HUYGENS

TITRE : **HUYGENS FLIGHT CHECKOUT F#1 & F2 TEST REPORT**

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RESUME D'AUTEUR

Ce document présente l'évaluation technique de la sonde HUYGENS :

- pendant les deux premiers « Cruise check out » F1 & F2 effectués rapidement à Lancement + 8 jours & Lancement + 6 mois.
- pendant le spécifique « AGC in flight test » effectué à Lancement + 8 mois avec la HSA Callini de ? ? ? ? du soleil de 10°.

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1. SCOPE

The present report covers the flight cruise check-outs performed in the frame of the HUYGENS Phase E, i.e.:

- at launch + 8 days, the 23rd October 1997: **F1** (type of checkout was C0#2) from 07 : 45 :00 UTC to 11 :19 :06 UTC
- at launch + 6 months the 27th March 1998: **F2** (type of checkout was C0#1) from 01 :10 :18 UTC to 04 :50 :18 UTC
- at launch + 8 months the 28th May 1998: **AGC special test** from 12 :00 :00 to 12 :33 :30 UTC.

It aims at analysing the behavior of the HUYGENS Probe System during both tests.
Note that experiments behavior analysis is not part of this document.

⇒ F1: The present analysis is based on the best data retrieved from JPL and stored on board CASSINI SSR.

This set compared to the real time data shows the following improvements:

- a 4 mn TM loss due to DSN stations handover problem has been recovered
- an AGC spike at 08 :48 :28 UTC has disappeared: it was a feature induced by the data gaps of the real time TM stream
- reason for several lost packets has been identified except 3 super packets lost at 08 :43 :29.

⇒ F2: The whole check out running outside ground station visibility, DSN passes and additional play back has allowed HPOC to receive the following data w.r.t the start of the check out:

1. 00 :00 to 00 :53 (full time resolution).
2. 01 :20 to 01 :22 (full time resolution).
3. 01 :52 to 02 :11 (full time resolution).
4. 02 :39 to 03 :04 (full time resolution).

5. 00 :53 to 01 :52 (10 sec every min).

6. 02 :11 to 02 :39 (10 sec every min).

The present analysis is based on data provided by ESOC on the 24/04/98 by fax and complementary data (as requested by AEROSPATIALE in June 98) put on the ESOC server in July.

⇒ Investigation: AGC special test has been run after the Venus fly-by, the 28th May 1998.

Recorded data has been down linked by CASSINI in three passes on the 28th, 29th and 30th of May with regular samples of about 1 second every minute.

2. APPLICABLE DOCUMENTS

The tests have been performed according to the following documents:

- AD01: JPL Procedure CAS 348 Rev XX: Probe check outs
- AD02: Sequences ESOC: HUYGENS_F1_CO and HUYGENS_F2_CO
- AD03: ESOC database
  Doc. n° ESOC XX.

Reference documents for the present report are:

- RD01: PDRS AGC Anomalies
  Doc. n° HUY.AS/c.100.TN.0552
- RD02: KSC Baseline Test Report
  Doc. n° HUY.AS/c.100.TR.0529
- RD03: T° Flight Prediction Report
  Doc. n° HUY.MBB.340.AN.0045, Issue 03
- RD04: Preliminary Evaluation of F1 after 1 month in Orbit
  Fax 833/97 dated 17/11/97
- RD05: Huygens F1 checkout review report
  ESOC ref :TOS-OF/HUY/160/CS/HS date 11.02.98
- RD06: Minutes of meeting ESOC 16/04/98

- RD07: Minutes of meeting ESOC 17/04/98

- RD08: Thermal model adjustment and recalculation of temperatures
  Doc. n° TN-RIA54-98-0018-A date 07/07/98

- RD09: Solar flux impact on AGC/noise measurements
  ESOC ref: TOS/OF-S/BS/0002 date 28/05/98

- RD10 :Huygens F2 checkout review report
  ESOC ref :TOS-OF/HUY/200/CS/HS date 17.07.98

- RD11: Huygens AGC Inflight test (F2s) operational report
  ESOC ref :TOS-OF-HFR-003 date 25.09.98

- RD12: PDRS Transmitter: investigation of in orbit anomaly
  Doc. n° HUY-AL/R-380-TN-0397 date: 10/06/98.

3. CONFIGURATION

3.1. SPACECRAFT CONFIGURATION

- As far as F1 and F2 are concerned the CASSINI SPACECRAFT is in cruise towards Venus with the S/C -Z axis oriented to the Sun in order to have the High Gain Antenna shadowing the rest of the spacecraft.
- The accuracy of the HGA pointing to the Sun is 10 mrad during F1 and 20 mrad during F2.
- The relative distances to the Sun are respectively ~1AU for F1 and ~0.6 AU for F2.
- The CASSINI Telecommunication Subsystem status during F1 & F2 is presented in Tables 3.2-1 and 3.2-2 (JPL statement): it shows the HUYGENS flight rules have been followed.
- The investigation about that AGC variations is performed after the Venus flyby with the HGA off Sun pointed by 10°.

3.2. RADIO FREQUENCY SUBSYSTEM

The **RFS** related spacecraft states for Probe check out # 1 and # 2 was:

Common states were:

- TCU-A (Telemetry control unit)
- TM1 ON (TCU telemetry driver to DST-A)
- TM2 Off (TCU telemetry driver to DST-B)
- DST-A (Deep Space Transponder)
- X-TWT-B (Travelling Wave Tube Amplifier)
- TWNC OFF (coherent)
- USO ON and enabled
- Command rate 62.5 bps
- Convolution coding (15,1/6).

– F#1:

STATES	BEFORE	DURING	AFTER
S/C Telemetry mode	RTE & SPB_14220	PCHK 24885	RTE & SPB_14220
S/C ranging modulation		Low throughput	
S/C antenna		LGA-1	
Telemetry modulation index		Step 45 (78 degrees)	
Telemetry sub-carrier		High (360 kHz)	
DST receiver		In lock on the coherent	
Ranging suppression		3 dB uplink	

TABLE 3.2-1

– F#2:

STATES	BEFORE	DURING	AFTER
S/C Telemetry mode	RTE & SPB_14220	PCHK 24885	RTE & SPB_14220
S/C ranging modulation	High 0.81 radians	Low throughput 0.27 radians	High 0.81 radians
S/C antenna	LGA-2	LGA-1	LGA-2
Telemetry modulation index	Step 30 55 degrees	Step 47 80 degrees	Step 30 55 degrees
Telemetry sub-carrier	Low 22.5 kHz	High 360 kHz	Low 22.5 kHz
DST receiver		Out of lock No uplink	
Ranging suppression		NO	

TABLE 3.2-2

NOTE 1: In order to switch from LGA-2 to LGA-1 and vice versa ,the X-TWTA-B was turned from Operate to Stand by for 5 seconds, and then back to Operate. We did not expect to see a signal from LGA-1 during F#2 due to the spacecraft geometry. We monitored the beginning of the F#2 activity and saw the signal go away as expected. On the next tracking pass, the RFS command counter reported the expected number of RFS commands.

NOTE 2: DST receiver AGC varies with the temperature.

4. FLIGHT CHECK OUT 1 (F1)

4.1. OPERATIONS

F1 consists in the execution of a so-called Checkout scenario 2 (CO#2).

The relevant SASF was loaded on board CASSINI, then executed at a pre-programmed time. Thanks to the relatively close distance from Earth, Probe telemetry was transmitted and monitored in quasi real time by the complete ESA/AS team from the ESOC facilities.

The C0#2 architecture is based on:

- PSA activation through Orbiter CDS power on TC at So-60 mn
- Probe wake up by the CASSINI Orbiter via the Solid State Power Switches at So-24 mn
- T0 simulated by Resume command at So and To detection at So+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
- ACP is in dormant mode during the first 110 mn then in "mechanisms check mode" from 140 to 153 mn. Special commands are sent to unlock the gate valve (to one third of the mechanism), previously locked to cope with Launch phase constraints
- GCMS runs its calibration sequences:
  - threshold scan
  - lens scan1
  - high power mode
  - lens scan 2

- calibrate.

– DISR runs the calibration Sequences 1 and 2.

The F1 "as run" key events are:

EVENTS	SEQUENCE TIMING	EXECUTION TIME IN UTC
PSE turn on	S0-01:00:00	1997-296 T07:45:00
RUSO ON	S0-00:59:44	1997-296 T07:45:16
Select RUSO	S0-00:59:43	1997-296 T07:45:17
PROBE turn on	S0-00:24:00	1997-296 T08:09:00
TUSO ON	S0-00:23:44	1997-296 T08:09:16
Select TUSO	S0-00:23:43	1997-296 T08:09:17
Time-out on To detection	S0-00:00:45	1997-296 T08:44:45
To detection		1997-296 T08:45:00
PROBE OFF	T0+2:33:06	1997-296 T11:18:12
PSA A Off	T0+2:34:00	1997-296 T11:19:06

4.2. RESULTS

As already mentioned, the analysis is based both on real time analysis during the test execution and on post-test retrieved data.

Reference for the analysis is **the CO#2 performed on 5th of August in the frame of the Baseline Test** with CASSINI in mated configuration in the KSC PHSF.

The main outcomes of the evaluation are:

the timing requested by the scenario are correctly followed by the CDS and all TCs are correctly executed except one by the GCMS at 09 :14 :23

timeline shows no anomaly (an overview of the sequence is given by the DDB information versus time)

all the status informations were checked and cross validated in the course of the test.

The following presents the analysis of F1, per function.

4.2.1. Frames and packets structure

This section deals with the review of the data basically 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 except one (resp. 2) packet missing on chain A (resp. B) at T08:43:29.

- **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, together with a monotonous increase of the Seq. Count is nominally reported on both chains when the Probe is not yet powered. Similarly 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. A Delta 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 $T_{probe\ ON}$.

4.2.2. 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.

It is, first, worth while mentioning that the RF configuration in which F1 was run cannot be strictly compared, at least quantitatively, to any of the tests run on ground, including mated tests.

Most significant differences are:

- during F1, the CASSINI X-band RF transmitter was permanently in operation; CASSINI LGA1, located inside the HGA was used

- the EMC environment in space is hardly comparable with the one inside clean rooms or launch pad.

However, for this first flight checkout, it is necessary to have a basis to refer to; the mated CO#2, run on the 5th of August 98 has been found to be the most representative.

- **PSA secondary voltages**: PSA 12 V, 5 V and LNA supply voltage (nominally 12 V), are is their nominal range and perfectly stable over the test.

- **RUSO status**: RUSO is turned ON 16 s after PSA A is ON. RUSO reports lock status at RUSO ON+16 mn 45 s, well in line with ground measurements and expected behavior.

- **TUSO status**: TUSO is turned ON 16 s after Probe is ON. TUSO reports lock status at TUSO ON+17 mn 20 s, well in line with ground measurements and expected behavior.

- **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 the 3rd attempt to switch to Basic Frequency; it shall be noticed that ground tests used to show a complete receiver lock on chain A during CO#2 at the 2nd attempt at worst. This is however not considered to be a concern (in total the sequence plans 28 attempts to switch to basic frequency).

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

– **AGC**: Anomalies notifications have been identified:

1. Loss of 4.5 dB on both chains:

The table hereunder evidences this point by summarizing the most recent tests outcomes: CO#2 Baseline Test run in clean room environment at KSC in mated configuration, Contigency Checkout run directly on the launch pad, and F1.

TEST	AGC A	AGC B
CO#2 mated in PHSF	-96 dB +/-0.4 /decrease 0.7 dB	-95.5 dB +/-0.2 /decrease 0.4 dB
CGCK on the pad	-100.5 dB +/-1 dB modulated 2.8 dB	-96.5 dB +/-0. 3 modulated 1.3 dB
F1	-101 dB+/-0.4 S shape period 85 mn	-100.6 dB+/-0.4 S shape period 85 mn

2. AGC evolution was not in line with expected: in the course of F1, AGC changes by about 2 dB on both chains.

Point 1 is detailed in RD01, where a preliminary analysis is performed. At the issue of F1 analysis, no final explanation were given.

Both problems are worked in the frame of a dedicated investigation team. (see § 6.2).

– **NCO**: as far as Probe System is concerned, NCO frequency changes are as expected, both on chain A (RUSO) and chain B (TCXO). Nevertheless, DWE have noticed a NCO frequency modulation increase by a factor of 2 w.r.t. ground tests (40 Hz instead of 20 Hz). 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.

4.2.3. Power

– In general, CASSINI TM, monitored in real time during the test, has shown:

- PSE total consumption of 58 W
- Probe total average maximum consumption of 130 W.

Both values are well in line with reference test results.

- **All Current limiters status and Pyro relays status** have been cross checked in real time during the test. No anomaly was generally noticed at that time.

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

- **Batteries voltages** telemetries are at the end of the test slightly higher than during the reference test:

  - battery 1 A 2.93 Volt instead of 1.6 V
  - battery 2 A 2.60 Volt instead of 1.6 V
  - battery 3 A 1.30 Volt instead of 1 V
  - battery 3 B 1.30 Volt instead of 1 V
  - battery 4 B 2.60 Volt instead of 1.6 V
  - battery 5 B 2.28 Volt instead of 1 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 leak current in a measurement diode. However, the Delta in the measured value is related to an increase in the PCDU temperature (see § 4.2.6.). It is a normal behavior.

Note that the lower battery 3 voltage parameter reflects the cross trapping of the relevant telemetry.

- **BDR currents** are in accordance with the operating modes of the Probe System and experiments:

	Pre To	To To+110 mn	To+140 mn	To+154 mn
BDR1	0.58 A	0.82 A	0.74 A	0.5/ 0.65 A
BDR2	0.49 A	0.72 A	0.67 A	0.45/0.55 A
BDR3	0.49 A	0.72 A	0.67 A	0.45/0.55 A
BDR4	0.49 A	0.72 A	0.67 A	0.45/0.55 A
BDR5	0.58 A	0.82 A	0.74 A	0.5/ 0.65 A

- **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
TX A	0.19 A	**TX B**	0.195 A
TUSO N	0.32 A warm up 0.13 A steady state	**TUSO R**	0.3 A warm up 0.123 A steady state
CDMU A	0.326 A	**CDMU B**	0.337 A
Prox Sensor A	0	**Prox Sensor B**	0
DISR1 N	0.16 A/peak 0.25 A	**DISR1 R**	0.15 A/peak 0.25 A
DISR2 N	0	**DISR2 R**	0
GCMS1 N	0.28 A in pre To 0.38 A in post To HPwM: 0.58 A	**GCMS1 R**	0.26 A in pre To 0.36 A in post To HPwM: 0.55 A
GCMS2 N	0	**GCMS2 R**	0
HASI1 N	0.2 A in post To	**HASI1 R**	0.18 A in post To
HASI2 N	0	**HASI2 R**	0
ACP1 N	0.07 A	**ACP1 R**	0.07 A
ACP2 N	0	**ACP2 R**	0
ACP3 N	Peaks up to 0.35 A	**ACP3 R**	Peaks up to 0.38 A
SSP N	0.32 A	**SSP R**	0.027 A

4.2.4. Data handling

This section deals with the analysis of all the telemetry data related to the CDMS.

- **Central Acceleration data**: The reported TM nominally shows a 0 g value, with a 1 LSB noise on accelerometer 1 mainly.

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

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

- **DDB F1 & F2 flags status**: S0 "detection" is correctly reported on both chains through F1 change. F2 nominally reports the TAT use over the whole sequence.

- **DDB Time**: For both chains, in line with Probe Real Time before T0, then with Probe Mission time from T0 (from Tp + 29 mn to Tp+152 mn 48 s).

- **DDB Altitude**: Nominally set to 320 km up to T0, then follows the TAT down to "surface" (Proximity Sensor is OFF).

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

4.2.5. On board softwares

4.2.5.1. 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 F1, 10#7000 is well in line with reference test data.

- **SASW CUT Processing Time**: It reflects the processor load for each CUT. As expected, Processing time ranges from 22 ms to 26 ms, 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 < 120 ms. **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. The constraint for a safe software operation is actually [**DTStart EXEC + FDI EXEC + DMA EXEC < 4.5 ms**].

- During F1, on both chains, **DTStart** nominally happens 18 ms after the CUT start; processing duration is in average 1.4 ms, 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 50 ms over the test duration (about 3 h), 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 0.8 ms, 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.
  Telemetry related to DMA interrupt is quite similar to FDI related telemetry, with the same comments.
  Duration of the interrupt servicing is, in average, 1.4 ms, in line with the reference tests results.

As a conclusion, we have [**DTStart EXEC + FDI EXEC + DMA EXEC** = 3.6 ms], and the criterion mentioned before, (**DTStart EXEC + FDI EXEC + DMA EXEC** < 4.5 ms) is fulfilled, ensuring in any case a correct software operation.

4.2.5.2. 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 F1, 10#7400 is well in line with reference test data.

- **POSW CUT Processing Time**: It reflects the processor load for each CUT. As expected, Processing time ranges from 56 ms to 68 ms, representing a nominal CDMU data handling processor load of about 55 % max. A slow increase of the processor load from To 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 Mission Time.

4.2.6. 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	F1 MEASURED RANGE INIT T° → END T°	PREDICTED RANGE INIT T° → END T°
MIMI elec T°	18° C → 22° C	TBD by JPL
Probe T° 1	15° C → 36° C	22° C → 47° C
Probe T° 2	15° C → 36° C	22° C → 47° C
LNA A Temp	-6° C → 0° C	-30° C → 0° C
LNA B Temp	-6° C → 0° C	-30° C → 0° C
SEPS Temp 1	-50° C → -50° C	-39° C → -36° C
SEPS Temp 2	-50° C → -50° C	-39° C → -36° C
SEPS Temp 3	-52° C → -52° C	-40° C → -37° C
SEPS Temp 4	-54° C → -54° C	-41° C → -38° C

Temperatures values acquired by the HUYGENS Probe are summarized in the table hereafter:

a. Descent module External units:

TM IDENTIFICATION	T° SENSOR Location	F1 MEASUREMENTS (23/10/97)			PREDICTIONS		
		T init	T end	**Delta T°**	T init	T maxi (**)	**Delta T°**
1A	SEPS A	-46.4	-46.4	**0**	-38.8	-35.6 (*)	3.2
2B	SEPS A	-46.4	-46.4	**0**	-38.8	-35.6 (*)	3.2
1B	SEPS B	-48.6	-49.1	**-0.5**	-40.1	-37.1 (*)	3
2A	SEPS C	-49.5	-49.5	**0**	-40.9	-37.8 (*)	3.1
3A	PJM A	-23.8	-23.4	**0.4**	-22.7	-18.8 (*)	3.9
3B	PJM B	-21.9	-21.6	**0.3**	-21.4	-17.6 (*)	3.8
4A	PJM C	-23.1	-22.8	**0.3**	-22.7	-18.6 (*)	4.1
4B	PDD	-19.4	-19.4	**0**	-21.7	-17.7 (*)	4

b. Descent Module Internal units

8A	PCDU	15	35	**20**	21.1	41.9	**20.8**
5A	BATT 1A	18.8	23.6	**4.8**	24.1	34.2 (*)	10.1
8B	BATT 1B	18.8	23.6	**4.8**	24.1	34.2 (*)	10.1
6B	BATT 2A	16.3	26.4	**10.1**	22.7	34.3 (*)	11.6
7B	BATT 3A	17.5	23.6	**6.1**	23.6	34.4 (*)	10.8
6A	BATT 3B	15.6	23.6	**8**	23.6	34.4 (*)	10.8
5B	BATT 4B	18.8	24.5	**5.7**	24.7	34.7 (*)	10
7A	BATT 5A	19.4	25.4	**6**	24	34.6(*)	10.6
9A	TX A	17.5	33.8	**16.3**	22.4	37.4	**15**
9B	TXB	17.5	30	**12.5**	23.7	35.7	**12**
10A	GCMS	17.5	31.2	**13.7**	22.8	35.9	**13.1**
10B	TUSO	15.6	38.7	**23.1**	21.5	42	**20.5**
11A	DISR I/F	-23.4	-22.8	**0.6**	-26.3	-22.2(*)	4.1
11B	DISR SH	5	9.1	**4.1**	17.3	26.5	**9.2**
12A	FOAM (int)	11.9	27.3	**15.4**	14.2	28.7	**14.5**
12B	CONE(foam ext)	-15.8	-13.9	**1.9**	-4.3	4.7	**9**

(**): Maximum temperature during the check-out and during the day following this check-out.

(*): For these units the maximum of temperature occurs after the end the check-out. So the direct comparison with the measurements is not possible.

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

IDENTIFICATION	F1 MEASURED RANGE INIT T° → END T°	PREDICTED RANGE
RUSO Lamp	113° C → 113° C	112° C - 116° C
RUSO resonator	75° C → 75° C	74° C - 78° C
RUSO crystal	72° C → 73° C	71° C - 75° C
TUSO Lamp	113° C → 113° C	112° C - 116° C
TUSO resonator	75° C → 75° C	74° C - 78° C
TUSO crystal	74° C → 75° C	74° C - 78° C
PSA A Temp	21° C → 39° C	5° C - 50° C
PSA B Temp	21° C → 39° C	5° C - 50° C
Tx A HPA	17° C → 35° C	22° C → 37° C
Tx B HPA	15° C → 32° C	22° C → 37° C
CDMU A DC/DC 1	16° C → 39° C	(*)
CDMU A DC/DC 2	16° C → 35° C	(*)
CDMU B DC/DC 1	15° C → 35° C	(*)
CDMU B DC/DC 2	15° C → 33° C	(*)

(*): For these T° measurements (units internal T°), reference test could be the Probe TV test.

Basically temperatures evolution in steady state during the cruise, which defines the check-out initial T°, and temperature evolution during F1, are considered to be close to the prediction. Detailed discussion about these results shall be found in RD04.

4.2.7. Experiments status word

The values have been checked in real time:

ACP: hex **52:** Filter high/Gate valve locked/CDMU B/Cruise during the first 110 mn in post

To

hex **42:** Filter high/Gate valve intermediate/CDMU B/Cruise during the last 13 mn.

DISR: Values reported are as expected and in line with the reference test:

- Mode INITialization during 40 sec: start on PROM (hex 9800) then (hex 9E78) with transfer from PROM to RAM execution and memory test successful
- Mode CALibration with Cycle count and Measurement count = 1 (hex B204)
  - then counting during the two sequences of calibration
  - Cal1 from B204 to B7FC: duration 33 mn
  - Cal2 from BE3C to BBFC: duration15 mn.

GCMS: Values reported are as expected and in line with the reference test:

- Mode INITialization during 7 mn 28 sec: FC released, CPU normal, running on RAM and CDMUA, patch applied and awaiting pressure check (hex F0A6 or F826 or F8A6)
- Mode RUN IN < To with all filaments OFF during 1 mn (hex F07A) then IPS1 filament ON (hex F27A) alternatively with sequence step counter
- Mode RUN IN < To running on CDMU B during 1 mn with all filaments OFF (hexB07A) then filament 1 ON (hex B43A) alternatively with sequence step counter
- Mode RUN IN > To running on CDMU B without TCs received during 19mn with filament1 ON (hex B43E) then filament 1+ISP1 ON (hex B63E) alternatively with sequence step counter
- Mode RUN IN > To running on CDMU B with filament1 + ISP1 ON with or without TCs received according to the specific tests (hex B63E or B6BE) alternatively with sequence step counter.

HASI: Values reported are as expected and in line with the reference test:

- Mode INITialization during 30 sec: hex 8000
- Mode ENTRY/DESCENT up to To+1mn running on CDMU A: hex FE54
- Mode ENTRY/DESCENT up to To+1mn running on CDMU B: hex FED4
- Mode DESCENT running on CDMU B: hex FED5.

SSP: Values reported are as expected and in line with the reference test:

- SSP B reports: INIT mode (hex C1D8)
  Running on CDMU B and Sounder in atmosphere mode (hex 6198)
- SSP A reports in accordance with the time and altitude:
  - INIT mode (hex 02D8) at turn ON
  - UPPER atmosphere mode and running on CDMU B (hex 2398->239B)
  - MID atmosphere mode and running on CDMU B (hex 2598->259B)
  - LOWER atmosphere mode and running on CDMU B (hex 2798->279B)
  - PROXIMITY mode and running on CDMU B (hex 2998->299B)
  - SURFACE mode and running on CDMU B (hex 2B98->2B9B)
  - EXTENDED surface mode and running on CDMU B (hex 2D98->2D9B).

The switches "8" to "B" are due to the Status Word bits 0 and 1 (TM FIFO A and B empty) flip flop.

5. FLIGHT CHECK OUT 2 (F2)

5.1. OPERATIONS

F2 consists in the execution of a so-called Checkout scenario 1 (CO#1).

The relevant SASF (file name=AB01_F2CKO0JQ ,SAF) was up-linked to the Orbiter CASSINI on March 12th 1998, then executed on board on March 27th 1998 at 01 : 10 UTC and finished at 04 :14 UTC.

The C0#1 architecture is based on:

- PSA activation through Orbiter CDS power on TC at So-30 mn
- Probe wake up by the CASSINI Orbiter via the Solid State Power Switches
- at So - 29 mn = Tp
- To simulated by Resume command after Tp+29 mn (So) and To detection at So + 6.375 s
- descent simulation run with chain A
- RF link on chains A & B makes use of TCXOs
- DISR run a simulated descent with spin simulation by TCs
- GCMS run a simulated descent with valves disable by TCs
- HASI and SSP run a simulated descent as in CO#2 (F1)
- ACP is in dormant mode during the first 110 min then in mechanisms check mode from 140 to 153 mn as in CO#2 (F1).

The F2 "as run" key events are:

EVENTS	SEQUENCE TIMING	EXECUTION TIME IN UTC
PSE turn on	S0-0:30:00	1998-86 T01:10:18
Select TCXO	S0-00:29:44	1998-86 T01:10:34
PROBE turn on	S0-00:29	1998-86 T01:11:18
Select TCXO	S0-00:28:44	1998-86 T01:11:34
To detection	To=So+6.375s	1998-86 T01:30 :35
PROBE OFF	T0+2:33:06	1998-86 T04:03 :41
PSA A Off	T0+2:34:00	1998-86 T04:04 :35

5.2. RESULTS

The analysis is based on retrieved data received on the 24th of April 1998 at AS/c. and the status and relay data available on the ESOC server in July 1998.

References for the analysis are the tests run in stacked configuration:

- the CO#1 performed at KSC/PHSH on the 2nd of August 1997 in the frame of the Baseline Test with CASSINI in mated configuration

- the F1 (CO#2) performed in Cruise on the 23rd of October 1997.

The main outcomes of the evaluation are:

- the timing requested by the scenario was correctly followed by the CDS and all TCs are correctly executed

- timeline shows no anomaly; an overview of the sequence is given by the DDB information versus time

- all the relays and status information were checked and cross validated.

The following presents a F2 analysis, per function.

5.2.1. Frames and packets structure

This section deals with the review of the data basically 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 during the full time resolution of the play back.
  The behavior of the Delta Sequence Count reflects the periods of under-sampling of the down stream telemetry.
  Three jumps are attributed to DSN/ESOC link problems.

- **PSA Delta Spacecraft Time**: A Delta value of 1 is nominally reported on both chains during the full time resolution of the play back.
  The behavior of the Delta Spacecraft time Count reflects the under-sampling of the down stream telemetry.
  Three jumps are attributed to DSN/ESOC link problems.

- **Super Packets Delta Seq. Count**: A Delta value of 1 is nominally reported on both chains during the full time resolution of the play back.
  The behavior of the Delta sequence count reflects the under-sampling of the down stream telemetry.
  Three jumps are attributed to DSN/ESOC link problems.

- **Super Packets Master and Virtual Channels Frame Counts**: Periodical reset of the Master channel frame counts on both chains is nominally noticed. During the under-sampling a shift is noticed, as expected.

- **Dump Super Packets Delta Seq. Count and Sequence Count and Real Time Counter**: A Delta value of 1, together with a monotonous increase of the Seq. Count is nominally reported on both chains when the Probe is not yet powered (1 mn after PSA On and 1 mn before PSA OFF). Similarly 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. A Delta of 24 is nominally reported for HK4 on both chains: it corresponds to the reset of this HK packet (contains Entry Acceleration data), 6.4 mn after $T_{probe\ ON}$. During the under-sampling a shift is noticed as expected. Three jumps are attributed to DSN/ESOC link problems.

5.2.2. Telecommunication

For this second flight checkout, the reported telemetry has been compared to both the mated C0#1 run on the 2nd of August, and the F1 checkout (mainly for AGC problem).

- **PSA secondary voltages**: PSA 12 V, 5 V and LNA supply voltage (nominally 12 V), are in their nominal range and perfectly stable over the test.

- **RUSO status**: RUSO is not powered during F2.

- **TUSO status**: TUSO is turned ON only 6 s at $T_{Probe\ ON}$ + 16 s then 7 s after To+10 s .

- **TCXOs status**: TM nominally reports TCXO selection on both chains A and B.

- **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 and B state 6 (carrier, subcarrier, bit sync and Sync Marker locked) has been reached as expected after the 1st attempt to switch to Basic Frequency. Several discrepancies have been flagged, happening during all phases of the returned telemetry (full resolution and under-sampling "modes"):

  - several bit synchro loss are noticed on Chains A and B. Some of them (3 on Chain B) are correlated with loss of carrier, subcarrier and synch marker.

  - two losses of lock on the Chain A and four on the Chain B are flagged through the RSW status telemetry.

This behaviour is specific to F2: observed anomalies have actually been fully explained (see RD10) by phenomena external to the Probe, i.e. errors on CASSINI SSR redding inducing truncated packets and errors coming from DNS passes.

AGC: Anomalies have been identified:

1. Further loss of some dBs on both chains when compared to the reference ground test and F1:

TEST	CHAIN A	CHAIN B
CO#1 at KSC	-97 dB+/-0.25/decrease of 0.5 dB	-96 dB+/-0.25/decrease of 0.5 dB
F1	-101 dB+/-0.4 (*)	-100.6 dB+/-0.4 (*)
F2	**-104 dB+/-0.5 (*)**	**-106 dB+/-0.4 (*)**

(*) The AGC values move down in the course of the test. This point is discussed hereunder.

2. Similarly to the F1 case, the AGC evolution is not in line with expected: in the course of the test, it changes by about 3 dB on Chain 1 and 6 dB on Chain B (in addition to the shift addressed in Point 1).

   Significant progress in the explanation of Point 2 have been made: a plot of the CASSINI HGA Sun Aspect Angle, provided by JPL, has clearly demonstrated a strong correlation between the AGC evolution during F1 and F2, and the actual pointing angle of the HGA to the Sun. In order to definitely confirm this assumption, it has been decided to run a specific test with the CASSINI HGA off Sun de-pointed by a minimum of 10°. Additionally, there is some good hope, at that stage, that the point 1 could also be clarified in the frame of this complementary test.

   This AGC special test is further discussed in section 6.3 of this document.

NCO: NCO frequency changes are generally in line with reference test results on both chains, and F1 test results on Chain B. One shall note that some of the losses of link discussed before appear here through the reset to 0 of the NCO. Finally, so called dF/dt parameters on both chains are within the expected range.

5.2.3. Power

CASSINI TMs have not been provided:

- PSE total consumption of TBD W
- Probe total average maximum consumption of TBD W.

All Current limiters status and Pyro relays status were correct.

Batteries voltages telemetries are at the end of the test slightly higher than during the reference test:

- battery 1 A 2.28 Volt instead of 1.7 V
- battery 2 A 2.28 Volt instead of 1.5 V
- battery 3 A 1.30 Volt instead of 0.7 V
- battery 3 B 1.30 Volt instead of 0.7 V
- battery 4 B 2.28 Volt instead of 1.7 V
- battery 5 B 1.96 Volt instead of 1.3 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 leak current in a measurement diode. However, the Delta in the measured value is related to an increase in the PCDU temperature (see § 5.2.6.). It is a normal behavior.

Note that the lower battery 3 voltage parameter reflects the cross trapping of the relevant telemetry.

BDR currents are in accordance with the operating modes of the Probe System and instruments:

	Pre To	To To + 110 mn	To + 140 mn	To + 154 mn
BDR1	0.46 A	0.77 A	0.7 A	0.42 A/ 0.55 A/0.9 A
BDR2	0.43 A	0.69 A	0.65 A	0.37 A/0.5 A/0.8 A
BDR3	0.43 A	0.69 A	0.65 A	0.37 A/0.5 A/0.85 A
BDR4	0.43 A	0.7 A	0.65 A	0.37 A/0.5 A/0.85 A
BDR5	0.47 A	0.77 A	0.73 A	0.44 A/0.58 A/0.95 A

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
TX A	0.19 A	**TX B**	0.195 A
TUSO N	0. 3 A during 16 sec	**TUSO R**	0.3 A during 16 sec
CDMU A	0.326 A	**CDMU B**	0.337 A
Prox Sensor A	0	**Prox Sensor B**	0
DISR1 N	0.17 A average	**DISR1 R**	0.17 A average
DISR2 N	0	**DISR2 R**	0
GCMS1 N	0.25 A in pre To 0.42 A in post To	**GCMS1 R**	0.23 A in pre To 0.40 A in post To
GCMS2 N	0	**GCMS2 R**	0
HASI1 N	0.2 A in post To	**HASI1 R**	0.18 A in post To
HASI2 N	0	**HASI2 R**	0
ACP1 N	0.065 A	**ACP1 R**	0.068 A
ACP2 N	0	**ACP2 R**	0
ACP3 N	Peaks up to 0.3 A one up to 1.1 A	**ACP3 R**	Peaks up to 0.35 A one up to 1.22 A
SSP N	0.32 A	**SSP R**	0.027 A

Probe power, derived from BDRs current is as expected, 100 W in average in post To, while the Probe power bus users consumption is nominally reported to be 85 W in average in post To.

5.2.4. Data handling

This section deals with the analysis of all the telemetry data related to the CDMS.

- **Central Acceleration data**: The reported TM nominally shows a 0 g value, with a 1 LSB noise mainly on accelerometer 1. This behavior was already noted during F1, and is not seen as a problem area.

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

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

- **DDB F1 & F2 flags status**: S0 "detection" is correctly reported on both chains through F1 change. F2 nominally reports the TAT use over the whole sequence.

- **DDB Time**: For both chains, in line with Probe Real Time before To, then with Probe Mission time from To (from Tp+29 mn) to Tp+152 mn 48 s.

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

- **DDB Spin**: TM reports Spin value in accordance with the alteration TCs i.e.:

  - 7 rpm< spin < 9 rpm during the first 15 mn of the descent
  - a peak of 12.5 rpm at To + 25 mn
  - a permanent decrease during the rest of the descent down to 2 rpm.

- **MTU Telemetry**: 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 F2.

5.2.5. On board softwares

5.2.5.1. 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 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 F2, 10#7000 is well in line with reference test data, and identical to F1 results.

- **SASW CUT Processing Time**: It reflects the processor load for each CUT. As expected, Processing time ranges from 16 ms to 27 ms, 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 < 120 ms. **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. The constraint for a safe software operation is actually [**DTStart EXEC + FDI EXEC + DMA EXEC** < 4.5 ms].

  During F1, on both chains, **DTStart** nominally happens 18 ms after the CUT start; processing duration is in average 1.4 ms, 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 50 ms over the test duration (about 3 h), 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 0.8 ms, 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.

  Telemetry related to DMA interrupt is quite similar to FDI related telemetry, with the same comments.

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

As a conclusion, we have [**DTStart EXEC + FDI EXEC + DMA EXEC** = 3.6 ms], and the criterion mentioned before, (**DTStart EXEC + FDI EXEC + DMA EXEC** < 4.5 ms) is fulfilled, ensuring in any case a correct software operation.

5.2.5.2. 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 16bits address of the top of the stack, which shall be lower than the Stack base address, i.e. 16#EFFF. Value reported during F2, 10#7425 is well in line with reference test data and F1.

- **POSW CUT Processing Time**: It reflects the processor load for each CUT. As expected, Processing time ranges from 55 ms to 60 ms, representing a nominal CDMU data handling processor load of about 47 % max. The processor load increase from To reflects the fact that the MTT processing time is correlated to the place of the event in the timeline, therefore the Mission Time.

5.2.6. 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	F2 MEASURED RANGE INIT T° → END T°	PREDICTED RANGE INIT T° → END T°
MIMI elec T°	18° C → 22° C	TBD by JPL
Probe T° 1	15° C → 30° C	22° C → 47° C
Probe T° 2	15° C → 30° C	22° C → 47° C
LNA A Temp	-1° C → 1° C	-30° C → 0° C
LNA B Temp	0° C → 2° C	-30° C → 0° C
SEPS Temp 1	-45° C → -43° C	-39° c → -36° C
SEPS Temp 2	-45° C → -42° C	-39° C → -36° C
SEPS Temp 3	-49° C → -47° C	-40° C → -37° C
SEPS Temp 4	-52° C → -50° C	-41° C → -38° C

Temperatures values acquired by the Probe are summarized in the tables hereafter:

a. Descent module External units:

TM IDENTIFICATION	T° SENSOR Location	F2 MEASUREMENTS (23/10/97)			PREDICTIONS		
		T init	T end	**Delta T°**	T init	T maxi (**)	**Delta T°**
1A	SEPS A	-44.1	-44	**0.1**	-38.8	-35.6 (*)	3.2
2B	SEPS A	-44.1	-43.6	**0.5**	-38.8	-35.6 (*)	3.2
1B	SEPS B	-47.7	-47.7	**0**	-40.1	-37.1 (*)	3
2A	SEPS C	-48.2	-48.2	**0**	-40.9	-37.8 (*)	3.1
3A	PJM A	-23.5	-22.8	**0.7**	-22.7	-18.8 (*)	3.9
3B	PJM B	-21.5	-20.9	**0.6**	-21.4	-17.6 (*)	3.8
4A	PJM C	-22.9	-22.5	**0.4**	-22.7	-18.6 (*)	4.1
4B	PDD	-18.7	-18.7	**0**	-21.7	-17.7 (*)	4

b. Descent module Internal units:

8A	PCDU	15	33.75	**18.75**	21.1	41..9	**20.8**
5A	BATT 1A	18.1	22.7	**4.6**	24.1	34.2 (*)	10.1
8B	BATT 1B	15	23.6	**8.6**	24.1	34.2 (*)	10.1
6B	BATT 2A	18	25.4	**7.4**	22.7	34.3 (*)	11.6
7B	BATT 3A	16.3	22.7	**6.4**	23.6	34.4 (*)	10.8
6A	BATT 3B	14.4	21.8	**7.4**	23.6	34.4 (*)	10.8
5B	BATT 4B	17.5	23.6	**6.1**	24.7	34.7 (*)	10
7A	BATT 5A	18.1	24.5	**6.4**	24	34.6 (*)	10.6
9A	TX A	17	32.5	**16.5**	22.4	37.4	**15**
9B	TXB	16.2	30	**13.8**	23.7	35.7	**12**
10A	GCMS	17	30	**13**	22.8	35.9	**13.1**
10B	TUSO	15	27.3	**12.3**	21.5	42	**20.5**
11A	DISR I/F	-23	-22.5	**0.5**	-26.3	-22.2 (*)	4.1
11B	DISR SH	5	9.1	**4.1**	17.3	26.5	**9.2**
12A	FOAM (int)	11.5	25.5	**14**	14.2	28.7	**14.5**
12B	CONE(foam ext)	-15	-13.5	**1.5**	-4.3	4.7	**9**

(**): Maximum temperature during the check-out and during the day following this check-out.

(*): For these units the maximum of temperature occurs after the end the check-out. So the direct comparison with the measurements is not possible.

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

IDENTIFICATION	F2 MEASURED RANGE INIT T° → END T°	PREDICTED RANGE
RUSO Lamp	101.7° C → 101.7° C	101.7° C
RUSO resonator	64.4° C → 64.4° C	64.4° C
RUSO crystal	64.4° C → 64.4° C	64.4° C
TUSO Lamp	101.7° C → 101.7° C	101.7° C
TUSO resonator	64.4° C → 64.4° C	64.4° C
TUSO crystal	64.4° C → 64.4° C	64.4° C
PSA A Temp	21.7° C → 39.1° C	5° C - 50° C
PSA B Temp	21.7° C → 39.1° C	5° C - 50° C
Tx A HPA	16.5° C → 34.9° C	22° C → 37° C
Tx B HPA	15° C → 31.6° C	22° C → 37° C
CDMU A DC/DC 1	16° C → 35° C	(*)
CDMU A DC/DC 2	16° C → 32.5° C	(*)
CDMU B DC/DC 1	15° C → 32.5° C	(*)
CDMU B DC/DC 2	15° C → 30° C	(*)

(*): For these T° measurements (units internal T°), reference test could be the Probe TV test.

Basically temperatures evolution in steady state during the cruise, which defines the check-out initial T°, and temperature evolution during F2, are considered to be close to the prediction.

Detailed discussion about these results shall be found in RD04.

5.2.7. Battery loss

HUYGENS Probe comprises 5 battery strings. The energy losses for each string until Probe separation from Orbiter in December 2004, presented by the System FAR design report were computed with the backup launch date foreseen in march1999 and temperatures estimated by DSS :

- hot case losses 1.85 Ah (Descent T° = 10 °C)
- nominal case losses 1.51 Ah (Descent T° = 0° C)

Using the same FAR temperature assumptions and updating only the real launch date i.e :15 October 1997 the estimations of each battery loss until separation from CASSINI are respectively :

- hot case = 1.24 Ah
- nominal case = 1.00 Ah

With the temperatures measured during the cruise from launch to the end of F#2 the estimation of the energy loss per battery in the nominal case is 0.95 Ah.

Finally, considering these updated energy losses, the budget for the complete mission, including failure cases, becomes :

Descent T°	Nominal case (0°)	Hot case (10°)
updated available energy	1340 Wh	1430 Wh
total energy need	1159 Wh	1159 Wh
margin	16 %	23 %

5.2.8. Experiments status word

The curves of the Status Word have X-axis in decimal from ZERO to 65000 it is therefore not possible to perform an accurate control of the relevant parameter. Nevertheless the shape of the curve is, for each instrument, similar to the curves of the last CO#1 used as a reference test.

Experiments detailed behavior analysis shall be found in the PIs F2 test reports: no anomaly related to the Probe System operation has been notified.

6. IN-FLIGHT AGC TEST

6.1. OPERATIONS

CASSINI HGA pointing was 10° off Sun.

The relevant SASF (file name = AGCST0k9.SAF) was up-linked to the Orbiter CASSINI, then executed on board on May 28th 1998 at 12 :00 UTC and completed at 12 :33 :30 UTC.

The Special test architecture is based on:

- PSA activation through Orbiter CDS power on TC at TPSA
- Select TCXO PSA at TPSA + 16 sec
- Probe wake up by the CASSINI Orbiter via the Solid State Power Switches at TPSA + 1 mn
- TCs "Suspend "and" Flag check-out suspended" on both channels at TPSA + 1 mn 12 sec
- Select TCXO Tx at TPSA + 1 mn 16 sec
- RF link on chains A & B makes use of TCXOs for 32 mn
- Probe and PSAs Off at TPSA + 33 mn.

The AGC special test "as run" key events are:

- Start of AGC in flight tests: PSAs power ON 1998-148 T 21 :20 :15
- PROBE power ON 1998-148 T 21 :21 :15
- POSW suspended 1998-148 T 21 :21 :27
- PROBE power OFF 1998-148 T 21 :53 :15
- End of AGC in flight tests: PSAs power OFF 1998-148 T 21 :53 :45.

The In Flight AGC Test was performed outside DSN station coverage on May 28th 1998. TM data was recorded on board CASSINI on the Solid State Recorder(SSR) and later downlinked to JPL via three DSN passes.

The HUYGENS Probe Operations Centre (HPOC) retrieved all available data from the JPL TDS server.

6.2. RESULT

Probe Data Relay Subsystem (PDRS)

The In Flight AGC Test confirmed that the AGC levels of both chains, when CASSINI HGA points at deep space, are consistent and in the expected range of values:

SEQUENCE	AGC A	VARIATIONS	AGC B	VARIATIONS	D A / B
AGC In Flight test	- 94.6 dB	+/- 0.1 dB	- 94.3 dB	+/- 0.1 dB	0.3 dB

Command & Data Management Subsystem (CDMS) & Probe On board Software(POSW

Nominal behavior in suspended mode.

Electrical Power SubSystem (EPSS)

Nominal behavior.

THermal control SubSystem(THSS)

Nominal behavior.

7. CONCLUSION

Cruise check out F1 and F2 have proven the capability of the Probe System, EPSS-CDMS-PDRS-POSW-SASW, to nominally perform the cruise flight checkout operations.

During F#1 the 3 packet missing on chain A corresponding to a jump on Super packet/sequence counter are not explained.

During F#1 one Telecommand was rejected by GCMS at To + 28 mn 38 sec. It was a part of the GCMS Threshold Scan. There is no damage for the GCMS and this corruption cannot be explained.

The only identified problem, again summarized in the table hereunder, is the continuous receiver AGC decreasing and variations since the Launch Pad Probe Contingency check-out, considering as a reference the Base Line Test (CO#1 and CO#2) run in the KSC PHSF with CASSINI in mated configuration.

PHASE	SEQUENCE	AGC A	VARIATIONS	AGC B	VARIATIONS
Base Line Test	CO#1	- 97 dB	0.5 dB	- 96 dB	0.5 dB
	CO#2	- 96	less 1 dB	- 95.5	0.5
Launch Pad	CGCK	- 100.5	2.8	- 96.7	1.3
Cruise F1	CO#2	- 101	2	- 100.6	2
F2	CO#1	- 104	3	- 106	6

⇒ The first variation had occurred during the Launch Pad CGCK:

- Chain A: -4 dB (average BLT was -96.5) and high peak to peak noise 2.8 dB
- Chain B: -1 dB (average BLT was -95.7) and high peak to peak noise 1.3 dB

⇒ F1 evidenced a new behavior:

- **AGC A stable** with a "normal" noise (< 1 dB) but with long term variation cycle ~ 83 mn.
- **AGC B drop by ~4 dB** and also a "normal" noise (< 1 dB) but with long term variation cycle ~ 83 mn.

⇒ AGC behavior has worsened during F2:

- **AGC drops on the two chains: 3 dB on AGC A and 5.6 dB on AGC B**
- "normal" noise (less 1 dB) and same long term variation but with a different period of about 65 mn.

ALENIA analysis (see RD12) excluded circuitry failures with a such effect.

A dedicated investigation team made some correlations and assumptions:

1. The reported AGC variations are correlated with the CASSINI HGA pointing at the Sun.
2. The AGC drop level is believed to be related to the Sun RF noise; the Sun having been more active during F2 than during F1, and CASSINI closer from the Sun during F2 than F1 (see RD09).
3. The digital AGC drop mechanism is as follows:

   In presence of a high noise at the Rx input, the analog AGC stage, operating in a wide bandwidth, would reduce the amplitude of the [signal + noise] at the A/D converted input. The result would be a reduced signal seen by the digital receiver, which operates in a much smaller bandwidth, and consequently reported in the digital AGC telemetry.
4. Different responses between Chain A and Chain B may be due to Sun noise polarization, and differences in receiver characteristics.

AGC In-flight test run on the 28th of May and the tests run at ESOC on the EM Probe on the 8th of April 1998 (see RD11)confirmed the points 1, 2 & 3.

Point 4, consisting in the anomalous loss of ~ 2.6 dB (resp. 4.5 dB) more on Chain B then on Chain A during F1 F2 , still remains unexplained.

The Probe receivers operate nominally in the absence of high solar RF noise input. The difference AGC A/B values in the presence of noise is presently not understood. F#3 will be performed in December 1998 with the HGA pointing at the Sun but at a distance of 1.6 AU such that the solar RF noise should be about 1/8 of that seen during F2.