HUYGENS

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RESUME D'AUTEUR

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

pendant le troisiéme « cruise check out » qui a eu lieue le 22 décembre 1998 après la manoeuvre d'orbite permettant le deuxiéme » fly by « de Vénus en Juin 1999.

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1. SCOPE

The present report covers the third flight cruise check-out (F3)performed in the frame of the HUYGENS Phase F

- at launch + 14 months the 22nd December 1998

It aims at analysing the behaviour of the HUYGENS Probe System and subsystems during the test. Note that experiments behaviour analysis is not part of this document.

⇒ The present analysis is based on the data stored on board CASSINI SSR the 22.12.1998. After the re-orientation of the CASSINI/Huygens spacecraft to point the High Gain Antenna to Earth on the 28.12.98 the check out data were downlinked via the DSN station in Goldstone to JPL then transferred to HPOC/ESOC.
After some processing all the engineering data plots were delivered to Alcatel on the 07.01.99 and all the status values were made available on the data server.

⇒ The reference test for comparison is F1 run the 23rd October 1999 at launch+8 days

2. APPLICABLE DOCUMENTS

The tests have been performed according to the following documents:

- AD01: Sequences ESOC: HUYGENS_F3_CO
- AD03: ESOC database
  Doc. n° ESOC XX.

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

3. CONFIGURATION

3.1. SPACECRAFT CONFIGURATION

- As far F3 is 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 TBD mrad
- The relative distance to the Sun is ~1.6 AU
- The CASSINI Telecommunication Subsystem status during F3 is presented in Tables 3.2-1(JPL statement): it shows the HUYGENS flight rules have been followed.

3.2. RADIO FREQUENCY SUBSYSTEM (TBC BY JPL)

The CASSINI **RFS** related spacecraft states for Probe check out F3 was:

- 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#3 : TBC by JPL

STATES	BEFORE	DURING	AFTER
S/C Telemetry mode	RTE & SPB_14220	PCHK 24885	RTE & SPB_14220
S/C ranging modulation	High 0.81radians	Low throughput 0.27 radians	High 0.81radians
S/C antenna	TBD	TBD	TBD
Telemetry modulation index	Step 30 55 degrees	Step 45 78 degrees	Step 30 55 degrees
Telemetry sub-carrier	Low 22.5 kHz	High 360 kHz	Low 22.5kHz
DST receiver		In lock on the coherent No uplink	
Ranging suppression		3 dB uplink	

TABLE 3.2-1

4. FLIGHT CHECK OUT 3 (F3)

4.1. OPERATIONS

F3 consists in the execution of a so-called Checkout scenario 2 (CO#2) with, in addition :

⇒ double TC « Flight check out » to increase the safety (mainly GCMS concern)
⇒ some modifications requested by the PIs and explicated below in italic letters.

The relevant SASF was loaded on board CASSINI, then executed at a pre-programmed time. After the successful re orientation of the CASSINI/Huygens spacecraft to point its HGA to earth on 28.12.98 ,Probe telemetry was down linked at a 142 kbps rate via the DSN station in Goldstone.

The F3 architecture is based on:

- PSA activation through Orbiter CDS power on TC at So-60 mn
- *Dump SASW A/B EEPROM at So-40mn*
- 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 *then SSP performs a specific investigation activity on APIS at So+153mn for 11 seconds*
- ACP is in dormant mode during the first 110mn then in "mechanisms check mode" from 140 to 153mn. *Special commands are sent to turn ON the pump for 5 seconds*
- GCMS runs its calibration sequences:
    - threshold scan
    - lens scan1

- high power mode
- lens scan 2
- calibrate.

– DISR runs the calibration Sequences 1 and 2.

– *DUMP POSW A/B EEPROM at So+156mn45sec*

The F3 "as run" key events are:

EVENTS	SEQUENCE TIMING	EXECUTION TIME IN UTC
PSE turn on	S0-01:00:00	1998-355 T22:30:00
RUSO ON	S0-00:59:44	1998-355 T22:30:16
Select RUSO	S0-00:59:43	1998-355 T22:30:17
PROBE turn on	S0-00:36:00	1998-355 T22:54:00
TUSO ON	S0-00:35:44	1998-355 T22:54:16
Select TUSO	S0-00:35:39	1998-355 T22:54:17
Time-out on To detection	S0-00:00:45	1998-355 T23:29:15
To detection		1998-355 T23:30:00
PROBE OFF	T0+2:37:50	1998-356 T02:07:50

4.2. RESULTS

As already mentioned, the analysis is based both on engineering data plots received on the 07.01.99 and data retrieved from the ESOC server during the 3rd week of January.

As already mentioned, reference for the analysis is F1, **the CO#2 performed on 23rd of October 1998**.

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

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

all the status information was checked and validated from the data retrieved.

The following presents the analysis of F3, 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
- **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.

Most significant differences are:

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

- during F3,the data was recorded on the SSR, then the transmission used the HGA for the first time.

- **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 expected behaviour and F1 results.

- **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 behaviour.

- **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 **6th** attempt to switch to Basic Frequency; it shall be noticed that F1 shows a complete receiver lock on chain A during CO#2 at the **3rd** attempt (ground at worst was **2nd**). This is however not a concern (in total the sequence plans 28 attempts to switch to basic frequency). An explanation for this phenomenon could be the initial T° of TUSO which is lower for F3 than for F1 : this leads to a longer time for the oscillator frequency to stabilise and enter in the 30kHz PSA acquisition bandwidth. It should be noticed also 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 (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 happens at the 1st attempt.

1. **AGC**:

The table hereunder evidences the evolution since the launch campaign in KSC. The AGC level for F3 is well in accordance with conclusions reached after the AGC specific test (see RD3).

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
F2	-104 dB+/-0.5	-106 dB+/-0.4
F3	**-98 dB→ 100.5 dB+/-0.4** (*)	**-97.8 dB →98.8dB+/-0.4** small amplitude max 99.3 dB

NCO: as far as Probe System is concerned, NCO frequency changes are as expected, both on chain A (RUSO) and chain B (TCXO) ,and very similar to F1. Nevertheless, DWE have noticed a NCO frequency modulation similar to F1&F2 (0.367Hz) with a maximum amplitude oscillation of 17Hz (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.

4.2.3. Power

– CASSINI T has shown:

- PSE total consumption of 58 W (TBC)
- Probe total average maximum consumption of 130 W (TBC)

Both values are well in line with reference test results.

– **All Current limiters status and Pyro relays status** have been cross checked on the retrieved data. 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 lower than during the reference test:

- battery 1 A 2.00 Volt instead of 2.93 V
- battery 2 A 2.00 Volt instead of 2.6V
- battery 3 A 1.00 Volt instead of 1.3 V
- battery 3 B 1.00 Volt instead of 1.3 V
- battery 4 B 2.00 Volt instead of 2.6 V
- battery 5 B 1.63 Volt instead of 2.28 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 measured value are lower than during F1
is correlated to lower PCDU temperature (see § 4.2.6.). It is a normal behaviour.
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 summarised in the following table. They are in perfect accordance with the reference test and expected behaviour.

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: 0.60 A	**GCMS1 R**	0.26 A in pre To 0.36 A in post To HPwM: 0.65 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 0.30 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 for the accelerometers 2A & 2B .

For the accelerometers 1A, 1B, 3A & 3B an average value of 0.04g (1 LSB) with a ±1 LSB noise was noticed. This is higher than the values measured during the previous check-out. It should be pointed out that the measured values correspond to 40mV, to be compared to the about 500 mV necessary to trigger the arming timer and Descent timeline (Ta and T0 threshol-see annex 1). This behaviour shall be carefully checked during the next check-out.

A first explanation can be settled based on already observed similar behaviours during the Central Accelerometers Sensor Unit (CASU) testing at unit level. Indeed, a phenomenon identified as *stiction* by the accelerometer manufacturer (Systron Donner) was measured, leading to more than 10mV offset at the CASU output.

It has been stated by Systron Donner that this offset will resume once the actual entry acceleration will be sensed. It shall be noticed that a dedicated vibration test performed by LABEN at CASU level did not fully confirmed it.

Consequently, there is presently some chances that the reported anomaly is a known problem.

- **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.
- **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.

4.2.5. On board software

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 23 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 F3, on both chains, **DTStart** nominally happens 19.1 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. The reported value is a worst case value over the 128 CUT major acquisition cycle and is actually the residual value of the 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 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.

  However, when compared to similar plots during F1 and during CO#2 on ground, a, minor anomaly has been observed : i.e CUT processing time peaks of about 10ms corresponding to the numerous TCs (mainly GCMS TCs) processing were expected for both chains, but are not present. Two phenomena can explain it : either the TCs have not actually been processed by the POSWs or this is a reporting side effect. As there are many evidences from other Probe telemetries and from Experiments feedbacks of the proper execution of all the TCs received by the POSWs, the second hypothesis appears to be the only valid.

  It is in fact anticipated that the difference between F3 and the other similar tests could be due to a « de-synchronisation », related to C0#2 sequence modifications (see §4.1), between the CUTs where the TCs processing happens, and the CUTs for which the processing times are computed.

  This,therefore,does not reflect any probe anomaly.

4.2.6. Thermal

4.2.6.1 Cruise check out F3

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	F3 MEASURED RANGE INIT T° → END T°	F1 MEASURED RANGE INIT T° → END T°
MIMI elec T°	16° C → 19° C	18°C -> 22°C
Probe T° 1	12° C → 33° C	15°C -> 36°C
Probe T° 2	12° C → 33° C	15°C -> 36°C
LNA A Temp	-8° C → -2.5° C	-6° C → 0°C
LNA B Temp	-8° C → -2.5° C	-6° C → 0°C
SEPS Temp 1	-53° C → -56° C	-50°C → -50° C
SEPS Temp 2	-52° C → -56° C	-50°C → -50° C
SEPS Temp 3	-56° C → -56° C	-52°C → -52°C
SEPS Temp 4	-56° C → -56° C	-54°C → -54°C

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

a. Descent module External units:

TM IDENTIFICATION	T° SENSOR	F3 MEASUREMENTS (22/12/98)			F1 MEASUREMENTS (23/10/97°		
	Location	T init	T end	**Delta**	T init	T maxi	**Delta**
1A	SEPS A	-50	-50	**0**	-46.4	-46.4	**0**
2B	SEPS A	-49.5	-49.5	**0**	-46.4	-46.4	**0**
1B	SEPS B	-53.5	-53.5	**0**	-48.6	-49.1	**-0.5**
2A	SEPS C	-54.3	-54.3	**0**	-49.5	-49.5	**0**
3A	PJM A	-28	-27.2	**0.8**	-23.8	- 23.4	**0.4**
3B	PJM B	-25.7	-25.3	**0.4**	-21.9	-21.6	**0.3**
4A	PJM C	-26.9	-26.5	**0.4**	-23.1	-22.8	**0.3**
4B	PDD	-23.2	-23.1	**0.1**	-19.4	-19.4	**0**

b. Descent Module Internal units

8A	PCDU	10.8	31.2	**20.4**	15	35	**20**
5A	BATT 1A	15	19.4	**4.4**	18 .8	23.6	**4.8**
8B	BATT 1B	13.1	19.4	**6.3**	18.8	23.6	**4.8**
6B	BATT 2A	11.2	22.7	**11.5**	16.3	26.4	**10.1**
7B	BATT 3A	15	19.4	**4.4**	17.5	23.6	**6.1**
6A	BATT 3B	10.8	19.4	**8.6**	15.6	23.6	**8**
5B	BATT 4B	14.4	20	**5.6**	18.8	24.5	**5.7**
7A	BATT 5A	15	20.9	**5.9**	19.4	25.4	**6**
9A	TX A	13	30	**17**	17.5	33.8	**16.3**
9B	TXB	13	24.3	**11.3**	17.5	30	**12.5**
10A	GCMS	13	27	**14**	17.5	31.2	**13.7**
10B	TUSO	11	35	**24**	15.6	38.7	**23.1**
11A	DISR I/F	-23.4	-26.6	**0.6**	-23.4	-22.8	**0.6**
11B	DISR SH	1	5.9	**4.9**	5	9.1	**4.1**
12A	FOAM int		23.6	**15.6**	11.9	27.3	**15.4**
12B	CONE (foam ext)	-19.5	-17.1	**2.4**	-15.8	-13.9	**1.9**

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

IDENTIFICATION	**F3 MEASURED RANGE INIT T° → END T°**	**F1 MEASURED RANGE**
RUSO Lamp	113° C → 113° C	113° C → 113° C
RUSO resonator	75° C → 75° C	75 °C → 75 °C
RUSO crystal	72° C → 73° C	72 °C → 73 °C
TUSO Lamp	112.5° C → 112.5°	113 °C → 113 °C
TUSO resonator	76.5° C → 76.5° C	75 °C → 75 °C
TUSO crystal	74° C → 75° C	74° C → 75° C
PSA A Temp	18° C → 37.3° C	21 °C → 39 °C
PSA B Temp	18° C → 36.4° C	21 °C → 39 °C
Tx A HPA	13° C → 31.6° C	17 °C → 35 °C
Tx B HPA	13° C → 28.8° C	15 °C → 32 °C
CDMU A DC/DC 1	12° C → 35° C	16 °C → 39 °C
CDMU A DC/DC 2	12° C → 31.3° C	16 °C → 35 °C
CDMU B DC/DC 1	11° C → 31.3° C	15 °C → 35 °C
CDMU B DC/DC 2	11° C → 29° C	15 °C → 33 °C

Conclusion :

The initial steady state is colder than during F1 due to a longer distance to the SUN (1.6 AU instead 1AU) ;the trend is in accordance with the table 6 of RD02 (1.7 (see annex 2.1)computed after the model adjustment done in july 1998 and the mission predictions are still the best estimates

The dynamic evolution during F3 is equivalent to F1 ;the thermal behaviour is identical and correct.

4.2.7. Experiments status word

The curves of the Status Word for each instrument, are similar to the curves of the last CO#2(F1) used as a reference test.

Experiments detailed behaviour analysis shall be found in the PI's F3 test reports: no anomaly related to the Probe System operation has been notified.

5. CASSINI INSTRUMENTS CHECK OUT (ICO)

The third Flight Check-out (F3) was followed by a manoeuvre called ICO from the 28th December 1998 to the 25th January 1999 with a cone angle variation SPE from 13° to 3° plus five days at SPE=0°.
During this period two non expected events occurred :

❶ temperatures of the probe were colder by 5°C than predicted
❷ temperature of the RFE was observed to rise by about 20°C (7°C/hour) for some hours, five times during the ICO

5.1. PROBE TEMPERATURES

The thermal predictions for the Probe during the Cassini ICO indicate higher values than the measured ones although the overall shape is maintained. This status is consistent with the conclusions of RD2 :

- Deviations between calculated and measured temperatures were typically

  <2°C for components within the Probe
  <6°C for components on the top platform and for the SEPS

- The influence of the Orbiter is not negligible because although the Sun Aspect Angle was as expected (see annex 2.2) the HGA temperatures were higher than foreseen : HGA rear E2505 -60°C instead of -82°C
  HGA front E2501 -35°C instead of -57°C

Moreover the predictions were done in worst case conditions with end of life values for the MLI and paint efficiency ;these two effects may explain the slight difference.

Finally, Alcatel remind that the Probe thermal behaviour during the Descent phase into Titan's atmosphere is driven by different parameters than during the Cruise phase.
It will therefore not be affected by the above considerations and the calculated temperatures in RD2 for the Entry phase and Descent phase are still the best estimates.

5.2. RFE TEMPERATURES RISES

The ICO included five tests involving the Radio Science Subsystem while the Probe was inactive. The temperature of the RFE was observed to rise by about 20°C during each of these events.
The RFE is a small package fixed on the top ring structure above the Cassini Bus bay 6.
It includes the Probe Low Noise Amplifier and an S-Band diplexer, it amplifies and filters two S-band signals from the High Gain Antenna to the PSAs and also routes on the channel B a signal from the S-band Cassini transmitter to the high Gain Antenna RHCP port.

A JPL analysis shows that the RFE behaviour is obviously a direct response to the Cassini S-band transmitter output power and a loss rate of about 0.5dB in the RF diplexer equivalent to 1.5 watts.
Alcatel and Saab, based on the Worst Case Analysis, state there is no risk for the unit and no problem of life time during the cruise even with the assumption of about 30 S-band transmission cycles in total.(see annex 3)

6. CONCLUSION

The third Cruise Check out was run the 22nd December 1998 on the way of the second fly by of Venus after having flown more than 1 billion of kilometres and at distance from the sun around 1.6 AU.
All the Huygens sub systems remain in good condition and the RF link through the HGA was excellent without loss of any packet and data and with an AGC in accordance with the expected value due to the Sun interference.

Nevertheless four items will be checked carefully at the next check out :
- **accelerometers 1 and 3 noise level**
- **POSW CUT processing time : TCs processing time**
- **Chain A complete lock time.**
- **SASW EEPROMs contents ;**

As a recommendation for F4, to ease the comparison with the F2 results Alcatel propose :

- **not to off point the HGA from the sun**
- **to implement the DWE turn ON only from F6 instead of F4**
- **to keep the SASW and POSW EEPROMs content as it is.**

Additionally, an unexpected RFE temperature increase during the ICO which has followed F3 was noted : it is linked with the RFIS S-band transmitter turn ON and there is no risk to operate it again for a maximum of about 30 cycles during the Cruise phase.

Annex 1 : Central Acceleration data ,first analysis

All the necessary information concerning Ta/T0 errors computation have been extracted from the FAR documentation. It can be summarized as follows:

- the upper limit of the range, the earliest Ta detection, is driven by the maximum acceptable Mach number/dynamic pressure. The driver for the threshold is in fact the Mach number : it has to be < 1.76 Mach. The Max profile is the sizing one; it leads to establish the upper limit criterion : Ta threshold shall be < 10m/s²

- The lower limit of the range, the latest PDD fire time (corresponds to the latest T0, be careful, not S0), is driven by the maximum acceptable Probe incidence at Back cover release, which has to be < 20°. The Min profile is here the sizing case; it leads to establish the lower limit criterion : T0 shall happen before 7.2m/s².

- the accelerometers stiction contribution taken into account in the error budgets was about 2% of the thresholds (precisely 12mV), linearly summed (it is a bias). With this figure, the earliest Ta threshold was 9.96m/s², and t
- he latest T0 was 7.25m/s², thus compliant with the allocation defined above, but with minimum additional margins.

This range considering a stiction value of 40mV (ie 2 LSB equivalent bias,
as reported in the F3 TM, in worst case) will be :

<u>Earliest Ta = 11.08m/s², corresponding to Mach=1.87</u>
<u>Latest T0 = 6.75m/s², corresponding to Incidence < 10°.</u>

This shows that :

- The early arming limit is violated
- The incidence limit is still not violated (it seems we actually had taken some "comfort" margin due to the exponential shape of the incidence increase).

The first comments are :

- we should not hurry too much to conclude because we need to go in an even more detailed analysis : real upper limits for the pilot parachute, ...
- the present upper limit for arming is there to actually cope with a firing-upon-arming failure case. In nominal case, the violation of the upper limit (provided it is not too high to still have a consistent arming timeline ...) is not a problem.

Annex 2.1 :ORBITER sensors trend

Annex 2.2 : ICO SUN Angle

Annex 3 - Saab Erickson statement