

VEMD READ-OUT & ANALYSIS REPORT



Report EAI n°: EAI 51_2017
Date of examination: 03/05/2017, Marignane, FRANCE
Attendees : BEA representatives, Airbus Helicopters representatives

AIRCRAFT

Type of helicopter: AS350 B3
S/N and registration: SN3228 / N413LP
Customer: HELICORP INC
Date of the accident: 21/02/2017, San Juan, Puerto Rico, USA

EQUIPMENT EXAMINED

Designation: VEMD mounted and powered on Airbus Helicopters test bench

REASON FOR EXAMINATION

Examination of the recovered parts of the wreckage to determine if there are any evidences of pre-crash failures, to identify any evidences of installed power/torque and to find all evidences which could give information on the crash sequence.

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1. V.E.M.D data (Vehicle and Engine Multifunction Display)

The V.E.M.D. is a multifunction screen which ensures the display of vehicle and engine parameters in flight mode. "THALES Avionics" is the manufacturer of this equipment for this aircraft:

- VEMD Part/Number of the accident = **B19030MD05**
- VEMD Serial/Number of the accident = **3067**

In the P/N the two last digits (05) indicate the software version:



A maintenance mode is available in the VEMD where three types of data are available:

- **Over limits** of parameters: Values of over limits are available but they are not dated. In this case, it's not possible to associate strictly the data with a known event.
- **Failures** information: Failures are available, the system provides a probable list of items which could be the probable cause of the problem and the list of associated parameters when this pages is available. These parameters are very interesting as a complement of investigation data.
- **Flight Report**: Values of flight/cumulated Ng/Nf cycles and the flight duration. It is also noted if failures or over-limits are detected.

NOTA 1:

VEMD architecture and the associated sensors are not compliant with any Flight Data Recorder specifications. Only raw data provided by the system can't be sufficient to confirm a possible scenario. This data must be confirmed by wreckage's information, and/or testimonies.

Powered the aircraft after an accident to read the VEMD can lead to the loss of data or can lead to record new data out of the crash sequence.

2. DATA SOURCES

2.1 PICTURES SOURCE

All the pictures shown in this document are issued from the VEMD N°3067, which was powered on the Airbus Helicopters test bench with the participation of a Safety Investigator from BEA.



2.2 APPLIED PROCESS

- Power on in “Maintenance” mode verifying and noting the possible failures.
- During this operation, the accident flight #1602 was not closed.
- So, it was necessary to close it with the Airbus Helicopters test bench.

3. “MAINTENANCE MODE”

The VEMD has been powered in “Maintenance” mode.

The “Flight report” submode has been opened.

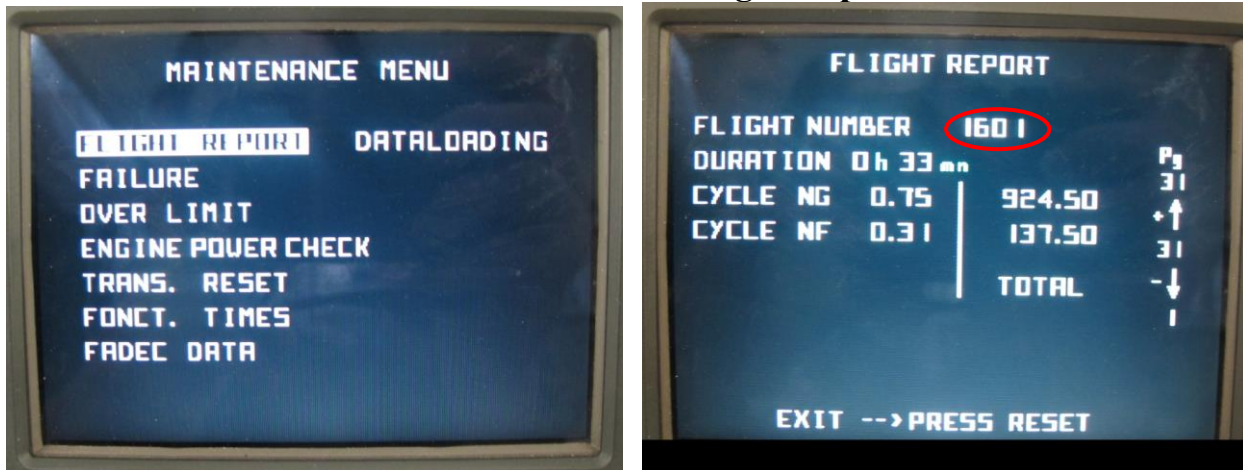
The last flight recorded #1601 in the ‘Flight report mode was not the accident flight.

Indeed, when the “Failure” submode has been opened, the last flight recorded with failures was #1602 and the page indicated the next flight without an increment as expected.

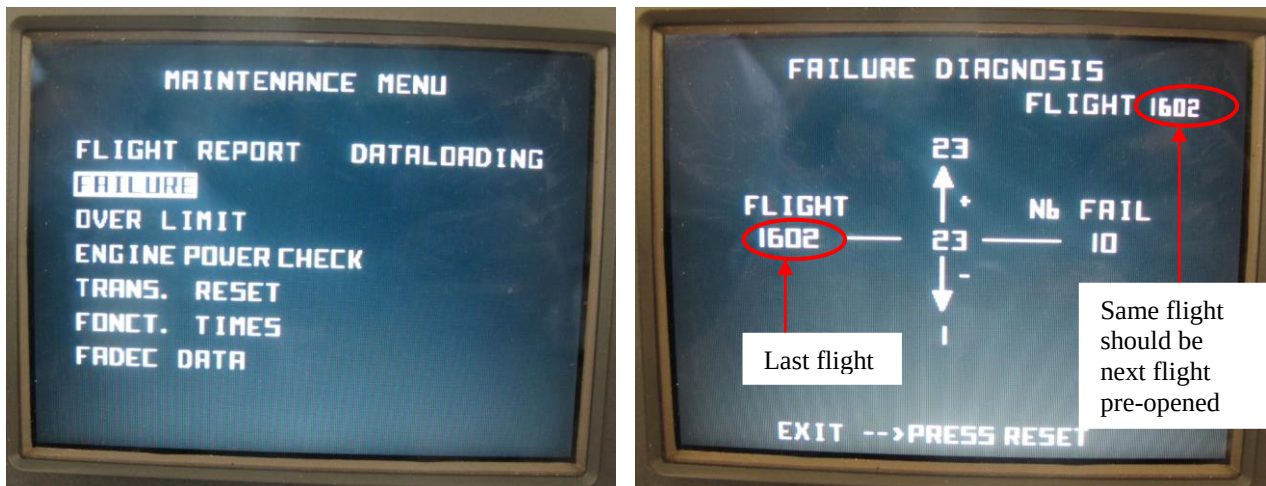
That means that the flight #1602 was the accident flight and was not closed.

The Airbus Helicopters closure process was necessary in this case after to have checked the Failures and Over-Limits (See NOTA 3).

“Maintenance” mode – “Flight Report” submode



“Maintenance” mode – “Failure” submode



NOTA 2:

The flight duration counter starts when the engine gas generator speed (NG) exceeds 10% or the main rotor speed is over 70 rpm. The counter stops and the flight is closed when the gas generator speed (NG) is lower than 10% and the main rotor speed is lower than 70rpm.

NOTA 3:

The closure process has been applied on the last flight, by applying Flight and Ground parameters in line with NOTA 2 on the test bench.

The flight report generated for this flight #1602 gave flight duration of 1h14min with failures detected confirming that the accident flight was indeed the #1602.

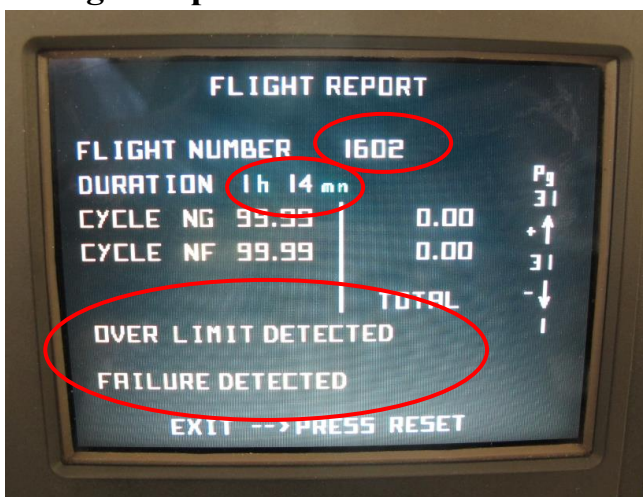
3.1 “FLIGHT REPORT” SUBMODE

3.1 “FLIGHT REPORT” SUBMODE

The “Flight Report” submode has been opened.

For the last flight recorded #1602 which was the accident flight, the flight duration was equal to 1h14min, over-limits and failures have been detected.

“Maintenance” mode – “Flight Report” submode



Due to the application of the closure process, the cycles were no longer correct as the test bench cannot replicate them.

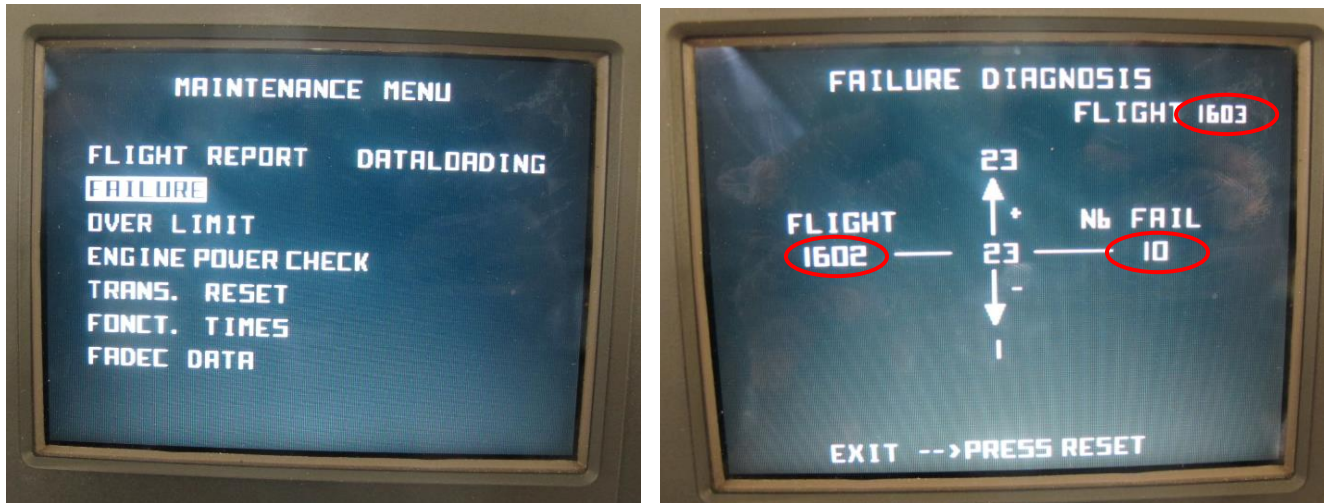
NOTA 4:

The flight time displayed is rounded: for 1hours 14 minutes flight time displayed, the actual time between the two NG values can range from 1h13min30s to 1h14min29s.

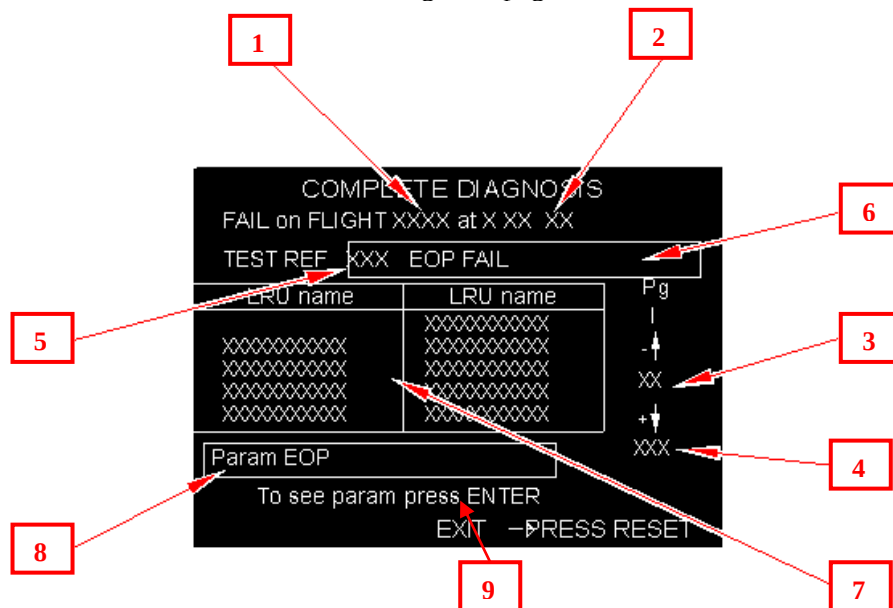
3.2 “FAILURE” SUBMODE

The “Failure” submode has been opened.
10 failures have been recorded during the accident flight #1602.

“Maintenance” mode – “Failure” submode



The following information is available in the failure diagnosis page:



- 1-Flight number
- 2-Failure detection time
- 3-Failure number
- 4-Number of failures
- 5-Failure identification number
- 6-Failure identification label + Channel (L for Left and R for Right)
- 7-LRU:Line Replaceable Unit
- 8-Involved parameter + Status : I for Intermittent and P for Permanent (until the end of the flight) + number time.
- 9-When parameters associated to the failure are available (not systematic)

NOTA 5:

The LRU is an help for the maintenance but can not be a factual data concerning the origin of the failure.

3.2.1 Failure 1/10 Test Ref 134: NG A

“Maintenance” mode – “Failure” submode – Failure 1/10



FAIL			
NG		98.7	%
NG FA.		101.2	%
TQ F.		75.3	%
T4		748	°C
T4 FA.		775	°C
NF		513	RPM
FAIL1		0000	HEX
FAIL2		0080	HEX
LOG 1		5204	HEX
LOG 2		4020	HEX

Failure 1/10 Test Ref 134: NG A

This failure concerns the NG A failure: gas generator rotation speed validity.

It appeared on the left channel (L).

It was intermittent (I) at the flight duration of 1h13min18s for a total flight duration of 1h14min.

The associated parameters showed gas generator rotation speed 98.7%NG, Torque 75.3%TQ, Temperature 748°C T4 and free turbine rotation speed 513rpm (eq. NR).

The following codes were also available in the associated parameters:

Label 350 – FAIL1_FADEC = 0000

Label 351 – FAIL2_FADEC = 0080 Bit21 => NG A failure (Alternator)

Label 353 – LOG1_OUT = 5204 Bit16 => Self-test ended
 Bit23 => Control mode = Flight
 Bit26 => Bleed valve closed
 Bit28 => Proportional mode

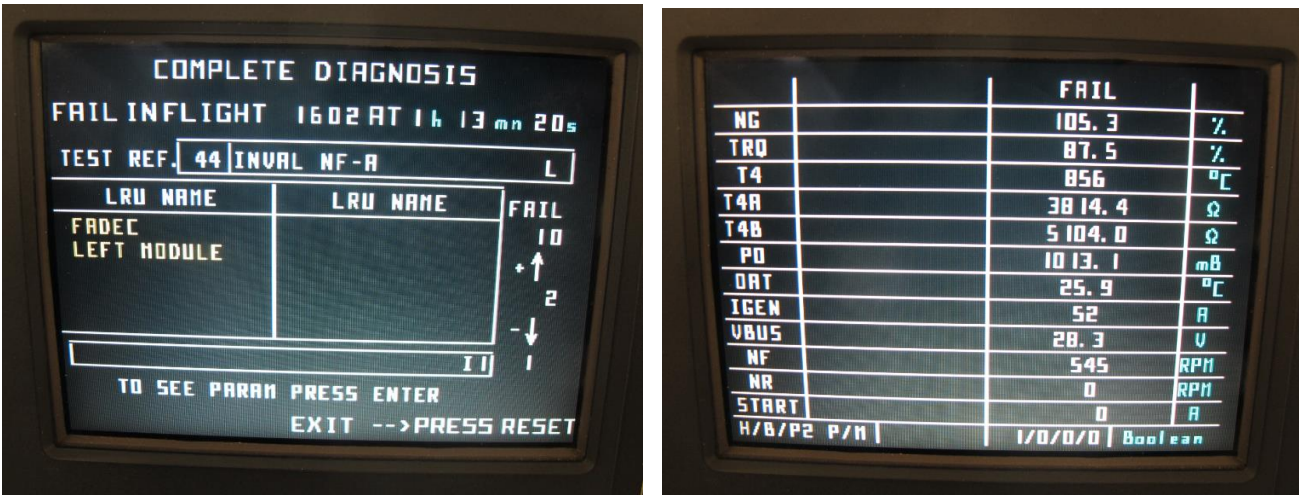
Label 354 – LOG2_OUT = 4020 Bit19 => Degraded operation
 Bit28 => Mixed mode

When this NG A failure was recorded, the FADEC self-test were ended and the governing state was in flight.

The mixed mode corresponds to an intermediate mode: the fuel metering unit is out of the neutral position (eq. to the twist grip out of flight notch) and engine governing is still ensured by the stepper motor until it reaches its stops.

3.2.2 Failure 2/10 Test Ref 44: INVALID NF-A

“Maintenance” mode – “Failure” submode – Failure 2/10



Failure code 44: INVALID NF-A

This failure concerns the free turbine rotation speed sensor A validity.

It appeared on the left channel (L).

It was intermittent (I) at the flight duration of 1h13min20s (2s after the first failure) for a total flight duration of 1h14min.

The associated parameters showed gas generator rotation speed 105.3%NG, Torque 87.5%TQ, Temperature 856°C T4 and free turbine rotation speed 545rpm (eq. NR).

The NR acquisition seems to be invalidated (value=0).

This INVALID NF-A failure is due to the free turbine overspeed which reached 545rpm (eq. NR) equivalent to approximately 140% of the nominal free turbine speed.

Note:

The gas generator rotation speed is recorded to a very high value of 105.3%NG.

3.2.3 Failure 3/10 Test Ref 131: NF-B

“Maintenance” mode – “Failure” submode – Failure 3/10



FAIL			
NG	105.4	%	
NG FA.	105.8	%	
TQ F.	87.8	%	
T4	861	°C	
T4 FA.	868	°C	
NF	545	RPM	
FAIL1	0000	HEX	
FAIL2	0000	HEX	
LOG 1	5204	HEX	
LOG 2	4060	HEX	

Failure code 131: NF-B

This failure concerns the free turbine rotation speed sensor B validity.

It appeared on the left channel (L).

It was intermittent (I) at the flight duration of 1h13min20s for a total flight duration of 1h14min.

The associated parameters showed gas generator rotation speed 105.4%NG, Torque 87.8%TQ, Temperature 861°C T4 and free turbine rotation speed 545rpm (eq. NR).

The following codes were also available in the associated parameters:

Label 350 – FAIL1_FADEC = 0000

Label 351 – FAIL2_FADEC = 0000

Label 353 – LOG1_OUT = 5204

Bit16 => Self-test ended
 Bit23 => Control mode = Flight
 Bit26 => Bleed valve closed
 Bit28 => Proportional mode

Label 354 – LOG2_OUT = 4060

Bit19 => Degraded operation
 Bit20 => Failure without effect on control
 Bit28 => Mixed mode

The NF-B failure is sent by the FADEC, however there are no FAIL 1 or 2 codes recorded declaring this failure. Moreover, the initial failure NG-A (failure 1) has disappeared while this is a non-reversible message.

The NF value 545rpm (eq. NR) seems to be the last valid NF value sent by the FADEC.

This value will be frozen for the next failures.

The loss of NF-B triggers the Bit 20 (failure without effect on control) which is consistent with a redundancy failure.

3.2.4 Failure 4/10 Test Ref 133: NF-A

“Maintenance” mode – “Failure” submode – Failure 4/10



	FAIL	
NG	105.5	%
NG FA.	105.8	%
TQ F.	87.8	%
T4	863	°C
T4 FA.	871	°C
NF	545	RPM
FAIL1	0000	HEX
FAIL2	0000	HEX
LOG 1	5204	HEX
LOG 2	4060	HEX

Failure code 133: NF-A

This failure concerns the free turbine rotation speed sensor A validity.

It appeared on the left channel (L).

It was intermittent (I) at the flight duration of 1h13min20s for a total flight duration of 1h14min.

The associated parameters showed gas generator rotation speed 105.5%NG, Torque 87.8%TQ, Temperature 863°C T4 and free turbine rotation speed 545rpm (eq. NR).

The following codes were also available in the associated parameters:

Label 350 – FAIL1_FADEC = 0000

Label 351 – FAIL2_FADEC = 0000

Label 353 – LOG1_OUT = 5204

Bit16 => Self-test ended
 Bit23 => Control mode = Flight
 Bit26 => Bleed valve closed
 Bit28 => Proportional mode

Label 354 – LOG2_OUT = 4060

Bit19 => Degraded operation
 Bit20 => Failure without effect on control
 Bit28 => Mixed mode

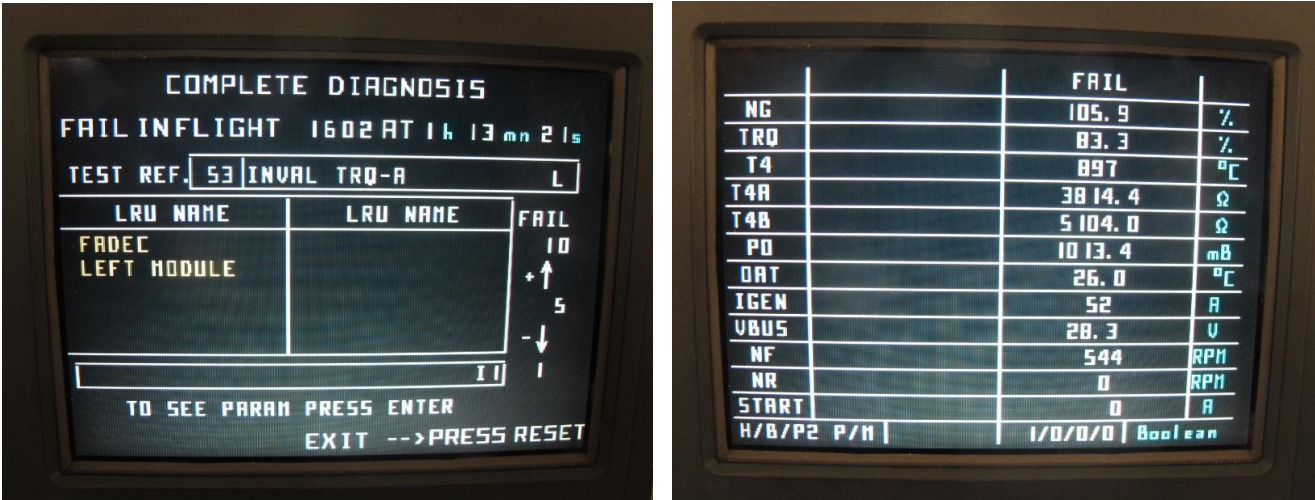
As for failure 3/10, the NF-A failure is sent by the FADEC, however there are no FAIL 1 or 2 codes recorded declaring this failure.

The NF value 545rpm (eq. NR) seems to be the last valid NF value sent by the FADEC.

The loss of NF-B triggers the Bit 20 (failure without effect on control) which is not consistent with a dual failure (NF-A and NF-B). A total control failure should have been triggered (the total failure is triggered on block 6/10 one second later).

3.2.5 Failure 5/10 Test Ref 53: INVALID TRQ-A

“Maintenance” mode – “Failure” submode – Failure 5/10



Failure code 53: INVALID TRQ-A

This failure concerns the torque sensor validity.
It appeared on the left channel (L).
It was intermittent (I) at the flight duration of 1h13min21s (3s after the first failure and 1s after the previous one) for a total flight duration of 1h14min.

The associated parameters showed gas generator rotation speed 105.9%NG, Torque 83.3%TQ, Temperature 897°C T4 and free turbine rotation speed 544rpm (eq. NR).
The NR acquisition seems to be invalidated (value=0).

The torque acquisition seems to be invalid (raw value + conformation).

3.2.7 Failure 7/10 Test Ref 126: TRQ FADEC

“Maintenance” mode – “Failure” submode – Failure 7/10



	FAIL	
NG	105.6	%
NG FA.	104.7	%
TRQ F.	55.7	%
T4	900	°C
T4 FA.	903	°C
NF	544	RPM
FAIL1	1100	HEX
FAIL2	0000	HEX
LOG 1	5204	HEX
LOG 2	4200	HEX

Failure code 128: TRQ FADEC

This failure concerns the torque conformation validity.

It appeared on the left channel (L).

It was intermittent (I) at the flight duration of 1h13min21s for a total flight duration of 1h14min.

The associated parameters showed gas generator rotation speed 105.6%NG, Torque 55.7%TQ, Temperature 900°C T4 and free turbine rotation speed 544rpm (eq. NR).

The following codes were also available in the associated parameters:

Label 350 – FAIL1_FADEC = 1100

Bit22 => Raw torque failure

Bit26 => Torque conformation failure after power

Label 351 – FAIL2_FADEC = 0000

Label 353 – LOG1_OUT = 5204

Bit16 => Self-test ended

Bit23 => Control mode = Flight

Bit26 => Bleed valve closed

Bit28 => Proportional mode

Label 354 – LOG2_OUT = 4200

Bit23 => Total failure

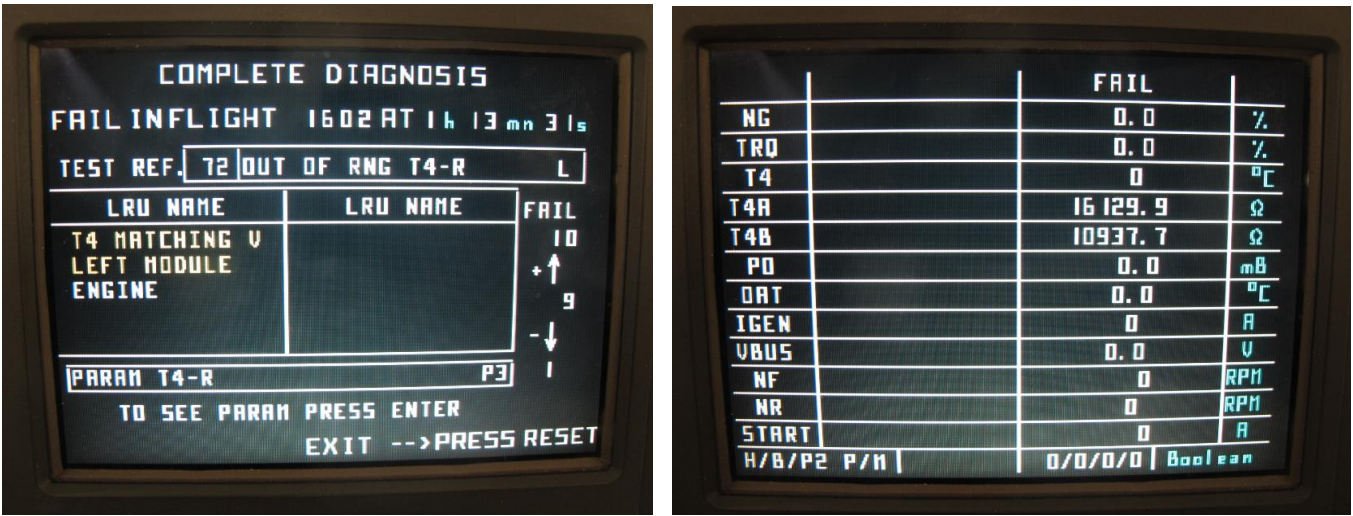
Bit28 => Mixed mode

As for the failure 6/10, the torque acquisition seems to be invalid (raw value + conformation).

This failure is raised if the FADEC does not receive at least one input from the selector.

3.2.9 Failure 9/10 Test Ref 72: OUT OF RANGE T4-R

“Maintenance” mode – “Failure” submode – Failure 9/10



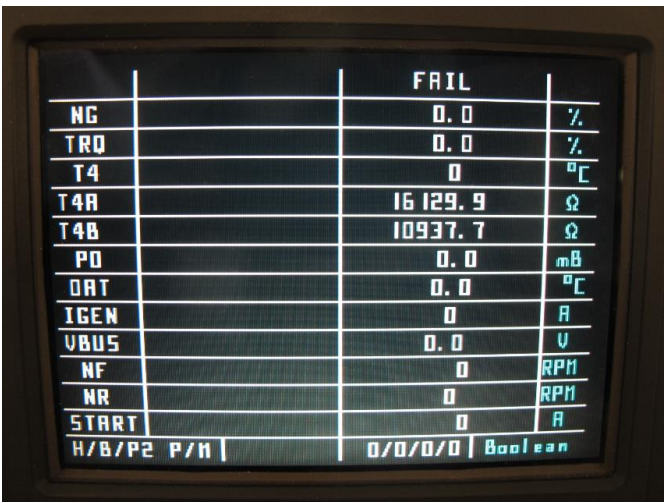
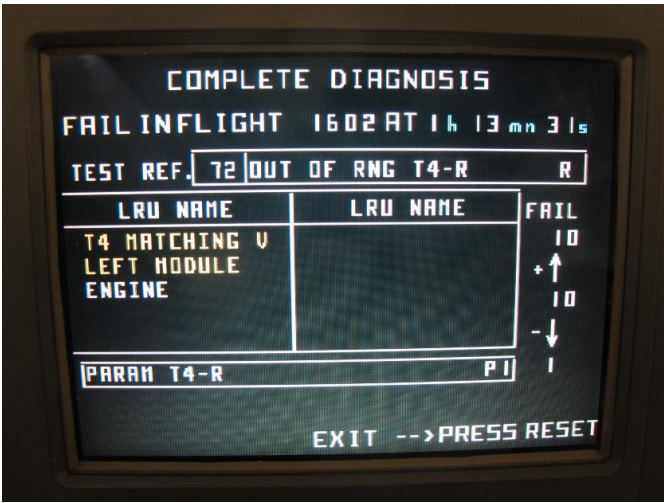
Failure code 72: OUT OF RNG T4-R

This failure concerns the T4 validity.
It appeared on the left channel (L).
It was intermittent (I) at the flight duration of 1h13min31s for a total flight duration of 1h14min.

Despite T4-A and T4-B, whole parameters recorded are null.
T4-A and T4-B represent the resistivity of the thermocouple lines.
This failure is most probably due to the aircraft power on without the FADEC installed: not relevant for the event understanding.

3.2.9 Failure 10/10 Test Ref 72: OUT OF RANGE T4-R

“Maintenance” mode – “Failure” submode – Failure 9/10



Failure code 72: OUT OF RNG T4-R

This failure concerns the T4 validity.
It appeared on the left channel (R).
It was intermittent (I) at the flight duration of 1h13min31s for a total flight duration of 1h14min.

Despite T4-A and T4-B, whole parameters recorded are null.
As for the failure 9, this failure is not relevant for the event understanding.

3.3 “OVER LIMIT” SUBMODE

The “Over Limit” submode has been opened.

“Maintenance” mode – “Over Limit” submode



		OVER LIMIT		602	
		TIME	LIMIT	MAX	
TRQ	000 mn 00 s	>TRQ TRA			Pg 32 + ↑ - ↓ 1
	000 mn 00 s	>TRQ MED		000 %	
	000 mn 00 s	>TRQ EXT			
T4	000 mn 00 s	>T4 LOU			
	000 mn 00 s	>T4 MED		0000 °C	
	000 mn 09 s	>T4 HI		0987 °C	
NG	000 mn 00 s	>NG HNT		106.1 %	
	000 mn 11 s	>NG TRA			
NF	000 mn 04 s	>NF TRA		543 RPM	
	000 mn 00 s	>NF EXT			
NR	445	445	000	000	000 RPM

One over-limit appeared for the combustion chamber temperature with a maximum value reached during the flight phase of 987°C T4. The associated duration of 9s means corresponds to the time during which the T4 value exceeded 941°C.

A second over-limit appeared for the gas generator rotation speed with a maximum recorded value of 106.1% NG. The associated duration of 11s corresponds to the time during which the NG value exceeded 102.3%.

A third over-limit appeared for the free turbine rotation speed with a maximum recorded value of 543rpm NR. The associated duration of 4s corresponds to the time during which the NF value has been comprised between 120% and 150%.

Experience has shown that NF and T4 over-limits frequently appear after a blade shedding.

The very high value of NG may be due to an over-dosage of the fuel flow (possible mixed mode combined with a collective pitch decrease).

Note:

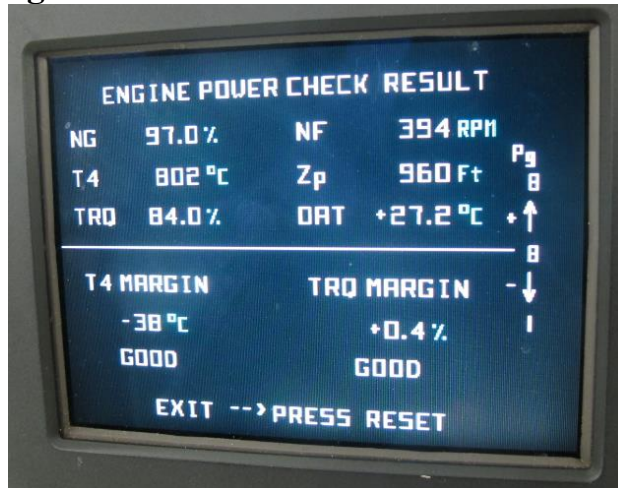
The last over-limit appeared for the main rotor rotation speed with a maximum value reached during the flight of 445rpm. This value is not fully representative with the maximum NF value recorded due to this standard of ASU card which limit the record to approximately 450rpm.

However, the VEMD records the five highest values (over 430 rpm) of the flight and those values are incremented each time that the main rotor rotation speed decreases to 426rpm. That means that the main rotor has probably reached two time values higher than 445rpm.

3.3 “ENGINE POWER CHECK” SUBMODE

The ‘Engine Power Check Result’ submode has been opened
The last engine power check result which is not dated was good.

“Maintenance” mode – “Engine Power Check” submode



Note:

For information, the last eight engine power checks are recorded in the VEMD and not dated.

Engine power check number	T4 Margin		TRQ Margin	
1	-40°C	Good	+0,6%	Good
2	-39°C	Good	-0,4%	Bad
3	-40°C	Good	+0,8%	Good
4	-38°C	Good	+0,5%	Good
5	-40°C	Good	-0,1%	Bad
6	-43°C	Good	-0,5%	Bad
7	-32°C	Good	+0,9%	Good
8 (last)	-38°C	Good	+0,4%	Good

As the Engine power check results are not dated, only the last result is relevant.

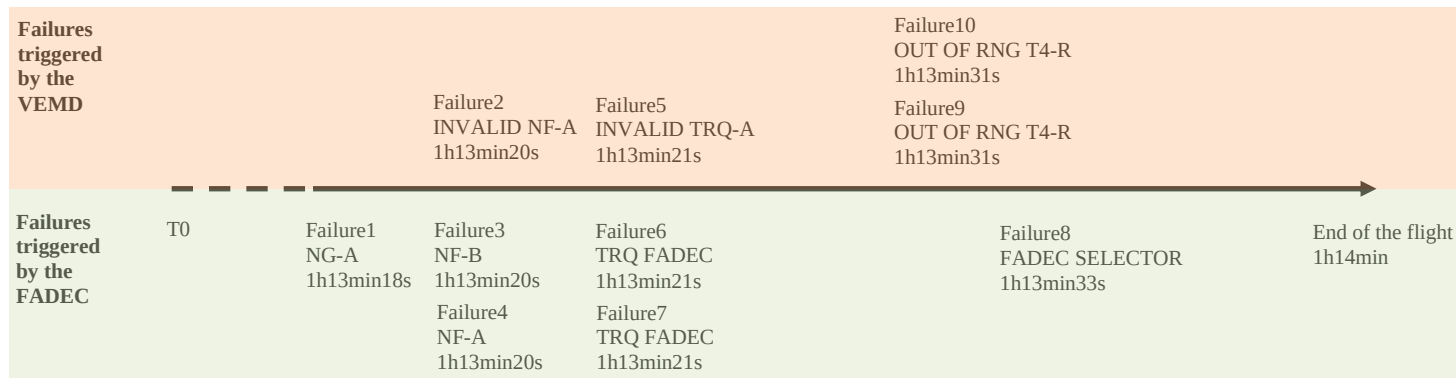
In case of bad engine power check result, the Safran HE troubleshooting manual recommends to perform an engine cleaning and then another engine power check. If the second result is always bad, dedicated maintenance card of Safran HE have to be applied.

4. CONCLUSION

The accident flight was the flight number #1602.

The flight duration was equal to 1h14min.

Failures and Over Limit were detected during this flight following this chronology:



When the first NG-A failure was recorded, the hexadecimal code indicates the mixed mode activation.

I.e.: The fuel metering unit is out the neutral position (eq. to the twist grip out of flight notch) and engine governing is still ensured by the stepper motor.

The following failures are most probably due to the free turbine overspeed.

When both NF failures are recorded (1h13min20s), the associated parameters showed gas generator rotation speed 105.9%Ng, Torque 83.3%TQ, T4 897°C and free turbine rotation speed recorded of 544rpm (eq. NR).

The very high value of NG may be due to an over-dosage of the fuel flow (possible mixed mode combined with a collective pitch decrease).

The T4 and NF over-limits are consistent with an engine blade shedding.

Failures 5 to 10 are not relevant for the event understanding.



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