	JP.LEBRETON	5

Internal Diffusion Sheet

P.MAUTE	**X**
B.MASSON	**X**
AM SCHIPPER	**X**
P. COUZIN	**X**
G.ROUYER	**X**
R.DUPRE	**X**

Change Notice

ED.	REV.	DATES	MODIFIED PAGES	CHANGES	APPROVAL
01	00	30/06/04		First Issue	

TABLE OF CONTENTS

1. SCOPE

The present report covers the tenth flight cruise check-out (F11) performed in the frame of the phase F of the HUYGENS Probe.

F11 was run at launch + 65.5 months on the 3rd of May 2003. The test was also run after the **Probe Relay Tests 5** (PRT5), which was the last test to characterize the PSE performance in realistic RF link conditions.

This document aims at analyzing the behavior of the HUYGENS Probe system and subsystems during the test.

Note that experiments behavior analysis is not part of this report.

In addition,

- The present analysis is based downlinked to HPOC/ESOC in near real time via JPL and the DSN Goldstone station DSS-25. This data set was completed on the 5th of May.
- The reference test for comparison is mainly F9, run on the 15th of April 2002 at launch + 53 months.
- After processing all the engineering data plots on the one hand, and dedicated status files on the other hand (relays, software status), were delivered to ALCATEL.

2. APPLICABLE DOCUMENTS

The tests have been performed according to the following documents:

- AD01: ESOC F11 sequence
- AD02: Spacecraft Data Operations Handbook (SDOH) : DOPS-SMD-HUY-DB-004, ISSUE 1.0, June 1996.

Reference documents for the present report are:

- RD01: T° Flight Prediction Report
  Doc. n° HUY.MBB.340.AN.0045, Issue 03
- RD02: Thermal model adjustment and recalculation of temperatures
  Doc. n° TN-RIA54-98-0018-A date 07/07/98
- RD03: Huygens Flight checkout F1 & F2 test report
  Doc. n° HUY.AS/c.100 .TR .600
- RD04: Huygens Flight checkout F3 test report
  Doc. n° HUY.AS/c.100 .TR .601
- RD05: Huygens Flight checkout F4 test report
  Doc. n° HUY.AS/c.100 .TR .602
- RD06: Huygens Flight checkout F5 test report
  Doc. n° HUY.AS/c.100 .TR .603
- RD07: Huygens Flight checkout F6 test report
  Doc. n° HUY.AS/c.100 .TR .604
- RD08: Huygens Flight checkout F7 test report
  Doc. n° HUY.AS/c.100 .TR .605
- RD09: Huygens Flight checkout F8 test report
  Doc. n° HUY.ASPI.HIT.RE.0001
- RD10: Huygens Flight checkout F9 test report
  Doc. n° HUY.ASPI.HIT.RE.0002

- RD11: Huygens Flight checkout F10 test report
  Doc. n° HUY.ASPI.HIT.RE.0003

- RD12: Huygens F11 Checkout Operational Report
  Doc. n° TOS-OF-HFR-011

3. CONFIGURATION

3.1. SPACECRAFT CONFIGURATION

– F11 has happened 14 months before the CASSINI Saturn Orbit Insertion. The Orbiter-Z axis, ie the High Gain Antenna axis is oriented towards the Earth. At the time of F11 the Sun-Spacecraft-Earth angle is about 5.3°. Location of CASSINI at F11 time, and planets/Sun geometry is illustrated in Fig.3.2 & 3.3. S/C orientation is Earth.

– The accuracy of the HGA pointing to the Earth, ie CASSINI AACS deadband is +/-2mrad for the X & Y axes and +/-20mrad for the Z axis of CASSINI

– The relative distance to the Sun is ~8.24AU (see Fig 3.1) and to the Earth is ~8.85AU

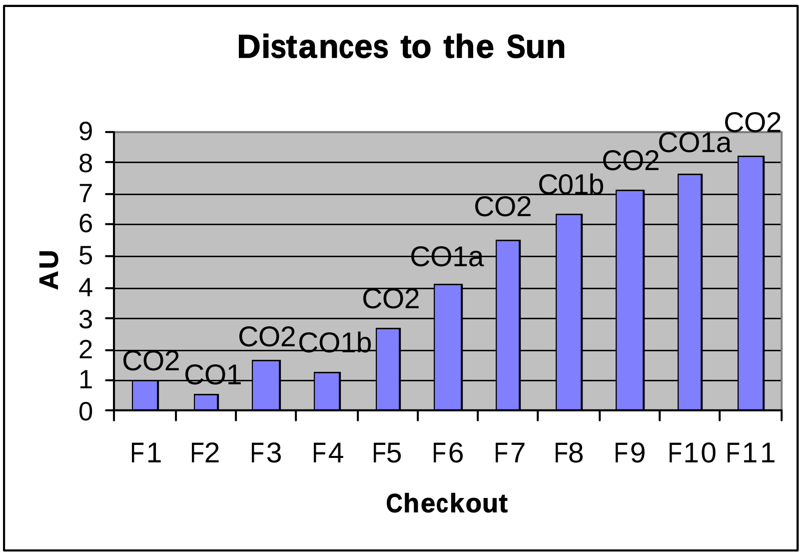

Fig. 3.1: CASSINI – Sun distance

– The CASSINI communication configuration status during F11 is :
  - Prime antenna is the HGA

– CASSINI instruments status is : in sleep mode, muted.

3.2. RADIO FREQUENCY SUBSYSTEM

TBD

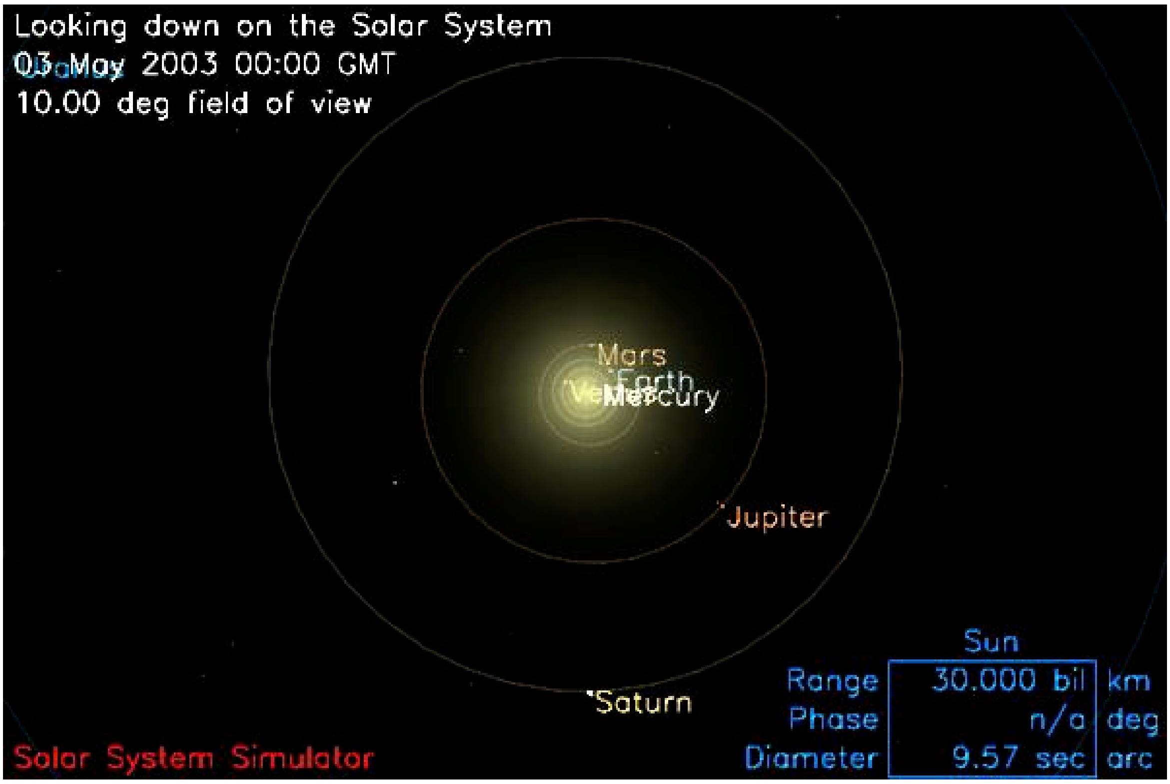

Figure 3.2 : Planetary configuration at F11

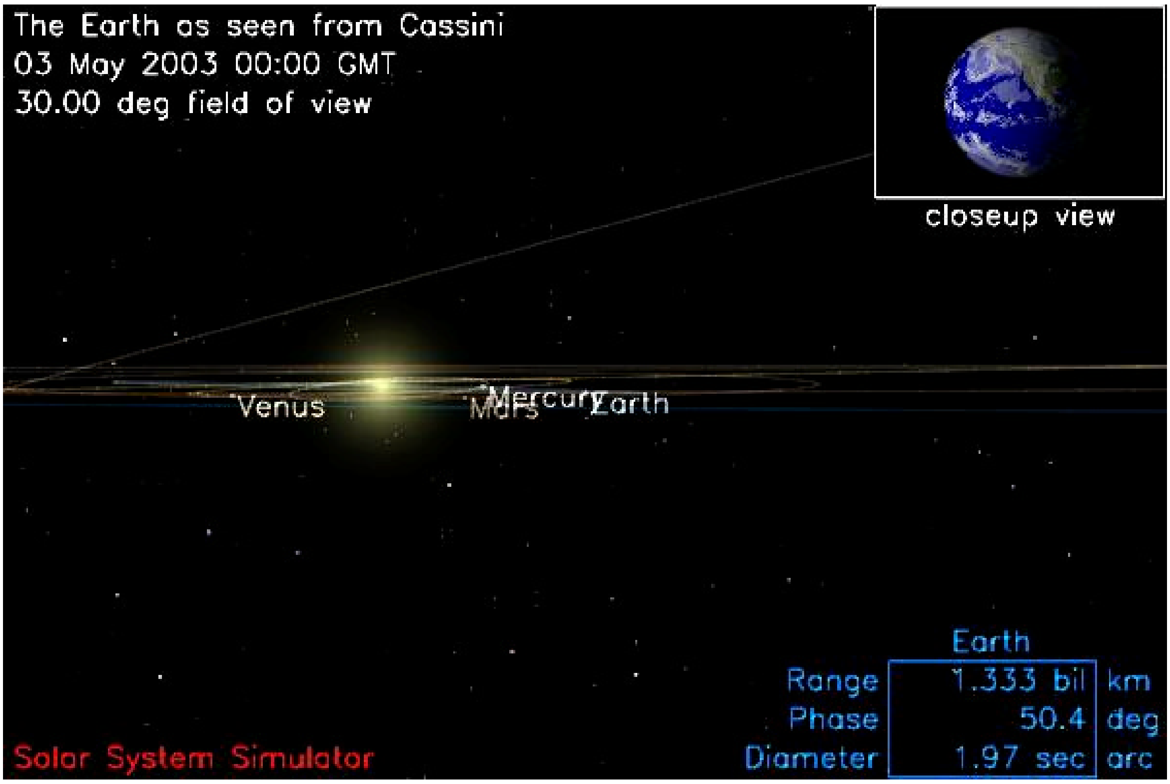

Figure 3.3 : SUN-EARTH position at F11

4. FLIGHT CHECK OUT 11 (F11)

4.1. OPERATIONS

F11 consists in the execution of a so-called Checkout scenario 2 (CO#2), ie a simulated descent without use of TUSO/RUSO. Compared to the original CO#2 scenario, it also includes :

⇒ a repetition of the “ Flight check out ” alteration TC to have a better confidence in the TC execution. This mainly intends to ensure that GCMS will not operate its valves in checkout,

⇒ POSW and SASW E²PROMs dumps,

⇒ some modifications requested by the PIs and explicited below in italic letters.

The relevant SASF was loaded on board CASSINI, then executed at a pre-programmed time : execution start was at 16h44.48 UTC on the 3/5/2003. As already mentioned, CASSINI HGA was pointed towards the Earth, making feasible a real time transmission of the data. Probe telemetry was down linked at 248.85kbps via the DSN station in Goldstone.

The F11 structure is based on:

- PSA activation through Orbiter CDS “power on” TC at S_0-60mn
- Dump SASW A/B EEPROM at S_0-40mn
- Probe wake up by the CASSINI Orbiter via the Solid State Power Switches at S_0-36mn
- T_0 simulated by Resume command at S_0 and T_0 detection at S_0+6.375 s
- descent simulation run with Chain A indicated as "invalid" : experiments are directed to receive the broadcasted data from Chain B
- RF link on Chain A makes use of TUSO and RUSO (DWE experiment). *In order to better characterize the USO’s low frequency oscillations problem, checkout duration is increased by 1hour with TUSO remaining ON during this extra hour*.
- HASI and SSP run a simulated descent *then SSP performs a specific investigation activity on APIS at S_0+153mn11s for a 42s duration. HASI patch related to pre heating is applied.*

- ACP is in *engineering mode* during the first 110mn then in "mechanisms check mode" from 140mn to 153mn.

- GCMS runs a calibration sequence :

  - Threshold scan
  - Lens scan 1
  - High power mode
  - Lens scan 2
  - Calibrate

- DISR runs the calibration sequences 1 & 2. *In addition a sequence of loading and validation of the DISR patches covering the Pre-heating conditions has been inserted from S0+156mn45s to S0+227mn*. DISR has therefore be turned ON during that period.

- DUMP POSW A/B EEPROM starting at S_0+272mn55s

The F11 "as run" key events are:

EVENTS	SEQUENCE TIMING	EXECUTION TIME IN UTC
PSE turn on	S_0-1:00:00	2003-123T16:44:48
PROBE turn on	S_0-00:36:00	2003-123T17:08:48
T_0 detection	S_0+0:6:375	2003-123T17:44:48.375
PROBE OFF	S_0+4:34:00	2003-123T22:18:48
PSA's OFF	S_0+4:35:00	2003-123T22:19:48

Checkouts duration are compared in Fig.4.1 hereunder. This shows that F11 duration is the longest checkout ever run from Launch, comparable to F10 duration.

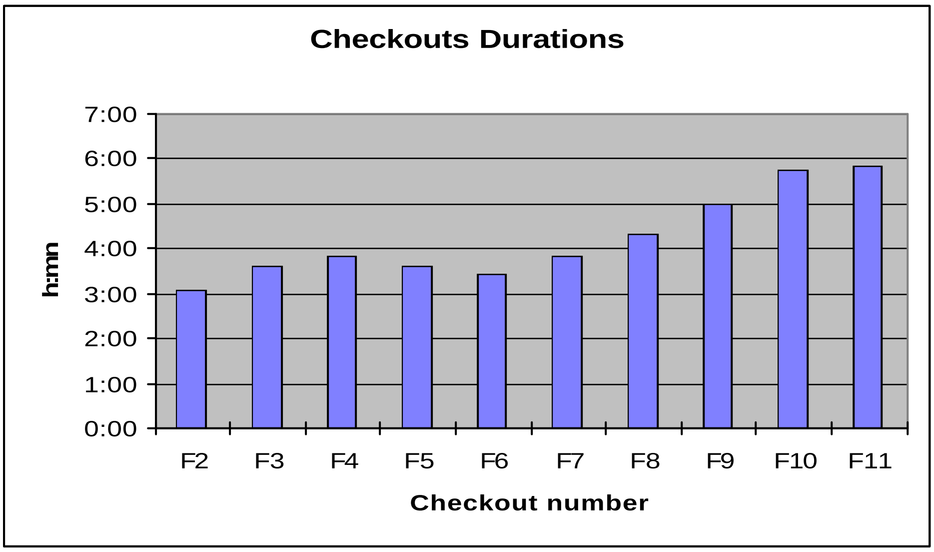

Fig. 4.1: Checkouts duration

4.2. RESULTS

As already mentioned, the analysis is based both on engineering data plots received at ALCATEL Cannes, while the various status of the Probe were made available in May 2003.

Reference for the analysis is **F9**, the previous CO#2 sequence performed on the 15th April 2002, however comparisons are also performed with F10 results (F10 is a CO#1a sequence run on the 16/09/2002).

The main outcomes of the as-run sequence evaluation are:

- the timing requested by the scenario are correctly followed by the CDS and all 1692 TCs sent by ground via the test sequence are correctly executed for both chain,
- the timeline shows no anomaly (an overview of the sequence is given by the DDB information versus time)
- all the status information was checked in details and validated from the data retrieved.

The following presents the analysis of F11, per function.

4.2.1. Telecommanding

This section addresses the Probe System commanding function through the analysis of the reported PSA, CDMU A & B Telecommand counters, and of the reported CDMU's Mission timeline commands counts. This provides a good overview of the execution of the checkout sequence, and of the Mission timeline.

The Figure 4.2 hereafter shows the evolution of the different counters along F11, where the time "0" corresponds to the start of F11 sequence, i.e. the turn ON of the PSA A & B. In this time scale, S_0 event happens at t=**3600s**, and T0 is "detected" at t=**3606.375s.**

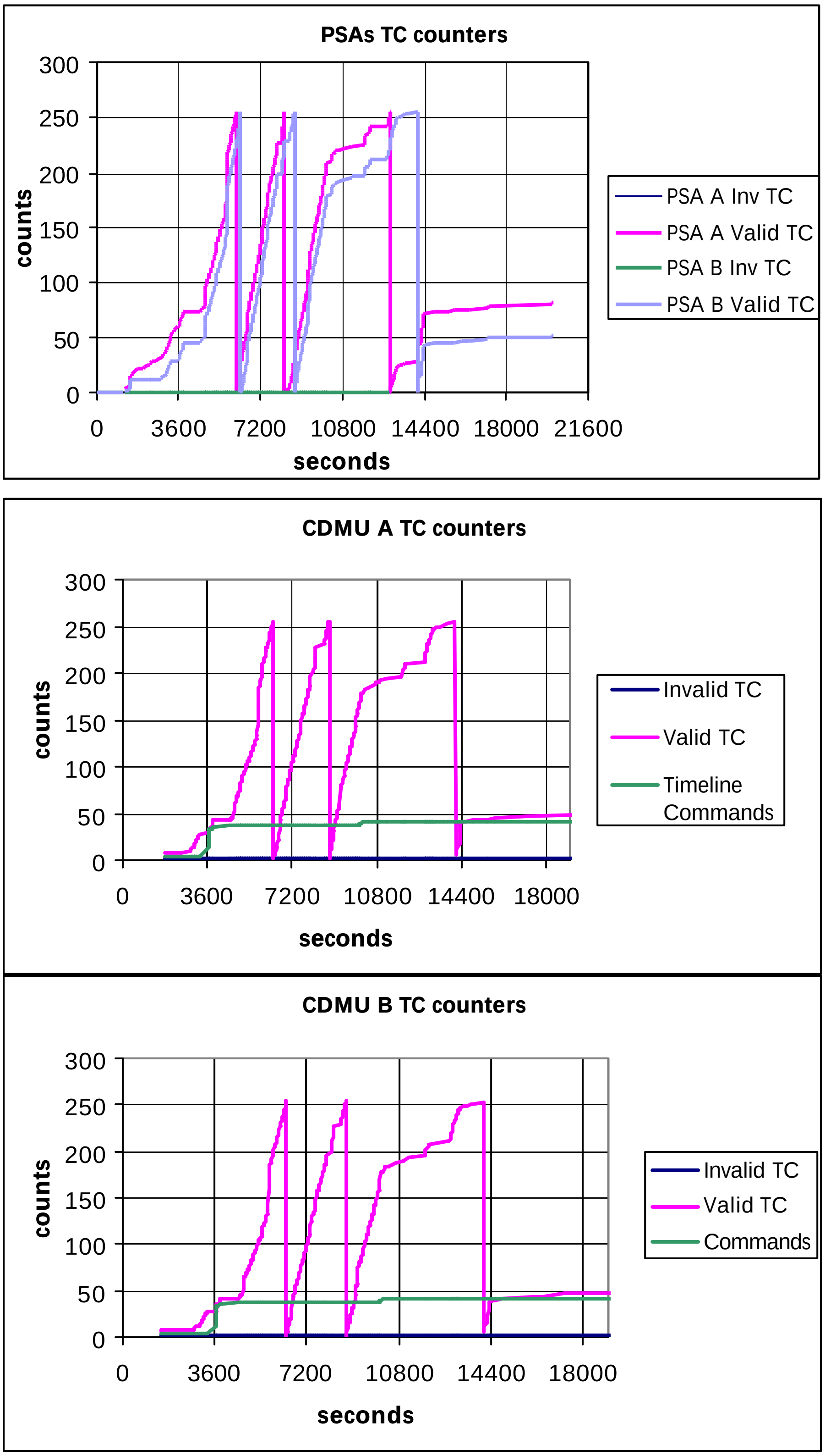

Fig 4.2 : Telecommand counters telemetry

It clearly appears that :

- All ground telecommands have been accepted as valid, both on PSA's and CDMU's side,
- More telecommands have been sent to PSA A, which is due to the numerous commands for switching to basic frequency on chain A,
- Exactly the same number of valid TC have been forwarded to CDMU A & B,
- The evolution of the automatic commands counts, identical for A and B channels is in line with the stored MTT

4.2.2. Telemetry Frames and packets structure

This section deals with the review of the data contained in the telemetry frame and packets headers, especially the various sequence counters evolution with time.

- **PSA Delta Seq. Count**: A Delta value of 1 is nominally reported on both chains.
- **PSA Delta Spacecraft Time**: A Delta value of 1 is nominally reported on both chains.
- **Super Packets Delta Seq. Count**: A Delta value of 1 is nominally reported on both chains
- **Super Packets Master and Virtual Channels Frame Counts**: Periodical reset of the Master channel frame counts on both chains is nominally noticed.
- **Dump Super Packets Delta Seq. Count and Sequence Count and Real Time Counter**: A Delta value of 1 in the sequence count and in the spacecraft time is nominally reported on both chains. Similarly, a monotonous increase of the Dump Super Packets absolute Seq. Count is nominally reported on both and the RT Count on both chains increases and resets when the Probe is OFF.
- **Probe HK packets Delta Seq. Counts**: a Delta value of 1 is nominally reported on both chains for HK1, 2 & 3. One Delta value of 24 is nominally reported for HK4 on both chains: it corresponds to the reset of this HK packet (which contains Entry Acceleration data), 6.4 mn after $T_{probe\ ON}$. This mechanisms will permit to report the entry acceleration profile to CASSINI then ground after the telecommunication link establishment, during the real mission.

4.2.3. Telecommunication

Here are addressed the telemetry parameters related to the telecommunication subsystem, its units, and the DWE experiment, as acquired in the Probe System housekeeping.

Main related features are :

- RF link on chain A makes use of TUSO and RUSO
- CASSINI HGA is pointed towards the Earth, and the Sun is constantly outside the HGA main lobe.

- **PSA secondary voltages**: PSA 12V, 5V and LNA supply voltage (nominally 12V), are in their nominal range and perfectly stable over the test,
- **RUSO status**: RUSO is turned ON 16s after PSA A is ON. RUSO reports lock status at about RUSO ON+16 mn , well in line with expected behaviour and F9 results.
- **TUSO status**: TUSO is turned ON 16 s after Probe is ON. TUSO reports lock status at about TUSO ON+16mn. This duration is explained by the higher TUSO initial temperature, the higher the temperature, the shorter the time to lock. Note that the mission timeline, after the implementation of the Probe Pre Heating strategy, permits warm up duration as long as 4h30mn.
- **TCXOs status**: TM nominally reports TCXO selection on B chain and not on A chain,
- **HPA/TX power**: As expected, HPA is OFF, and no power is monitored at TX output.
- **Receivers status**: TM nominally reflects a RSW state of 2 until TXs are turned ON, on both chains.

  On Chain A, state 6 (carrier, subcarrier, bit sync and Sync Marker locked) has been reached after about 5.1mn, ie at the **7th** attempt, consistently with the behaviour observed during F9 (it shall be noticed that F1 showed a complete receiver lock on chain A during CO#2 at the **3rd** attempt ; and on ground at worst, lock was achieved at the **2nd** attempt). As noted from F4, this is not a concern (in total the sequence plans 28 attempts to switch to basic frequency) and this phenomenon is related to the initial T° of TUSO . A colder T° leads to a longer time for the TUSO oscillator frequency to stabilize and enter in the 30kHz PSA acquisition bandwidth. It should be pointed out that this problem will not happen during the mission : about 4h30mn TUSO warm up time is foreseen before PSA attempts to acquire the Probe RF signal in basic frequency mode (as in checkout because of the CASSINI-Huygens geometry change in the frame of the recovery mission). At that time, the frequency variation of the transmitted signal will be far below the requested 30kHz.

  As expected, on Chain B (no TUSO/RUSO), switch to basic frequency is successful at the 1st attempt.

- **AGC**: The table hereunder evidences the AGC evolution since the first flight checkout. The AGC level for F11 is well in accordance with conclusions reached after the AGC specific test (see RD3) and confirmed by F3, F4, F5, F6, F7, F8, F9 and F11 : the favorable AGC level is explained by the Earth-spacecraft-Sun geometry illustrated in Fig. 3.2 & 3.3, considering that the HGA is pointed towards the Earth, and by the spacecraft-Sun distance. The AGC history is illustrated in Fig. 4.3.

  A simultaneous drop in the AGC values on both chains by 0.2dB about 40mn before the end of the test is noticed. No convincing correlation has been found with on board events, but, however, this issue is considered as a minor observation as far as the Probe System is concerned.

TEST	AGC A	AGC B
F1	-101 dB+/-0.4 S shape period 85 mn	-100.6 dB +/-0.4 S shape period 85 mn
F2	-104 dB+/-0.5	-106 dB+/-0.4
Off Sun Test	-94.6 dB+/-0.1	-93.3 dB+/-0.1
F3	-98 dB→ -100.5 dB+/-0.4	-97.8 dB →-98.8dB+/-0.4 small amplitude max 99.3 dB
F4	-98 dB +/-1dB S shape period 40 mn	-97 dB +/-1dB S shape period 40 mn
F5	-93.5 dB +/-0.5dB	-93 dB +/-0.5dB
F6	-93.8 dB +/-0.5dB	-93 dB +/-0.5dB
F7	-94.2dB +/-0.8dB	-93.1 dB +/-0.5dB
F8	-93.5dB +/-0.5dB	-93 dB +/-0.5dB
F9	-93.5dB +/-0.7dB	-93 dB +/-0.5dB
F10	**-93.2dB +/-0.7dB**	**-92.5 dB +/-0.5dB**
F11	**-93.8dB +/-0.7dB**	**-92.8 dB +/-0.5dB**

- **NCO**: as far as the Probe System is concerned, NCO frequency changes are as expected, both on chain A (RUSO) and chain B (TCXO), and very similar. It shall be underlined that the NCO frequency modulation noticed by DWE, similar to those observed during F1, F3, F4, F5, F7, F8, F9 (~0.367Hz with a maximum amplitude oscillation of about 20Hz, see DWE report) is currently **not a Probe**

System concern Also, so called dF/dt parameters on both chains are within the expected range.

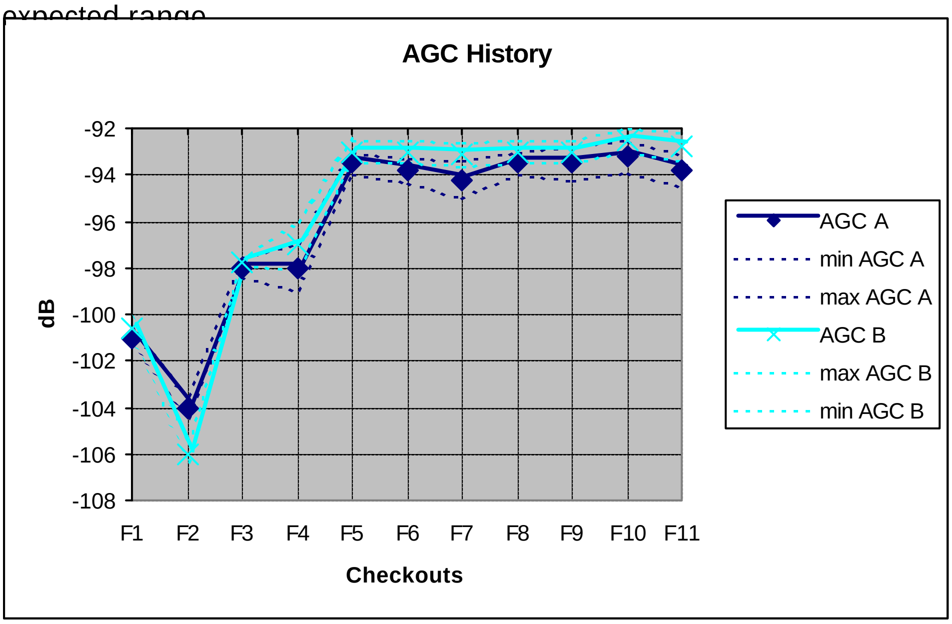

Fig 4.3 :AGC History

4.2.4. Power subsystem

- ❑ **CASSINI Telemetry** has shown that :

- PSA A power consumption ranges from 40W during RUSO warm up phase, down to 32W afterwards,
- PSA B average consumption is 25W , which means a total PSE steady state consumption of 57W, identical to F9,
- Probe total average maximum consumption is 150W.

These values are well in line with reference test results.

- ❑ **Current limiters status and Pyro relays status** have been cross checked with the retrieved telemetry :

- Nominal Current Limiters status changes during F11 are displayed in Fig 4.4. They are fully in line with the Mission Timeline and F11 sequencing (S0 happens at 3600s).

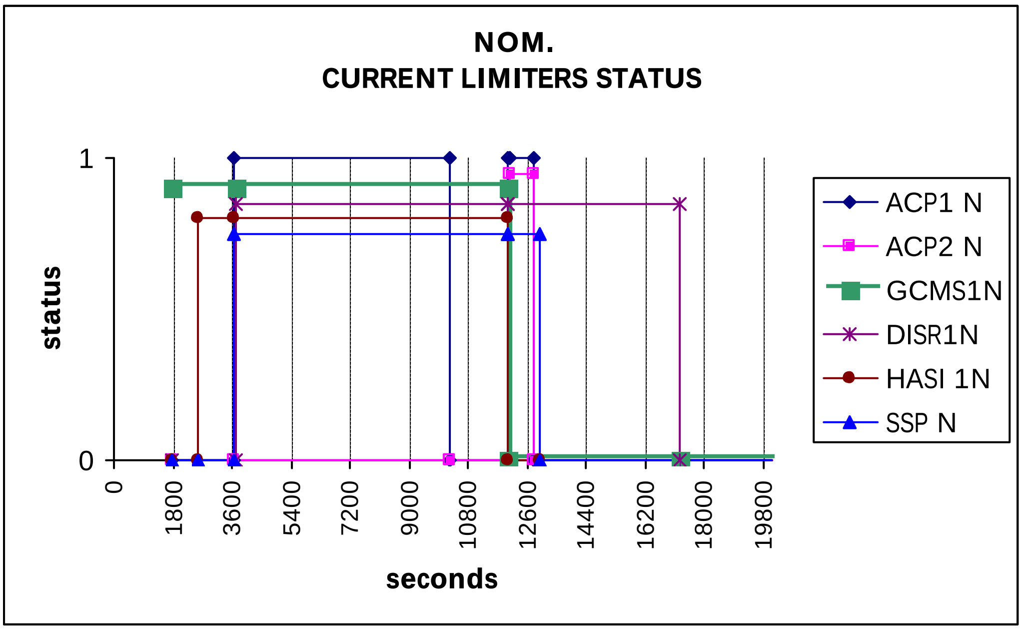

Figure 4.4 : Nominal current limiters status changes along F11 ("0" = start of F11)

- Pyros selection relays status changes during F11 are displayed in Fig 4.5 for both chains, with a zoom around T0. Note that the DISR Cover selection relay is not reported via the dedicated SRS telemetry but only via the standard relay status TM ; this telemetry is the one displayed in the Fig 4.5 plots for matter of completeness. All the nominal and redundant relays are set and reset by each of the chains at the proper time, fully in line with the Mission Timeline and F11 sequencing. It shall be noted that the period of reporting of the pyro selection relay status is 16s ; the SRS telemetry reports whether a change in the status has occurred.

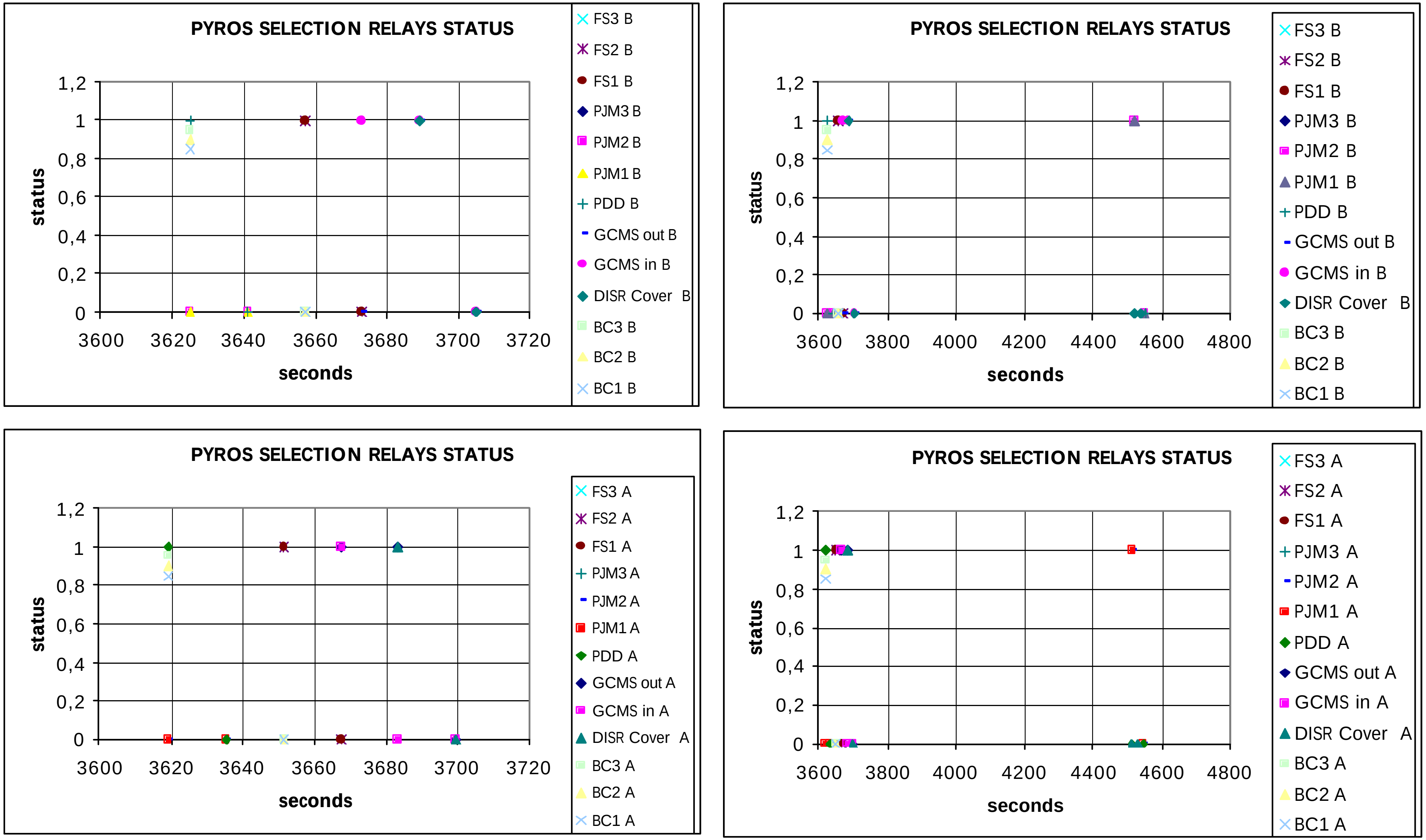

Figure 4.5 : Reported selection relay status changes during F11 (NB : S0 is at t=3600s)

- **Main bus voltage** is 28.09 Volts, as expected.
- **Batteries voltages** telemetry at the end of the test are slightly higher than the one observed during F8, F9 & F10.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
battery 1 A	2.93 V	2.28 V	2.00 V	2.6 V	2.00 V	2.28 V	2.6 V	2.6 V	2.6 V	2.6 V	2.93V
battery 2 A	2.6V	2.28 V	2.00 V	2.28V	2.00 V	1.96 V	2.28 V	2.6 V	2.6 V	2.6 V	2.93 V
battery 3 A	1.3V	1.30 V	1.00 V	1.30 V	1.00 V	0.98 V	1.30 V	1.30 V	1.30 V	1.30 V	1.63 V
battery 3 B	1.3 V	1.30 V	1.00 V	1.30 V	1.00 V	0.98 V	1.30 V	1.30 V	1.30 V	1.30 V	1.63 V
battery 4 B	2.6 V	2.28 V	2.00 V	2.30 V	2.00 V	1.96 V	2.28 V	2.6 V	2.6 V	2.6 V	2.93 V
battery 5 B	2.28 V	1.96 V	1.63 V	1.96 V	1.63 V	1.63 V	2.28 V	2.28 V	2.28 V	2.28 V	2.6 V

Note that these voltages, as long as batteries are not connected to the PCDU, are not in any way representative of the actual batteries voltages. They actually reflect the leakage current in the measurement diode which is somewhat proportional to the PCDU temperature. These slightly higher voltages are fully consistent with the higher PCDU final temperature, as it will be addressed in section 4.2.7.

The lower battery 3 voltage is due to the cross trapping of the relevant telemetry measurement electronics.

- **BDR currents** are in accordance with the operating modes of the Probe System and experiments and comparable to the reference test, ie, at different phases of the mission :

	Pre To	To to To+110 mn	To+140 mn	To+156 mn	To+227 mn	To+274 mn	Reference test
BDR1	0.55 A	0.82 A	0.82 A	0.58 A	0.45 A	0.37 A	F9
BDR2	0.49 A	0.72 A	0.72 A	0.51 A	0.4 A	0.33 A	F9
BDR3	0.49 A	0.72 A	0.72 A	0.51 A	0.4 A	0.33 A	F9
BDR4	0.49 A	0.72 A	0.72 A	0.51 A	0.4 A	0.33 A	F9
BDR5	0.55 A	0.82 A	0.82 A	0.58 A	0.45 A	0.38 A	F9

The unbalancing of the BDR's 1 & 5 is nominal, very close to the designed value (14% difference between BDR 1& 5 wrt BDR 2, 3 & 4), set to compensate the batteries 2, 3 & 4 discharge during the coast phase when supplying the MTU.

- **Units and Experiments currents** are summarized in the following table. They are in perfect accordance with the reference test and expected behavior.

UNITS	CURRENT	UNITS	CURRENT	Reference test
TX A	0.19 A	**TX B**	0.195 A	F9
TUSO N	0.32 A warm up 0.127 A steady state	**TUSO R**	0.3 A warm up 0.120 A steady state	F9
CDMU A	0.326 A	**CDMU B**	0.337 A	F9
Prox Sensor A	0	**Prox Sensor B**	0 (unit is OFF)	
DISR1 N	0.16 A/peak 0.25 A	**DISR1 R**	0.15 A/peak 0.24 A	F9
DISR2 N	0	**DISR2 R**	0	F9
GCMS1 N	0.25 A in pre To 0.42 A in post To	**GCMS1 R**	0.24 A in pre To 0.39 A in post To	F9
GCMS2 N	0	**GCMS2 R**	0	F9
HASI1 N	0.2 A in post To	**HASI1 R**	0.18 A in post To	F9
HASI2 N	0	**HASI2 R**	0	F9
ACP1 N	0.07 A	**ACP1 R**	0.07 A	F9
ACP2 N	0	**ACP2 R**	0	F9
ACP3 N	Peaks up to 0.30 A	**ACP3 R**	Peaks up to 0.38 A	F9
SSP N	0.33 A	**SSP R**	0.03 A	F9

4.2.5. Data handling

This section deals with the analysis of all the telemetry data related to the CDMS, and to the PSA's data handling functions.

– **Central Acceleration data**: The reported TM on A and B nominally shows a 0 g value for the accelerometer 1 (parameters 1A, 1B)., 2 (parameters 2A, 2B).and 3 (parameters 3A, 3B) .

  It shall be underlined that spurious drifts on the accelerometers 1 and 3 telemetry were evidenced during F1, F2, F3 & F4. While the noise peaks reported within F1 and F2 were marginal, the problem got much worse during F3 with noise peaks reaching up to 2 LSBs, then slightly improved during F4.

The situation during F5, F6, F7 and F8 improved again : only accelerometer 1 TM seldom showed 1LSB peaks. F9 and F10 were in line with these measurements, marginally degraded wrt F8. F11 shows an apparent return to fully nominal conditions.

Tentative explanations for the spurious acceleration values were provided in the F3 report, giving as a possible explanation a stiction effect at the level of the accelerometers 1 & 3. This is actually not in contradiction with the observed improvement, the stiction being strongly dependent upon the initial conditions of the test, and the entry acceleration parameters shall be kept under a close monitoring. It shall also be noticed that the stiction (dry friction) phenomenon may apply on both positive and negative directions. The fact that no spurious appears from accelerometers 1, 2 & 3 during F11 could thus reflect a negative shift of these sensors, not visible because the negative values are “ cut ” by the TM acquisition electronics.

The figure 4.6 shows the “ CASU LSB noise ” history over the different checkouts.

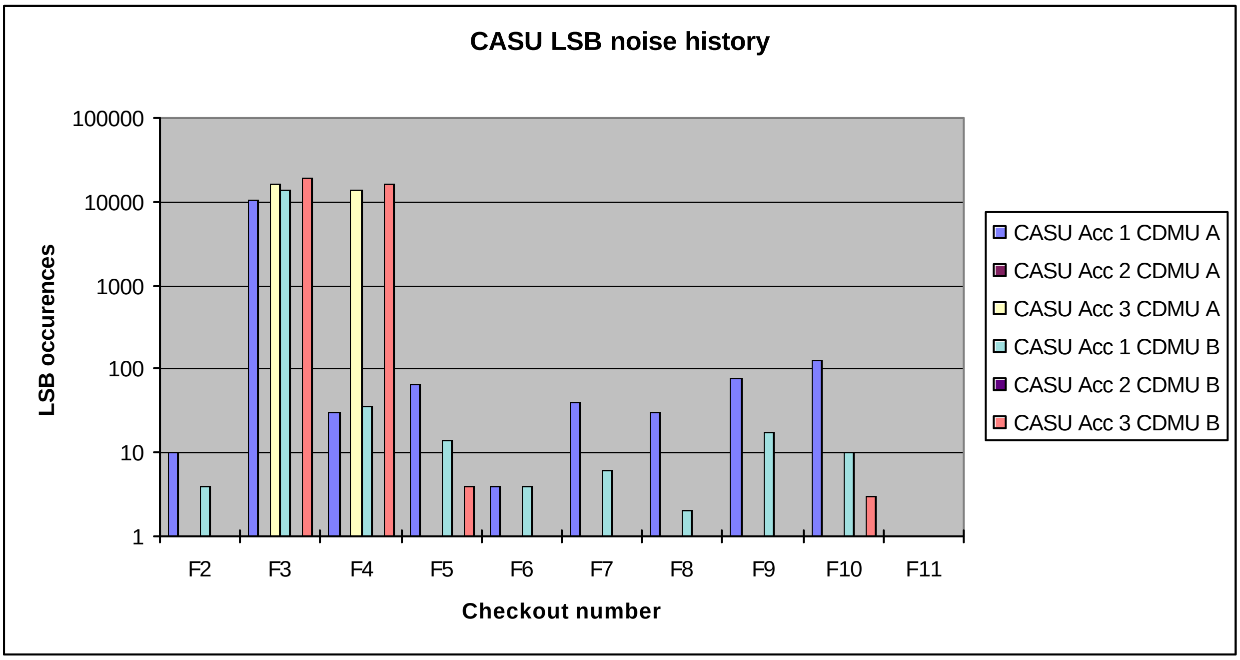

Fig 4.6 CASU Noise History

- **Radial Acceleration data**: The reported TM nominally shows a 0 g value.

- **DDB Mission Phase flags**: The telemetry properly reports the mission modes changes : mission modes switch between Flight Checkout, Flight Checkout Suspended and De-activate modes following F11 sequence.

- **DDB F1 & F2 flags status**: T_0 "detection" is correctly reported on both chains through F1 change. F2 nominally reports the TAT use over the whole sequence. Note that T_0 corresponds to the time of pilot chute firing, and $T_0 = S_0 + 6.375$s where S_0 corresponds to the g-threshold detection by the POSW.

- **DDB Time**: For both chains, it is in line with Probe Real Time before T_0, then with Probe [Mission Time - 6.375s] from T_0 (ie. here from Tp+60mn6.375s to probe OFF).

- **DDB Altitude** : Nominally set to 320 km until T_0, then follows the Time Altitude Table (TAT) down to "surface" (Proximity Sensor is OFF).

- **DDB Spin** : TM reports permanently 0rpm since Spin is not simulated in CO#2 type sequences.

- **µprocessor Valid** : As expected, analysis of the Probe status shows that both CDMUs have been set as " invalid " from Tp+35mn, giving the experiments the opportunity to listen to the B chain (CO2). Processor Valid evolution along F11 is shown in Fig 4.7 hereafter.

- **MTU** : All three timers registers content, as read by both CDMUs, are reported to be 16#FFFF. These are the expected values when the MTU is turned on, but not programmed, as per F1, F2, F3, F4, F5, F6, F7, F8, F9, F10.

- **EEPROM's** : As for all previous checkouts, a complete CDMUs EEPROM (16kW) and PSA EEPROM (8kW) dump was performed, and the content was compared to the expected one, ie. in the present case, the memory contents as dumped during F9 and F10. No difference was noticed for all 4 memory banks, showing a good immunity of the CDMUs and PSA's EEPROM chips to Single Event Upsets in unbiased conditions.

- **Processor boards** : no anomaly in the PSA's and CDMU's init was noticed. In addition, no double nor single RAM (CDMU's o PSA's) error was flagged by the EDAC circuitry all over F11 duration.

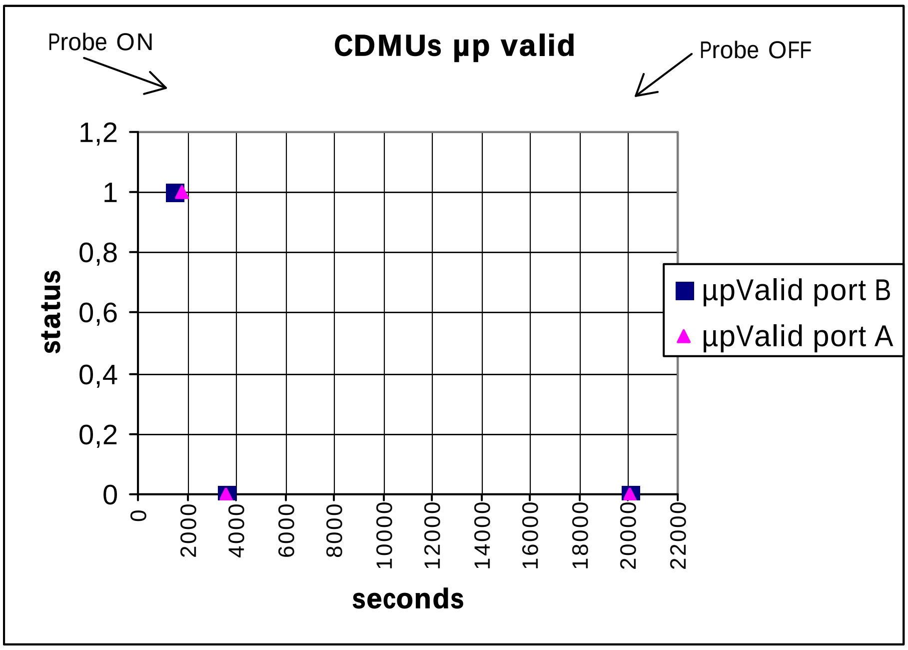

Fig 4.7 : µp Valid changes along F11 (S_0 is at t=3600s)

– **Reference voltages** : this telemetry provides highly accurate information on the current performance of the CDMUs acquisition chain in view to possibly adjust the analog parameters calibration curves, and especially the Entry Accelerometers ones, on board. There are 3 stabilized reference voltages :

- 4.54V, and
- 300mV and
- 500mV

the later ones being set to be close to the voltage corresponding to the S_0 g-threshold, ie. 522mV.

The Fig 4.8 and 4.9 hereafter show the evolution over F11 of the stabilized voltages as acquired by the CDMU's. The telemetry of the CDMU's 5V supply voltage is also displayed. This clearly demonstrates the very good operation of the Analog acquisition chain. Also, no degradation from launch time is visible.

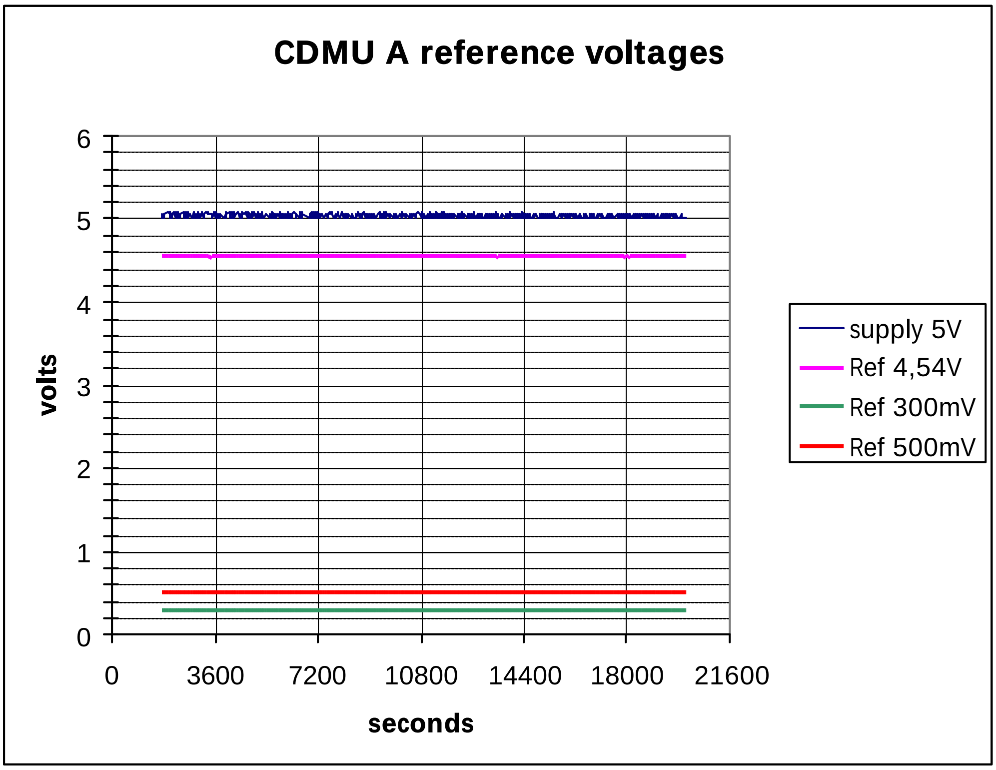

Fig 4.8 : CDMU A Voltages (5V is not stabilized)

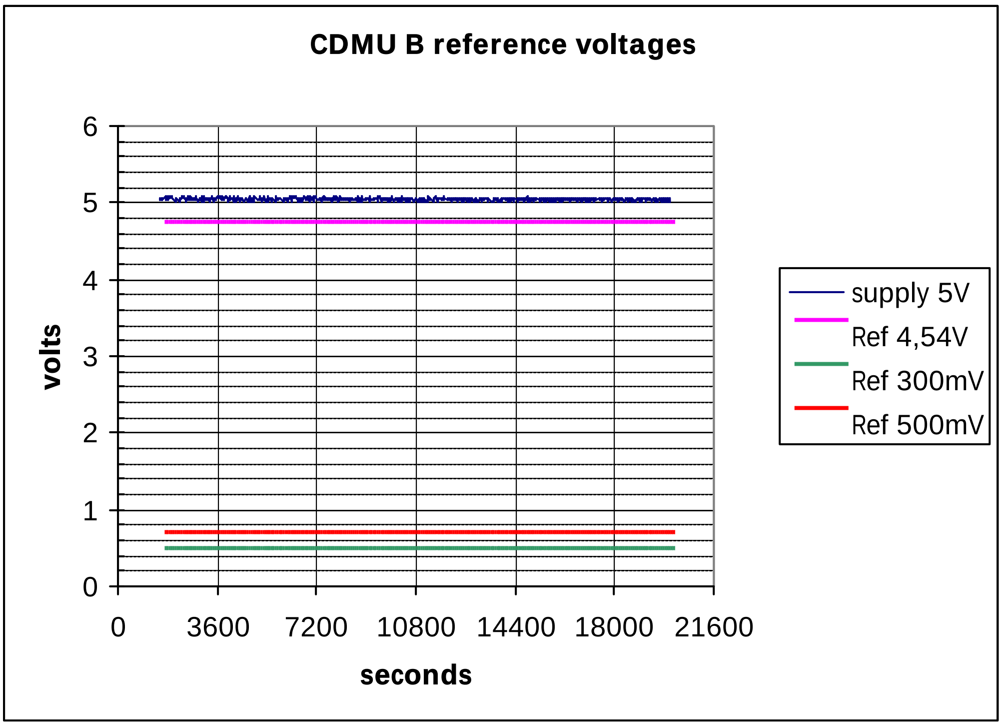

Fig 4.9 : CDMU B Voltages (5V is not stabilized)

4.2.6. On board software

4.2.6.1. SASW

This paragraph addresses the telemetry related to the SASW operation.

- **High Stack Water Mark:** This parameter aims at providing data on the stack usage by the SASW. It reports the 16bits address of the top of the stack, which shall be lower than the Stack base address, i.e. 16#EFFF. Value reported during F11 is in line with the requirement and basically in line with F1 to F10 results.

- **SASW CUT Processing Time**: It reflects the processor load for each CUT. As expected, and as per F1 to F9, processing time ranges from 16ms to 27ms, representing a nominal PSA data handling processor load of about 20 %.

- **DT Start/End Time, DT Start EXEC**: The DTStart parameter provides the time within the CUT when the Dead Time Start signal is received by the SASW. It shall be <120ms. DTEnd parameter provides the time within the CUT when the DTStart interrupt processing stops. The interrupt processing duration is given by the **DTStart EXEC** parameter.

  During F11, on both chains, **DTStart** nominally happens generally 18.7ms after the CUT start; processing duration is in average 1.4ms, in line with the reference test results.

- **FDI Start/End, FDI EXEC:** The **FDIStart** signal provides the time when a Probe frame is received. **FDIEnd** provides the time when the FDI is serviced, while **FDI EXEC** simply indicates the duration of the interrupt servicing.

  It shall be noticed that the **FDIStart** signal monotonously increases because of the Probe (CDMU's) TM clock drift w.r.t. CASSINI RTI.

  Fig. 4.10 & 4.11 show this clock drift computed as a function of the temperature measured at CDMU A and B DC/DC converters level over F3 to F11. The displayed drifts are absolute values, corrected with CASSINI RTI shifts valid for each checkout. These demonstrate that the TM clock on board the CDMU's is well within its stability requirement, and has not degraded from F3. F11 measurements and trend are in line with the previous checkouts figures.

  Processing duration, given by **FDI EXEC** parameter is in average 0.8ms, in line with all previous tests results.

- **DMA Start/End, DMA EXEC:** The DMAStart signal provides the time when a Direct Memory Access interrupt is received. **DMAEnd** provides the time when the DMA interrupt is serviced, while **DMA EXEC** indicates the duration of the interrupt servicing.

The evolution of the telemetry related to DMA interrupt is quite similar to FDI related telemetry, with the same comments.

Duration of the interrupt servicing is, in average, 1.4ms, in line with all previous tests results.

As a conclusion, we have [**DTStart EXEC + FDI EXEC + DMA EXEC** = 3.6ms], and the constraint for a correct software operation being [**DTStart EXEC + FDI EXEC + DMA EXEC**< 4.5ms] is fulfilled.

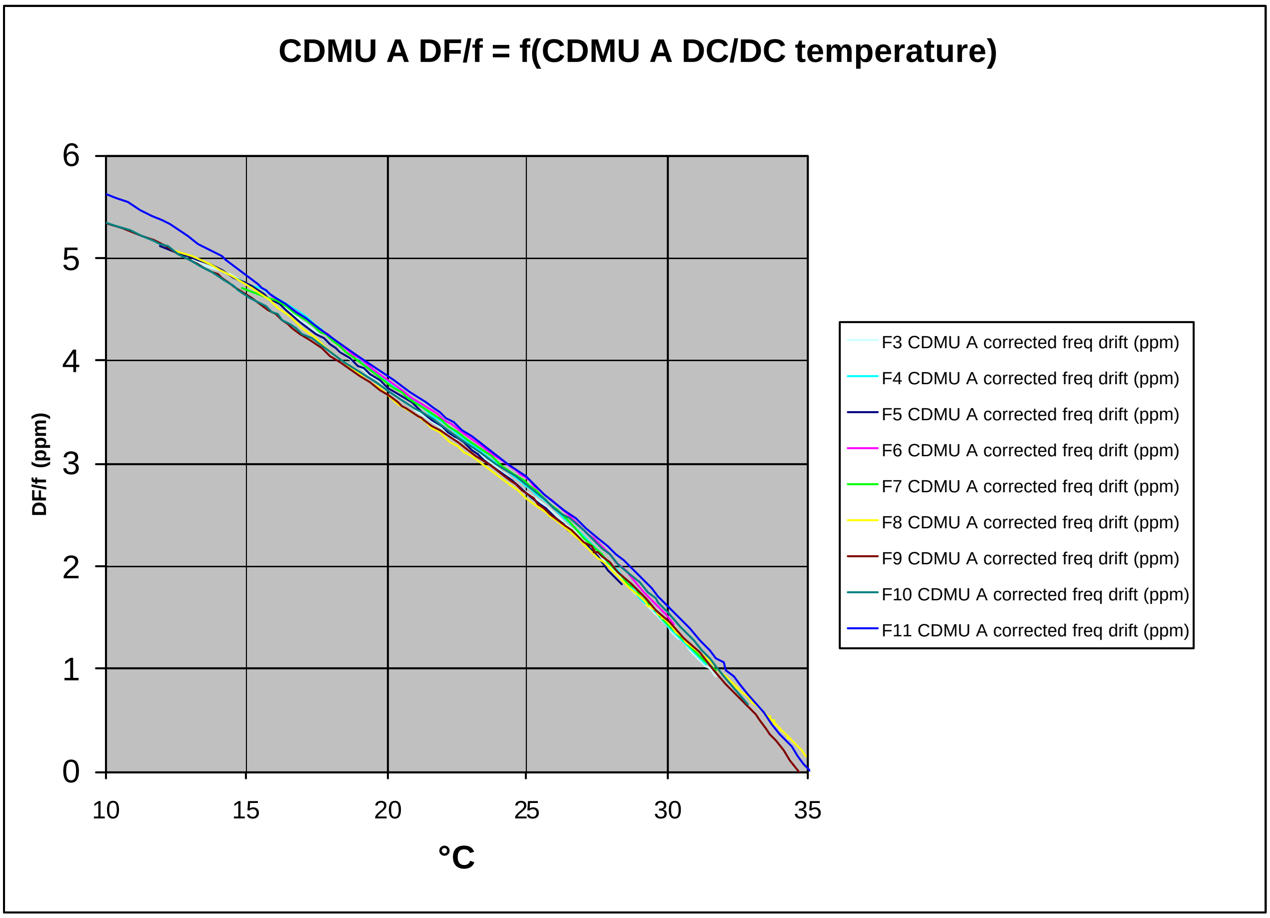

Fig 4.10 : Computed CDMU A Data clock drift wrt CASSINI RTI

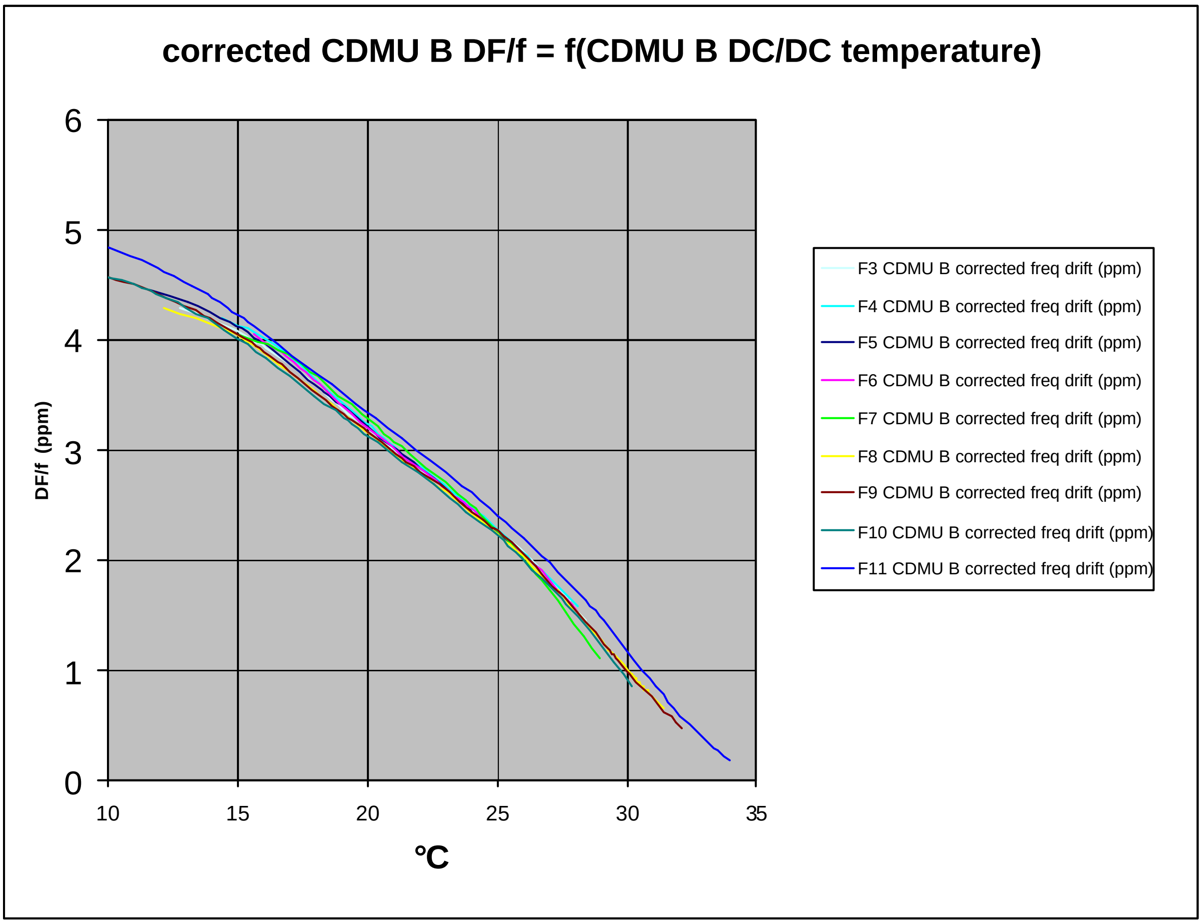

Fig 4.11 : Computed CDMU B Data clock drift wrt CASSINI RTI

4.2.6.2. POSW

This paragraph addresses the telemetry specifically related to the POSW operation.

- **High Stack Water Mark:** This parameter aims at providing data on the stack usage by the POSW. It reports the 16 bits address of the top of the stack, which shall be lower than the Stack base address, i.e. 16#EFFF. Value reported during F11, 10#7425 is well in line with previous test results.

- **POSW CUT Processing Time**: It reflects the processor load for each CUT. The reported value is a worst case value over the 128 CUT major acquisition cycle and is actually the residual value of the CDMU's µprocessor timer B at the end of the processing time.

  As expected, Processing time ranges from 56 ms to 60 ms, representing a nominal CDMU data handling processor load of about 55 % max. A slow increase of the processor load from T_0 time can be noticed; it reflects the fact that the TAT processing time is correlated to the current Mission Time.

  In total, the POSW processing time during F11 is very much comparable to F9, and shows a correct operation of the software over the whole checkout.

4.2.7. Thermal

This section discusses telemetry measurements related to the THSS : Probe and PSE temperatures in Probe housekeeping, including units internal T°, plus Probe and PSE temperatures in CASSINI housekeeping.

Temperatures values permanently acquired by CASSINI are summarized in the table hereafter:

IDENTIFICATION	F11 MEASURED RANGE INIT T° → END T°	F10 MEASURED RANGE INIT T° → END T°	F9 MEASURED RANGE INIT T° → END T°	F8 MEASURED RANGE INIT T° → END T°	F7 MEASURED RANGE INIT T° → END T°
MIMI elec T°	22.7°C → 25.7°C	22.5°C → 24.5°C	22.5°C → 24.5°C	22.5°C → 24.5°C	20.5°C → 22.5°C
Probe T° 1	7.5°C → 37°C	8°C → 35°C	10°C → 34.5°C	10°C → 34.5°C	13°C → 35°C
Probe T° 2	7°C → 35.5°C	7.5°C → 34.5°C	10.5°C → 34°C	10.5°C → 34°C	12.5°C → 35°C
LNA A Temp	-8°C → -2°C	-9°C → -3.5°C	-8.5°C → -4.5°C	-8.5°C → -4.5°C	-7°C → -3°C
LNA B Temp	-8.7°C → -2.5°C	-8.5°C → -3°C	-9°C → -3°C	-9°C → -3°C	-8°C → -3.5°C
SEPS Temp 1	-56.8C → -56.2°C	-56.8C → -56.8°C	-56.2C → -56.2°C	?	-51.2°C → -51.2°C
SEPS Temp 2	-55.7°C → -55.2°C	-56.1°C → -55.5°C	-55.3°C → -55.3°C	-53.2°C → -53.2°C	-50.2°C → --50.2°C
SEPS Temp 3	-58.3°C → -57,5°C	-58.5°C → -58°C	-57.5°C → -57.5°C	-55.5°C → -55.5°C	-53.2°C → -53.2°C
SEPS Temp 4	-59.2°C → -59.2°C	-59.2°C → -59.2°C	-58.8°C → -58.8°C	-57°C → -57°C	-53.5°C → -54°C

Temperatures values, in °C, acquired by the HUYGENS Probe are summarized in the tables hereafter:

a. Descent module External units:

TM IDENTIFICATION	T° SENSOR	F11 MEASUREMENTS (3/05/2003)			F10 MEASUREMENTS (16/09/2002)			F9 MEASUREMENTS (15/04/2001)			F8 MEASUREMENTS (20/09/2000)		
	Location	T init	T end	**Delta**	T init	T end	**Delta**	T init	T end	**Delta**	T init	T end	**Delta**
1A	SEPS A	-54.3	-54.3	**0**	-54.4	-54.4	**0**	-54.5	-53.5	**1**	--50	-50	**0**
2B	SEPS A	-54.3	-54.3	**0**	-54.4	-54.4	**0**	-54.5	-53.5	**1**	-50	-50	**0**
1B	SEPS B	-57	-57	**0**	-57	-57	**0**	-57	-56.1	**1.1**	-53.5	-53.5	**0**
2A	SEPS C	-57.8	-57.8	**0**	-58	-58	**0**	-58	-57	**1**	-54.3	-54.3	**0**
3A	PJM A	-30.2	-29.4	**0.8**	-31	-30	**1**	-30	-29	**1**	-27.5	-26.9	**0.4**
3B	PJM B	-28.2	-27.5	**0.7**	-29	-27.5	**1.5**	-29.4	-28.4	**1**	-25.5	-25	**0.5**
4A	PJM C	-30	-29.	**1**	-30	-29.	**1**	-28	-27.2	**0.8**	-26.8	-26.3	**0.6**
4B	PDD	-26.2	-25.9	**0.3**	-26	-25.6	**0.4**	-26	-25.3	**1.3**	-23	-23	**0**

b. Descent Module Internal units

TM IDENTIFICATION	Sensor Location	F11 MEASUREMENTS (3/05/03)			F10 MEASUREMENTS (16/09/02)			F9 MEASUREMENTS (15/04/02)			F8 MEASUREMENTS (20/09/01)		
		T init	T end	Delta	T init	T end	Delta	T init	T end	Delta	T init	T end	Delta
8A	PCDU	6	35	29	5.5	33.8	26.8	7	33.8	26.8	10.5	33.75	23.2
5A	BATT 1A	11.3	18.8	7.5	11.3	19.4	8.1	11.6	18.7	7.1	15	21	6
8B	BATT 1B	11.5	18.7	7.2	11.5	19.3	7.8	11.5	19.3	7.8	14.8	21	6.2
6B	BATT 2A	7	24.5	17.5	6.5	20	13.5	6.5	20	13.5	11.5	24.5	13
7B	BATT 3A	11.5	20.9	9.4	11.5	234.5	11.53	11.5	234.5	11.53	13	22	8
6A	BATT 3B	5.5	21.8	16.3	5.5	20.9	15.4	6.5	20.9	14.4	10.5	22	11.5
5B	BATT 4B	10.5	21.8	11.3	10.5	21.8	11.3	11.3	20.9	9.6	13.8	22.7	8.9
7A	BATT 5A	11.3	20.9	9.6	11.3	20.9	9.6	11.6	20.9	9.3	15	22.7	7.7
9A	TX A	9	32.5	23.5	9	31.2	22.2	10	31.2	21.2	12.5	32.5	20
9B	TX B	9	30	21	9	30	21	10	39.1	19.1	12.5	30	17.5
10A	GCMS	9	26.4	17.4	9.5	25.6	16.1	10	26.5	16.5	13	28.1	15.1
10B	TUSO	7.5	37.5	30	7.5	27.3	19.8	8	36.5	28.5	11	36.2	25.2
11A	DISR I/F	-28.1	-28.1	0	-28.1	-28.1	0	-27.8	-27.8	0	-25.9	-25.9	0
11B	DISR SH	-2.5	7.3	9.8	-2.5	7.3	9.8	-2	6.8	8.8	0	8.1	8.1
12A	FOAM int	4	25.5	21.5	4	23.6	19.6	5	25.4	20.4	7	25.5	18.5
12B	CONE (foam ext)	-22	-17.7	4.3	-22	-17.7	4.3	-22	-17.7	4.3	-18.5	-16.1	1.6

c. Probe units internal T° reported through the Probe TM are summarized in the table hereafter:

IDENTIFICATION	F11 MEASURED RANGE INIT T° → END T°	F10 MEASURED RANGE INIT T° → END T°	F9 MEASURED RANGE INIT T° → END T°	F8 MEASURED RANGE INIT T° → END T°
RUSO Lamp	112.5° C → 112.5° C	101.7° C → 101.7° C	112.5° C → 112.5° C	112.5° C → 112.5° C
RUSO resonator	75° C → 75° C	64.4° C → 64.4° C	75° C → 75° C	75° C → 75° C
RUSO crystal	72° C → 73° C	64.4° C → 64.4° C	72° C → 73° C	72° C → 73° C
TUSO Lamp	112.5° C → 112.5° C	101.7° C → 101.7° C	112.5° C → 112.5° C	112.5° C → 112.5° C
TUSO resonator	76.4° C → 76.4° C	64.4° C → 64.4° C	76.5° C → 76.5° C	76.5° C → 76.5° C
TUSO crystal	73° C → 76° C	64.4° C → 64.4° C	73° C → 75.9° C	73° C → 75.8° C
PSA A Temp	20.5° C → 41° C	19.5° C → 39.1° C	19.5° C → 40° C	21.5° C → 40° C
PSA B Temp	20.5° C → 41° C	19.5° C → 39.1° C	19.5° C → 40° C	21.5° C → 40° C
Tx A HPA	12° C → 33.3° C	12° C → 33.7° C	12.5° C → 33° C	13° C → 33.6° C
Tx B HPA	12° C → 32.4° C	12° C → 32° C	12.5° C → 31° C	13° C → 31.6° C
CDMU A DC/DC 1	9.5° C → 38.8° C	9.5° C → 36.2° C	9° C → 39° C	11° C → 37.5° C
CDMU A DC/DC 2	9.5° C → 36.25° C	9.5° C → 33.75° C	9° C → 35° C	11° C → 35° C
CDMU B DC/DC 1	8.5° C → 36.25° C	8.5° C → 35° C	8° C → 35° C	11° C → 33.75° C
CDMU B DC/DC 2	8.5° C → 33.75 C	8.5° C → 31.25 C	8° C → 32.5° C	11° C → 31.25° C

Conclusion:

The initial steady state temperatures appear mostly related to the Sun to Spacecraft distance illustrated in Fig. 3.1, and to the Huygens Sun illumination : they are very similar to the one recorded during F10. This is reflected in most of the measured temperatures, with the delta ranges presented below :

	F11-F10	F10-F9	F9-F8	F8-F7	F6-F6	F6-F5
Average delta initial T°	0°C	0 to -1°C	-2 to -3°C	-2°C	+1.5°C	+1.5°C

The Figure 4.12 illustrates this overall behavior by showing the evolution of the PCDU initial temperature over the checkouts.

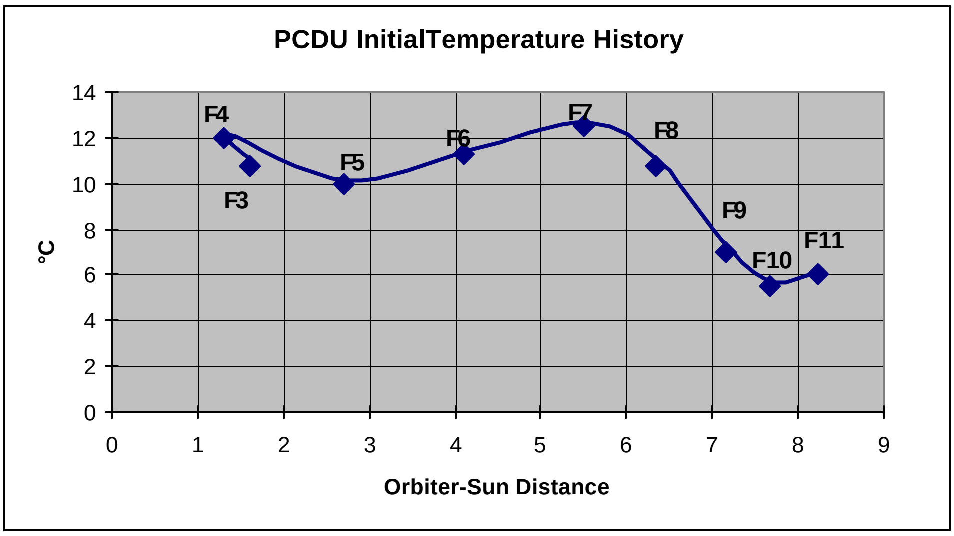

Fig 4.12 : initial PCDU temperature evolution

This can be explained by considering that HUYGENS was completely shadowed by CASSINI HGA during F1 to F5, partially subjected to - limited - solar illumination during F6 and F7. F8, F9, F10 and F11 reflect the effect of the Sun illumination decrease with the distance. Between F10 and F11, in relative, the CASSINI-Sun distance has only slightly increased, and the initial temperature change is therefore minimum. This trend is expected to continue until Probe separation.

The temperatures trends are in accordance with RD02, computed after the thermal model adjustment in July 98 (RD01).

They are in addition fully in line with F2, F3, F4, F5, F6, F7, F8, F9 & F10 measurements considering the respective checkouts durations (see Fig 4.1). This is clearly illustrated in Fig 13 for the PCDU case.

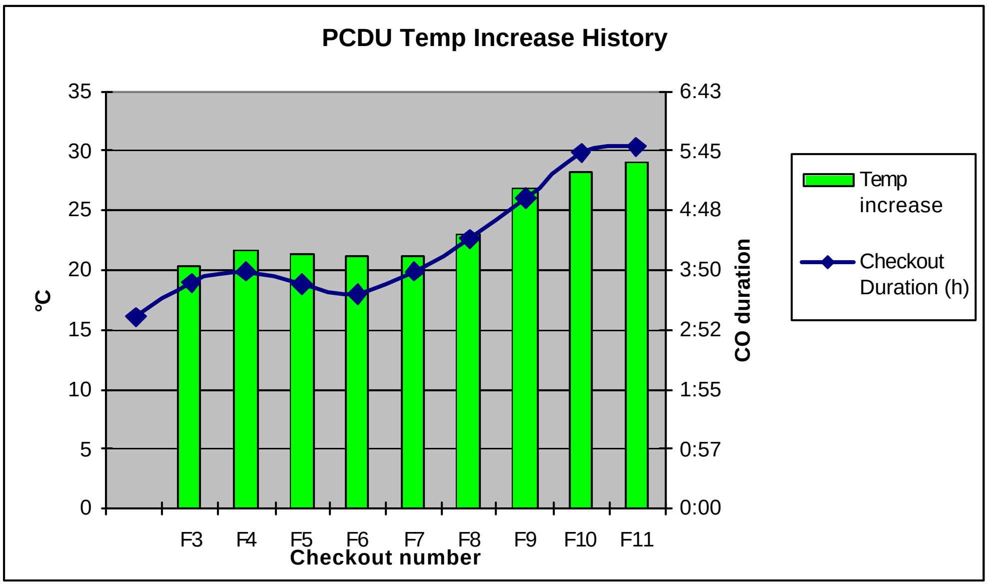

Fig 4.13 : initial PCDU temperature evolution wrt checkout duration

The overall Probe System thermal behavior is therefore considered nominal.

4.2.8. Experiments status word

The evolution of the Status Word for each instrument, is similar to its evolution during F9, used as the reference test, and considering F11 specificity's detailed in section 4.1.

Experiments detailed behavior analysis shall be found in the PI's F11 test reports: no anomaly related to the Probe System operation has been notified.

5. CASSINI CHECK OUTS

This chapter deals with the review of the technical issues raised, related to CASSINI and especially CASSINI experiments operations which have or may have an impact on the Huygens Probe System.

Belonging to that category, a statement was requested on the possibility to maintain nominally 6 of the CASSINI instruments in “ ON ” but “ sleep ” mode condition during future Probe Checkouts. EMC and 1553 Orbiter Data Bus issues have mainly been addressed via the analysis of documentation provided by JPL and dealing with :

- 1553 Bus muting
- EMC measurements recorded during “ quiet test ” on ground.

As mentioned in the F7 report, it was stated that :

- the mute mode proposed to be used to prevent data generation from CASSINI instruments during Probe Checkouts was fully satisfying HUYGENS request.
- the EMC results from ground testing were not considered to properly cover the conditions planned to be exercised in flight.

A dedicated flight test has been designed to assess the CASSINI instruments sleep mode impact on a “ dummy ” Probe Checkout.

This test has been run in august 2001, and has clearly demonstrated that the Probe was behaving nominally, and thus a flight checkout could be performed safely when CASSINI instruments were in sleep mode. As F8, F9 & F10, F11 was run with CASSINI instruments in sleep mode.

6. CONCLUSION

The eleventh Cruise Check out was performed on the 16th September 2002, at a distance from the Sun of ~8.24 AU.

ALL THE HUYGENS SUB-SYSTEMS OPERATED NOMINALLY AND WERE STABLE W.R.T. PREVIOUS CHECKOUTS.

The unexplained behavior, evidenced in the previous checkouts, related to the noise level on CASU accelerometers 1 and 3, has apparently disappeared. The issue however is still kept opened, and the corresponding TM parameters will continue to be carefully monitored.

The RF link between Probe and PSA was excellent, with an AGC signal in accordance with the expected value, without any Sun interference at CASSINI HGA input. The RF link with ground through the CASSINI HGA was nominal without loss of any packet and data.

This good quality of the overall HUYGENS to ground data path is confirmed by ESOC Reed Solomon analysis (see RD 12) which, except during transitions, shows that no Super Packet was rejected, while one single correction was performed over 37143 received Super Packets. In total, 80826 packets have been received and processed during F11, including PSE HK packets and dump super packets.

To conclude, the HUYGENS Probe System status, as analyzed from F11 after the Probe Relay Test 5 (run in Nov. 2002), is nominal. In addition, the Probe has demonstrated very stable performances over more than 5h of operation during which the overall Probe system environment (temperatures) has remained well within the units acceptance limits.