HUYGENS

TITRE : **HUYGENS FLIGHT CHECKOUT F5**
TEST REPORT

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RESUME D'AUTEUR

Ce document présente l'évaluation technique de la sonde HUYGENS pendant le cinquième " cruise check out " (F5). F5 s'est déroulé le 2 Février 2000.

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1. SCOPE

The present report covers the fifth flight cruise check-out (F5) performed in the frame of the phase F of the HUYGENS Probe

F5 was run at launch + 28 months on the 2nd of February 2000. It shall be pointed out that F5 was run the day before the so called **Probe Relay Test** (PRT) which aim was to characterize the PSE performance in realistic conditions. Therefore F5 also constitutes the reference for the Probe and PSE health before the PRT.

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 on the data downloaded in near real time to HPOC/ESOC during F5 through CASSINI high Gain Antenna during a single DSN pass. It was later cross checked with the same data recorded on board CASSINI SSR , and downloaded the day after F5.
- The reference test for comparison is mainly F3 run on the 22nd of December 1998 at launch+14 months.
- After some processing all the engineering data plots were delivered to ALCATEL during the week 6 2000, and all the status values were made available on the ESOC data server.

2. APPLICABLE DOCUMENTS

The tests have been performed according to the following documents:

- AD01: ESOC F5 sequence : DODS-SMD-HUY-FOP-001, issue 2.5
- 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 F5 Checkout Operational Report
  Doc. n° TOS-OF-HFR-005 Issue 1, date 02/2000

3. CONFIGURATION

3.1. SPACECRAFT CONFIGURATION

– F5 happens after the crossing of the asteroid belt in between Mars and Jupiter orbits. The Spacecraft is in cruise towards Jupiter with the -Z axis, ie the High Gain Antenna axis oriented towards the Earth. At the time of F5 the Sun-Spacecraft-Earth angle is about 19.5°, leaving Huygens partly illuminated. Location of CASSINI at F5 time, and planets/Sun geometry is illustrated in Fig.3.2 & 3.3. S/C orientation is Earth pointed with LGA2/Probe directed in the sunward direction

– 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 ~2.7AU (see Fig 3.1) and to the Earth is ~2.9 AU

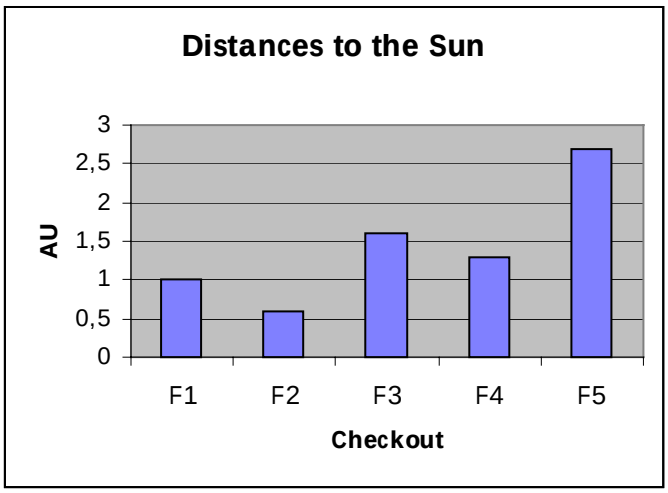


Fig. 3.1: CASSINI – Sun distance

– The CASSINI communication configuration status during F5 is :

- Prime antenna is the HGA rather than LGA-1

3.2. RADIO FREQUENCY SUBSYSTEM

TBD

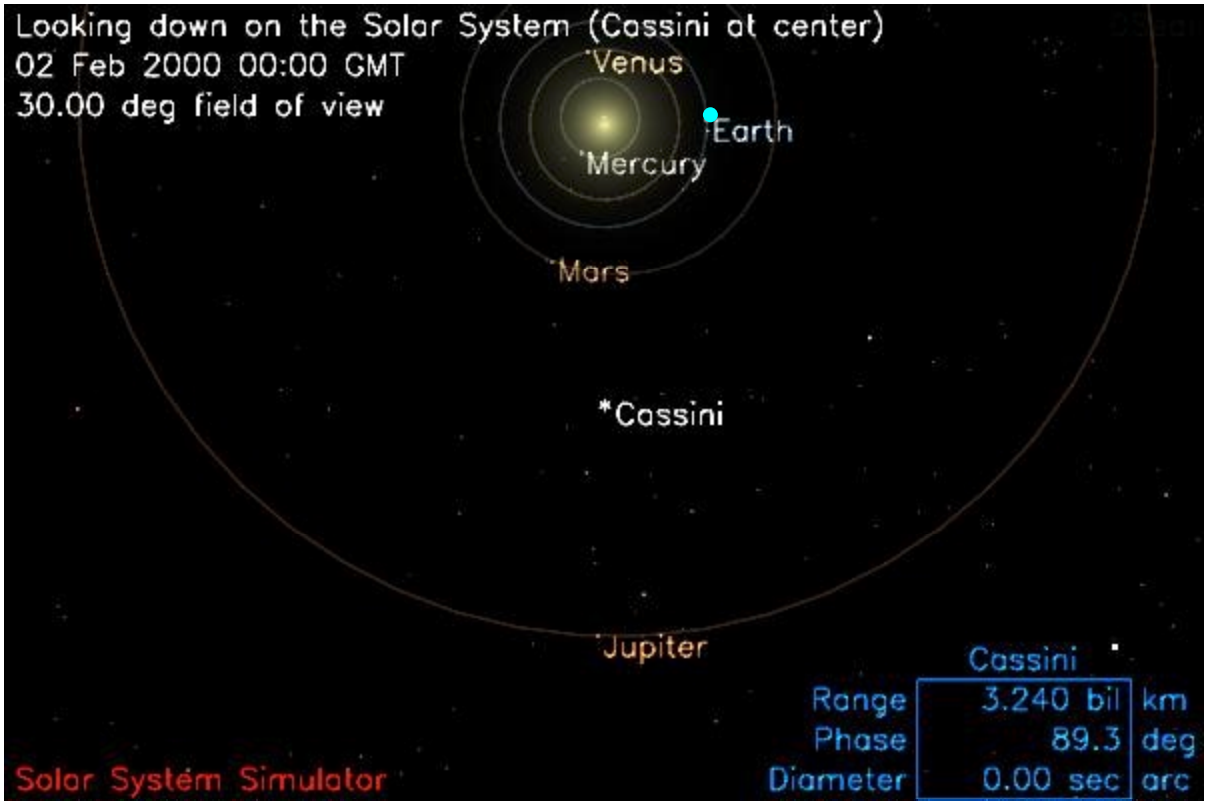


Figure 3.2 : CASSINI position during F5

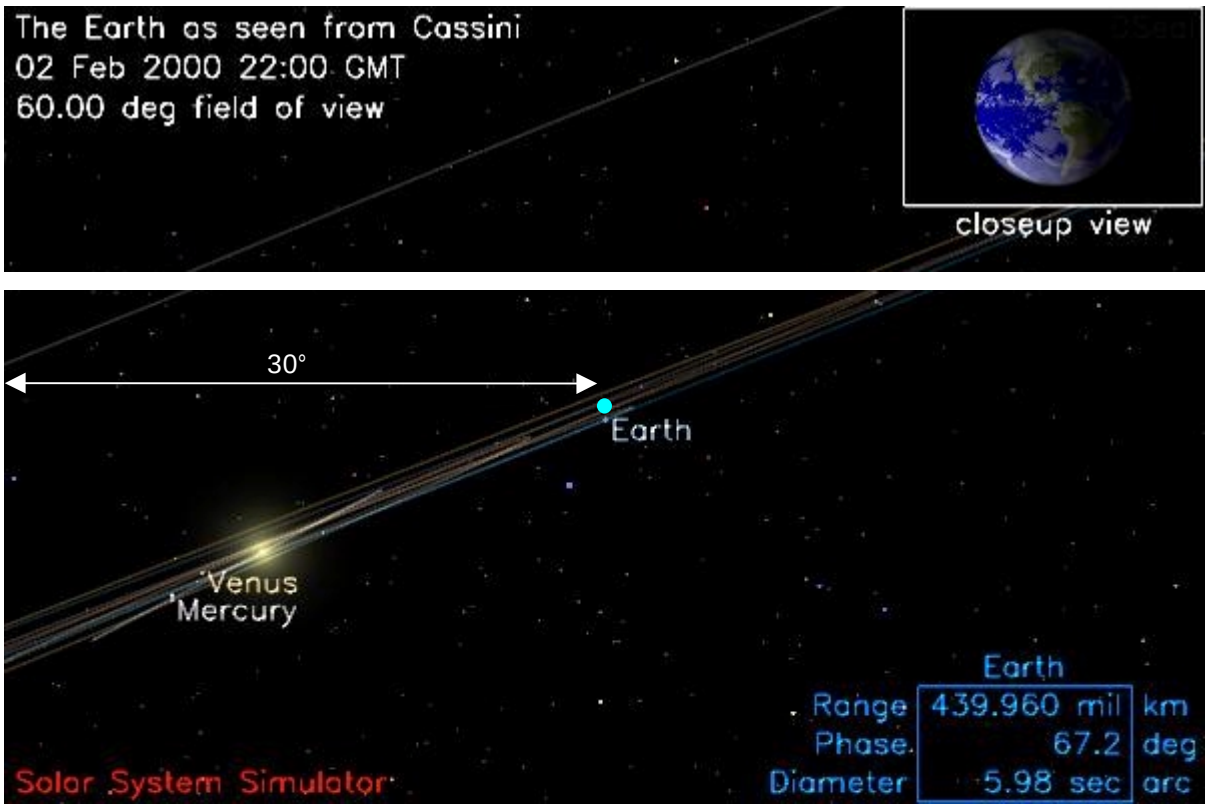


Figure 3.3 : SUN-EARTH position during F5

4. FLIGHT CHECK OUT 5 (F5)

4.1. OPERATIONS

F5 consists in the execution of a so-called Checkout scenario 2 (CO#2). 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 22h00 UTC on the 2/2/2000. 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 a 252.1 kbps rate via the DSN station in Goldstone.

The F5 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)
- HASI and SSP run a simulated descent *then SSP performs a specific investigation activity on APIS at So+153mn11s for a 42s duration.*
- ACP is in dormant mode during the first 110mn then in "mechanisms check mode" from 140 to 153mn.

- GCMS runs its calibration sequence :
  - Threshold scan
  - Lens scan 1
  - High power mode
  - Lens scan 2
  - Calibrate
- DISR runs the calibration sequences 1 & 2
- DUMP POSW A/B EEPROM starting at S0+156mn45sec

The F5 "as run" key events are:

EVENTS	SEQUENCE TIMING	EXECUTION TIME IN UTC
PSE turn on	S0-01:00:00	2000-033 T22:00:00
RUSO ON	S0-00:59:44	2000-033 T22:00:16
Select RUSO	S0-00:58:43	2000-033 T22:01:17
PROBE turn on	S0-00:36:00	2000-033 T22:24:00
TUSO ON	S0-00:35:44	2000-033 T22: 24:16
Select TUSO	S0-00:35:39	2000-033 T22:24:21
T0 detection	S0+0:6:375	2000-033 T23:00:06.375
PROBE OFF	S0+2:37:5	2000-034 T01:37:5
PSA's OFF	S0+2 :38:44	2000-034 T01:38:44

Checkouts durations are compared in Fig.4.1 hereunder. This shows that F3 and F5 durations were pretty similar.

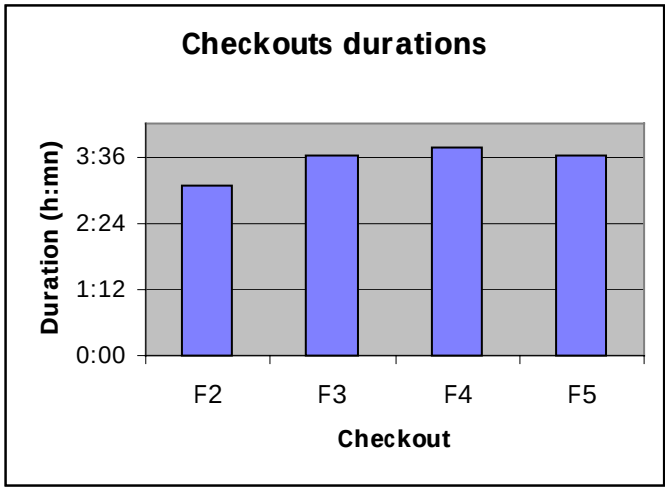


Fig. 4.1: Checkouts durations

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 on the 4/2/2000.

Reference for the analysis is **F3**, the previous CO#2 sequence performed on the 22nd of December 98, which was using TUSO and RUSO on the A chain; however comparisons are also performed with F4 results (F4 is a CO#1b sequence run of the 14/9/2000).

The main outcomes of the evaluation are:

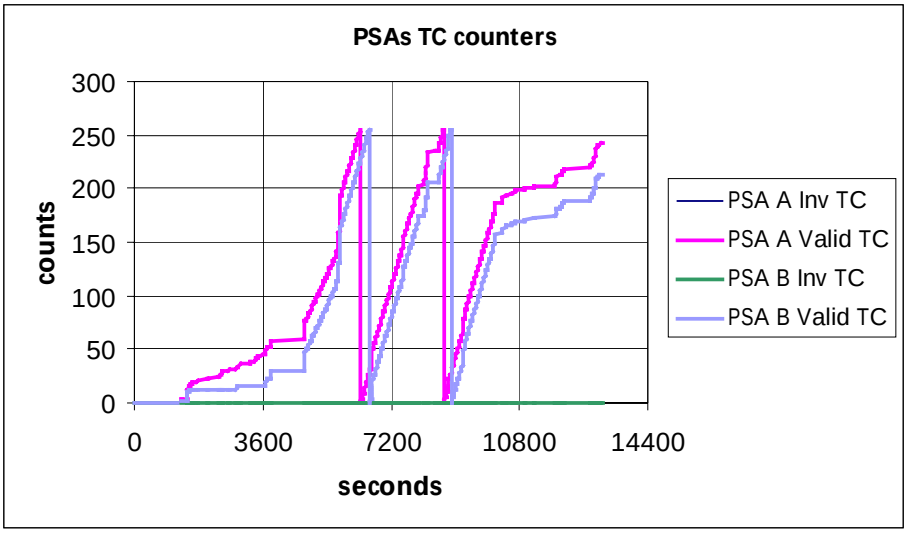
- the timing requested by the scenario are correctly followed by the CDS and all 7500 ground TCs are correctly executed for each chain,
- the timeline shows no anomaly (an overview of the sequence is given by the DDB information versus time)
- all the status information was detaily checked and validated from the data retrieved.

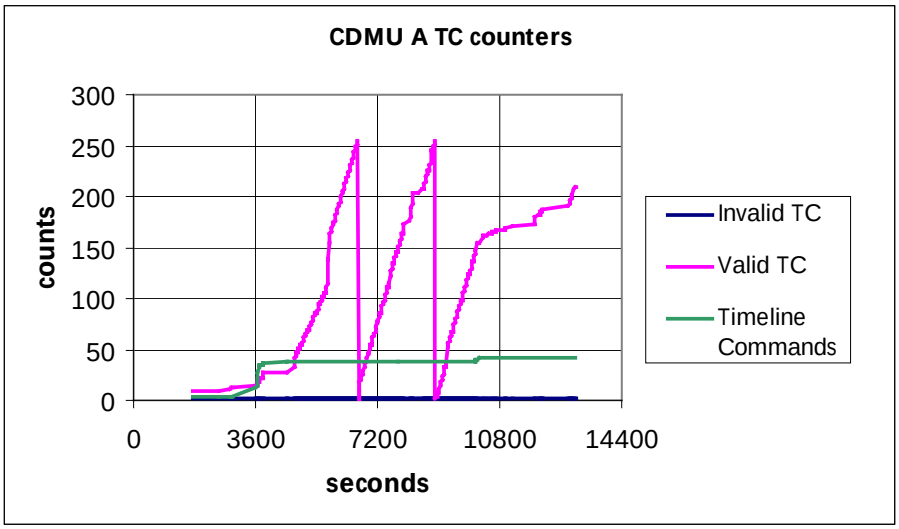
The following presents the analysis of F4, per function.

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 F5, where the time "0" corresponds to the start of F5 sequence, ie the turn ON of the PSA A & B. In this time scale, So event happens at t=3600s..





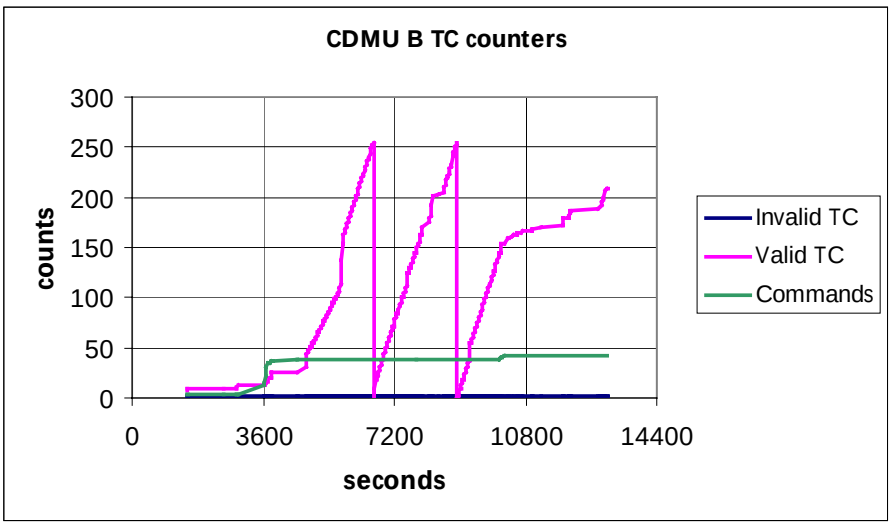


Fig 4.2 : Telecommand counters telemetry

It clearly appears that :

- All ground telecommands have been accepted as valid, both on PSAs and CDMUs 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 when the Probe is not yet powered. However few spurious increases (to up to 10 counts), simultaneously and of the same range, in the Dump Super Packet Delta Sequence count and the Dump Super Packet delta spacecraft time are flagged. These are not visible from the Dump Super Packets absolute Seq. Count for which a monotonous increase is nominally reported on both chains, when the Probe is not powered. Similarly the RT Count on both chains increases and resets when the Probe is OFF.

  This spurious increases in the super packets delta counts before Probe turn on has never been reported in the previous checkouts; this is however seen as a very minor anomaly since it is not correlated with any other abnormal behavior of the Probe system. This could actually be due to a problem in the retrieve of the telemetry (TBC by ESOC)
- **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 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 F3 results.
- **TUSO status**: TUSO is turned ON 16 s after Probe is ON. TUSO reports lock status at about TUSO ON+16mn, few minutes later than during F4 but similar to F3. This is explained by the TUSO initial temperature, as will be underlined later. Note that the mission timeline permits warm up duration as long as 30mn.
- **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 the **6th** attempt to switch to Basic Frequency; this is identical to F3 and close to F4 case (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 for F3 and F4, this is not a concern (in total the sequence plans 28 attempts to switch to basic frequency) and it is strongly believed this phenomenon to be related to the initial T° of TUSO which is basically identical between F3 and F5, about 10°C (against 12.5°C during F4), while it was higher during F1 ; a colder T° leads to a longer time for the TUSO oscillator frequency to stabilise and enter in the 30kHz PSA acquisition bandwidth. It should be pointed out that this problem will not happen during the mission : about 30mn TUSO warm up time is foreseen before PSA attempts to acquire the Probe RF signal, in Doppler mode (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 F5 is well in accordance with conclusions reached after the AGC specific test (see RD3) and confirmed by F3 than F4 : the very 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.

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**

- **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 to F3. Nevertheless, DWE have noticed a NCO frequency modulation similar to those observed during F1, F3 & F4 (~0.367Hz) with a maximum amplitude oscillation of about 20Hz (see DWE report) It shall be noticed that this is currently **not a Probe System concern.** Finally, so called dF/dt parameters on both chains are within the expected range.

4.2.4. Power

- **CASSINI Telemetry** has shown :
  - 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 F4,

- Probe total average maximum consumption is 150W.

Both 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 F5 are displayed in Fig 4.3. They are fully in line with the Mission Timeline and F5 sequencing.

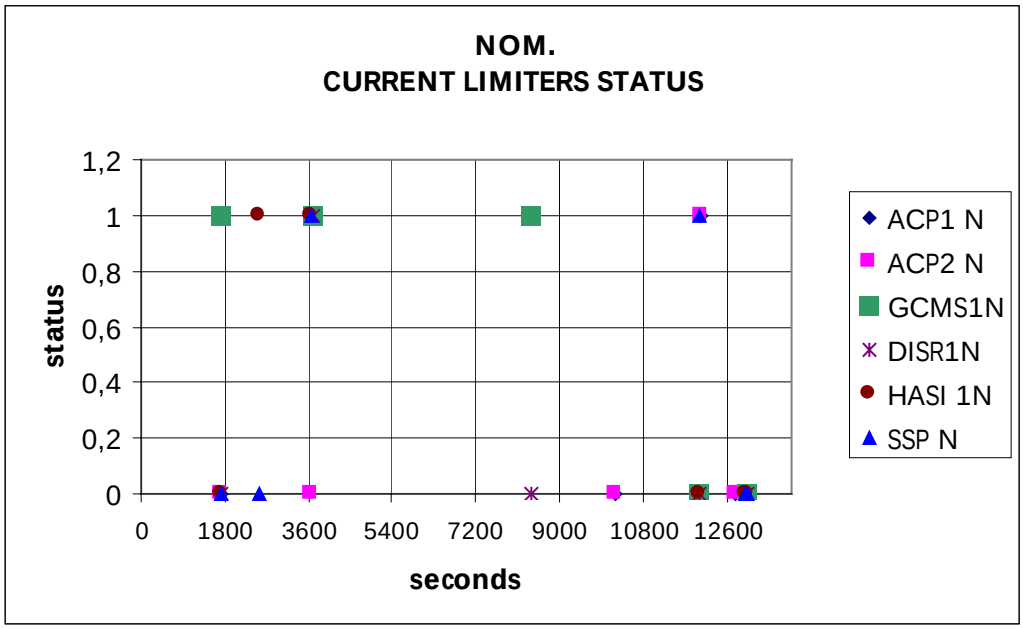


Figure 4.3 : Nominal current limiters status changes along F5 (“0” = start of F5)

- Pyros selection relays status changes during F5 are displayed in Fig 4.4 for both chains, with a zoom around T0. All the nominal and redundant relays are set and reset by each of the chain at the proper time, fully in line with the Mission Timeline and F5 sequencing.

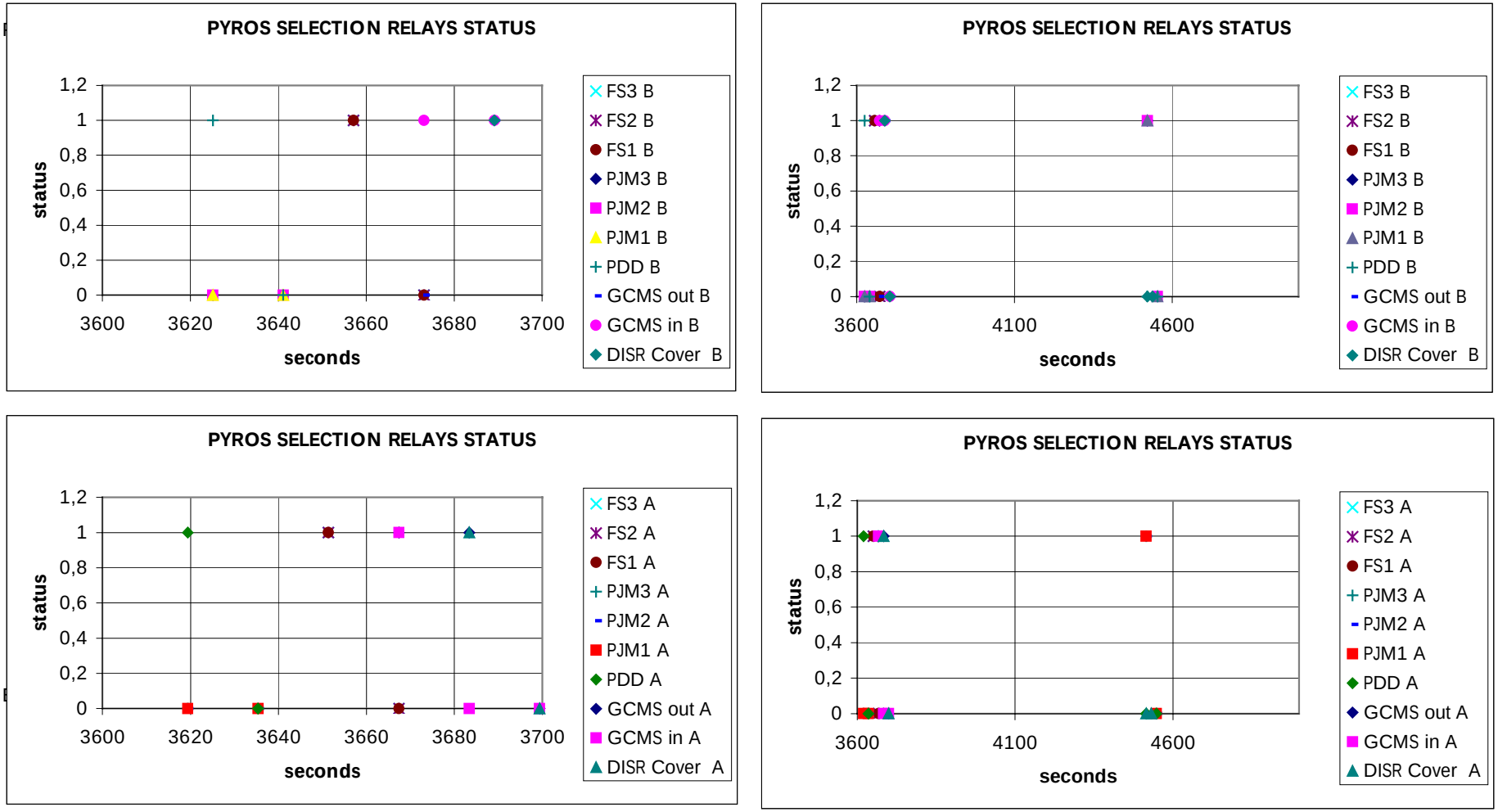


Figure 4.4 : Reported selection relay status changes along F5 (NB : S0 is at t=3600s)

- **Main bus voltage** is 28.09 Volts, as expected.

- **Batteries voltages** telemetry at the end of the test are similar to the telemetry reported during F3.

	F1	F2	F3	F4	F5
battery 1 A	2.93 V	2.28 V	2.00 V	2.6 V	2.00 V
battery 2 A	2.6V	2.28 V	2.00 V	2.28V	2.00 V
battery 3 A	1.3 V	1.30 V	1.00 V	1.30 V	1.00 V
battery 3 B	1.3 V	1.30 V	1.00 V	1.30 V	1.00 V
battery 4 B	2.6 V	2.28 V	2.00 V	2.30 V	2.00 V
battery 5 B	2.28 V	1.96 V	1.63 V	1.96 V	1.63 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 reflect the leakage current in the measurement diode. However, the fact that the measured value are similar to F3 reflects the respective PCDU temperature conditions during F3 & F5 (see § 4.2.7.). This is a normal behaviour.

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

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

	Pre To	To To+110 mn	To+140 mn	To+154 mn	Reference test
BDR1	0.55 A	0.82 A	0.74 A	0.5/0.65A	F3
BDR2	0.49 A	0.72 A	0.67 A	0.45A	F3
BDR3	0.49 A	0.72 A	0.67 A	0.45A	F3
BDR4	0.49 A	0.72 A	0.67 A	0.45/0.55 A	F3
BDR5	0.55 AA	0.82 A	0.74 A	0.5/0.65 A	F3

- **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	F3/F4
TUSO N	0.32 A warm up 0.127 A steady state	**TUSO R**	0.3 A warm up 0.120 A steady state	F3/F4
CDMU A	0.326 A	**CDMU B**	0.337 A	F3/F4
Prox Sensor A	0	**Prox Sensor B**	0	- (unit is OFF)
DISR1 N	0.16 A/peak 0.23 A	**DISR1 R**	0.15 A/peak 0.22 A	F3
DISR2 N	0	**DISR2 R**	0	F3
GCMS1 N	0.28 A in pre To 0.4 A in post To HP Mode : 0.60A	**GCMS1 R**	0.26 A in pre To 0.38 A in post To HP Mode : 0.60A	F3
GCMS2 N	0	**GCMS2 R**	0	F3
HASI1 N	0.2 A in post To	**HASI1 R**	0.18 A in post To	F3
HASI2 N	0	**HASI2 R**	0	F3
ACP1 N	0.07 A	**ACP1 R**	0.07 A	F3
ACP2 N	0	**ACP2 R**	0	F3
ACP3 N	Peaks up to 0.30 A	**ACP3 R**	Peaks up to 0.38 A	F3
SSP N	0.32 A	**SSP R**	0.027 A	F3

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 fonction.

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

  For the accelerometer 1, a value of 0g is reported on both 1A and 1B TM, with few spurious 1 LSB peaks.

  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 is definitely better : only accelerometer 1 TM seldom shows 1LSB peaks.

Explanations were provided in the F3 report describing the noticed noise as possibly coming from 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

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

- **DDB Mission Phase flags**: The telemetry properly reports the mission modes changes, identical to F3 : Flight Checkout Suspended and De-activate modes.

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

- **DDB Time**: For both chains, it is in line with Probe Real Time before To, then with Probe [Mission Time - 6.375s] from To (ie. from Tp+36mn6.375s to Tp+193mn50s).

- **DDB Altitude** : Nominally set to 320 km until To, 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 to invalid from Tp+35mn, giving the experiment the opportunity to listen to the B chain. Processor Valid changes along F5 are shown in Fig 4.5 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.

- **EEPROM's** : As for F3, 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 F4. No difference between F4 and F5 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 F5 duration.

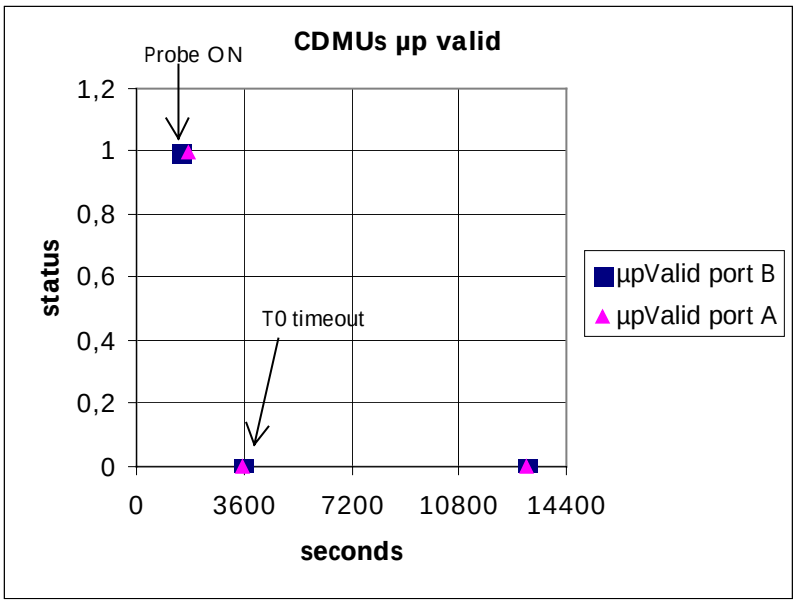


Fig 4.5 : µp Valid changes along F5 (S_0 is at t=3600s)

– **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 stabilised 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 4.6 and 4.7 hereafter show the evolution over F5 of the stabilised voltages as acquired by the CDMU's. The telemetry of the CDMU's 5V supply voltage is also displayed. This clearly demonstrate the very good operation of the Analog acquisition chain.

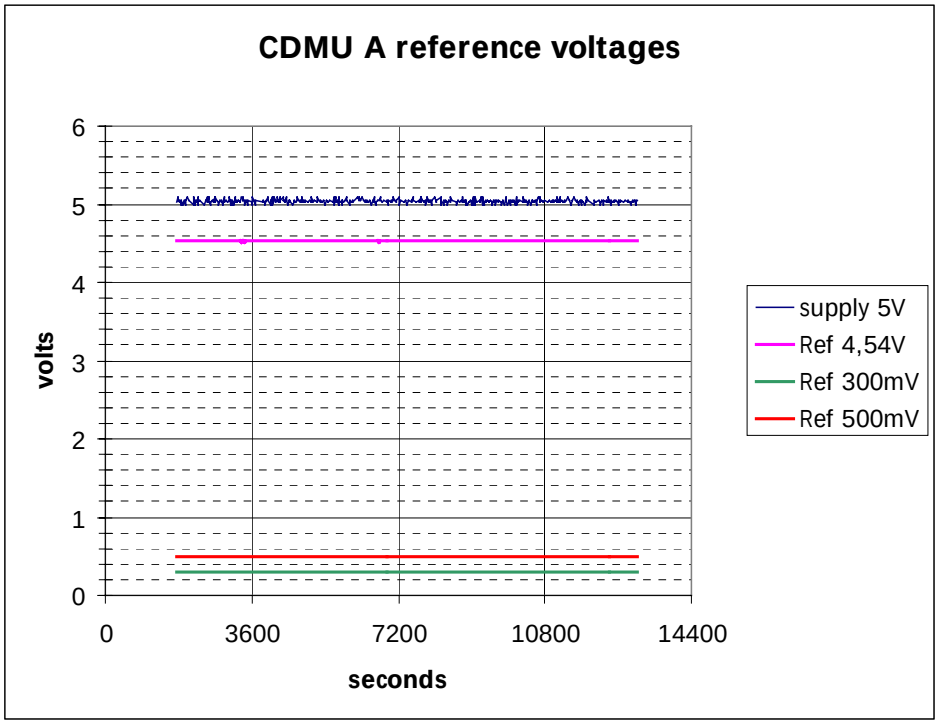


Fig 4.6 : CDMU A Voltages (5V is not stabilized)

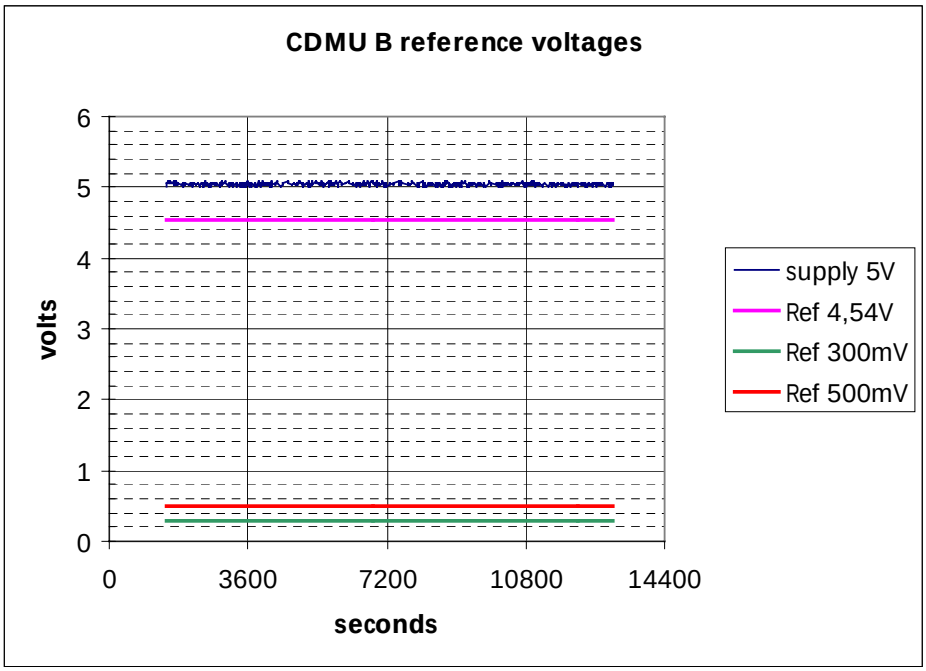


Fig 4.7 : CDMU B Voltages (5V is not stabilized)

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 F4, 10#7068 is identical to F1, F2, F3 & F4 tests data.

- **SASW CUT Processing Time**: It reflects the processor load for each CUT. As expected, and as per F1, F2, F3 & F4, 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 F5, on both chains, **DTStart** nominally happens 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 RTI (therefore CASSINI clock) drift w.r.t. the Probe (CDMUs) clocks.

  This drift is measured to be for both chains of about 40ms over the test duration (about 3h), in line with reference test results: this demonstrates that the CDMU oscillator stability has not changed. Processing duration, given by **FDI EXEC** parameter is in average 0.8ms, in line with the reference 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 the reference 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.

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 F5, 10#7425 is well in line with reference test data.

- **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 T0 time can be noticed; it reflects the fact that the MTT processing time is correlated to the place of the event in the timeline, therefore the current Mission Time.

  In total, the POSW processing time during F5 is very much comparable to F3, and denotes 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	F5 MEASURED RANGE INIT T° → END T°	F4 MEASURED RANGE INIT T° → END T°	F3 MEASURED RANGE INIT T° → END T°	F2 MEASURED RANGE INIT T° → END T°
MIMI elec T°	15°C → 19°C	22°C → 22°C	16° C → 19° C	18°C → 22°C
Probe T° 1	10°C → 32°C	12°C → 35°C	12° C → 33° C	15°C → 30°C
Probe T° 2	10°C → 32°C	12°C → 34°C	12° C → 33° C	15°C → 30°C
LNA A Temp	-10°C → -5°C	-4.7°C → 0.5°C	-8° C → -2.5° C	-1° C → 1°C
LNA B Temp	-10°C → -5°C	-5°C → 0.5°C	-8° C → -2.5° C	0° C → 2°C
SEPS Temp 1	-51°C → -50°C	-50.2°C → -49.5°C	-53° C→ -56° C	-45°C → -43° C
SEPS Temp 2	-50.5°C → -48.5°C	-50.2°C → -49.5°C	-52° C → -56° C	-45°C → -42° C
SEPS Temp 3	-50.5°C → -49.5°C	-52.5°C → -52.8°C	-56° C → -56° C	-49°C → -47°C
SEPS Temp 4	-54.1°C → -52.7°C	-54.8°C → -54.8°C	-56° C → -56° C	-52°C → -50°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	F5 MEASUREMENTS (2/02/2000)			F4 MEASUREMENTS (15/09/99)			F3 MEASUREMENTS (22/12/98)		
	Location	T init	T end	Delta	T init	T end	Delta	T init	T end	Delta
1A	SEPS A	-47.7	-47.7	**0**	-47.7	-47.7	**0**	-50	-50	**0**
2B	SEPS A	-47.7	-47.7	**0**	-47.7	-47.7	**0**	-49.5	-49.5	**0**
1B	SEPS B	-48.6	-48.6	**0**	-49.5	-49.5	**0**	-53.5	-53.5	**0**
2A	SEPS C	-51	-50	**1**	-51.7	-51.7	**0**	-54.3	-54.3	**0**
3A	PJM A	-27	-26.3	**0.7**	-26	-25.3	**0.7**	-28	-27.2	**0.8**
3B	PJM B	-25	-24.3	**0.7**	-24	-23.4	**0.6**	-25.7	-25.3	**0.4**
4A	PJM C	-26	-25.6	**0.4**	-25	-24.7	**0.3**	-26.9	-26.5	**0.4**
4B	PDD	-23	-22.5	**0.5**	-21.5	-21.3	**0.2**	-23.2	-23.1	**0.1**

b. Descent Module Internal units

TM IDENTIFICATION	Sensor Location	F5 MEASUREMENTS (2/02/2000)			F4 MEASUREMENTS (15/09/99)			F3 MEASUREMENTS (22/12/98		
8A	PCDU	10	31.3	**21.3**	12	33.7	**21.7**	10.8	31.2	**20.4**
5A	BATT 1A	14	18.8	**4.8**	16.5	21.8	**5.3**	15	19.4	**4.4**
8B	BATT 1B	12	18.8	**6.8**	16.5	21.8	**5.3**	13.1	19.4	**6.3**
6B	BATT 2A	10.5	21.8	**11.3**	13.1	24.5	**11.4**	11.2	22.7	**11.5**
7B	BATT 3A	14	18.8	**4.8**	14.3	21.8	**7.5**	15	19.4	**4.4**
6A	BATT 3B	10	18.8	**8.8**	12.5	21.8	**9.3**	10.8	19.4	**8.6**
5B	BATT 4B	14	19.4	**5.4**	15.7	21.7	**6**	14.4	20	**5.6**
7A	BATT 5A	14	20.	**6**	16.5	22.7	**6.2**	15	20.9	**5.9**
9A	TX A	12	29.1	**17.1**	14	32.5	**18.5**	13	30	**17**
9B	TX B	12	26.4	**14.4**	14	29.1	**15.1**	13	24.3	**11.3**
10A	GCMS	12	27.3	**15.3**	14.5	29.1	**14.4**	13	27	**14**
10B	TUSO	10	33.7	**23.7**	12.5	36.2	**23.7**	11	35	**24**
11A	DISR I/F	-25.6	-25.6	**0**	-25.2	-26.6	**0.8**	23.4	-26.6	**0.6**
11B	DISR SH	0	5.4	**5.4**	2.5	5.9	**6.1**	1	5.9	**4.9**
12A	FOAM int	7	22.7	**15.7**	9.5	25.4	**15.9**		23.6	**15.6**
12B	CONE (foam ext)	-19	-16.7	**2.3**	-17.5	-15.2	**2.3**	-19.5	-17.1	**2.4**

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

IDENTIFICATION	F5 MEASURED RANGE INIT T° → END T°	F4 MEASURED RANGE INIT T° → END T°	F3 MEASURED RANGE INIT T° → END T°
RUSO Lamp (ON)	112.5° C → 112.5° C	112.5° C → 112.5° C	113° C → 113° C
RUSO resonator (ON)	75° C → 75° C	75° C → 75° C	75° C → 75° C
RUSO crystal (ON)	72° C → 73° C	72° C → 73° C	72° C → 73° C
TUSO Lamp (ON)	112.5° C → 112.5° C	112.5° C → 112.5° C	112.5° C → 112.5° C
TUSO resonator (ON)	76.5° C → 76.5° C	76.5° C → 76.5° C	76.5° C → 76.5° C
TUSO crystal (ON)	74° C → 75° C	74° C → 75° C	74° C → 75° C
PSA A Temp	16.5° C → 36.4° C	22° C → 40° C	18° C → 37.3° C
PSA B Temp	16.5° C → 36.4° C	22° C → 40° C	18° C → 36.4° C
Tx A HPA	13° C → 30.4° C	14° C → 33.3° C	13° C → 31.6° C
Tx B HPA	13° C → 28° C	14° C → 31.2° C	13° C → 28.8° C
CDMU A DC/DC 1	10° C → 33.7° C	13° C → 37.5° C	12° C → 35° C
CDMU A DC/DC 2	10° C → 31.2° C	13° C → 33.7° C	12° C → 31.3° C
CDMU B DC/DC 1	10° C → 30° C	12° C → 33.7° C	11° C → 31.3° C
CDMU B DC/DC 2	10° C → 28.2° C	12° C → 30° C	11° C → 29° C

Conclusion:

The initial steady state temperatures appear mostly related to the Sun to Spacecraft distance illustrated in Fig. 3.1 : they are marginally cooler than during F3 and cooler than during F4. This is reflected in most of the measured temperatures, with the delta ranges presented below :

	F5-F3	F5-F4
Average delta initial T°	-1°C	-2°C to –4°C

However, temperatures of some external units (eg. SEPS) are similar to F4, ie. relatively warmer than anticipated from the above : this may be explained by the different orientation of CASSINI wrt Sun when compared to previous checkouts (see Fig. 3.2 & 3.3). HUYGENS was completely

shadowed by the HGA during F1 to F4, while it was be partially subjected to - limited - solar illumination during F5.

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

They are in addition fully in line with F4, F3 & F2 measurements considering the respective checkouts durations (see Fig 4.1). Especially, F5 compares very well to F3, for the initial T°, but also for the range of temperature increase over the test.

The overall Probe System thermal behavior is therefore considered as nominal.

4.2.8. Experiments status word

The evolution of the Status Word for each instrument, is similar to its evolution during F3, used as the reference test.

Experiments detailed behavior analysis shall be found in the PI's F5 test reports: no anomaly related to the Probe System operation has been notified.

5. CASSINI INSTRUMENTS CHECK OUT (ICO)

This chapter generally deals with the review of the technical issues raised in the F4 to F5 review time frame, related to CASSINI, and especially CASSINI experiments operations which have or may have an impact on the Huygens Probe System.

Basically, over this period, the concern addressed in the F3 and F4 reports about the Radio Front End (RFE) unit thermal behavior during operation of the CASSINI Radio Science experiment was closed based on an analysis performed by ESTEC, showing that the parts and processes used in the RFE were likely to comply with any heating induced by RSS operations.

On another hand, a statement was requested on the possibility to maintain some experiment in sleep, but still "ON", mode during the Huygens Probe mission, considering that this configuration was never tested on ground. The statement should address the power, data bus and EMC issues. The corresponding analyses are on going, and the relevant conclusions are not part of the present document.

6. CONCLUSION

The fifth Cruise Check out was completed on the 2nd September 2000, after the crossing of the asteroid belt, and at a distance from the Sun of ~2.7AU.

ALL THE HUYGENS SUB-SYSTEMS OPERATED NOMINALLY.

Especially one unexplained behavior, evidenced in the previous checkouts, related to the noise level on CASU accelerometers 1 and 3, was no more flagged. The issue however must be kept opened, and the corresponding TM parameters still need 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 06) which, except during transitions, shows that no Super Packet was rejected, while one single correction was performed over a total of 22967 received Super Packets.

To conclude, the HUYGENS Probe System status before the PRT (Probe Relay Test) was very good.