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Report

Accident on **9 August 2007**
off **the coast of Moorea (French Polynesia)**
to the **DHC6-300**
registered **F-OIQI**
operated by **Air Moorea**

Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile
Ministère de l'Ecologie, du Développement durable et de l'Energie

Foreword

This report presents the conclusions of the BEA on the circumstances and causes of this accident. In accordance with Annex 13 to the Convention on International Civil Aviation, with European Directive 94/56/CE and with the Civil Aviation Code (Book VII), the investigation is intended neither to apportion blame, nor to assess individual or collective responsibility. The sole objective is to draw lessons from this occurrence which may help to prevent future accidents or incidents. Consequently, the use of this report for any purpose other than for the prevention of future accidents could lead to erroneous interpretations.

SPECIAL FOREWORD TO ENGLISH EDITION

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.

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Glossary

CRM	Flight log entry
CVR	Cockpit Voice Recorder
IR	Instrument Rating
NP	Propeller speed
PSI	Pounds per square inch
SET	Single Engine Turbine
RFFS	Rescue and Fire Fighting Service
VR	Rotation Speed

Synopsis

Date and time
Thursday 9 August 2007 at 22 h 00[1]

Place of accident

Off the coast of Moorea (French Polynesia)

Type of flight
Scheduled public transport of passengers
Flight QE 1121

Aircraft
DHC6-300
registered F-OIQI

Owner
Air Moorea

Operator
Air Moorea

Persons on board
19 Passengers
1 Flight Crew

Summary

The aeroplane took off from Moorea aerodrome for a short flight bound for Tahiti Faa'a. It climbed normally to an altitude estimated at between three and four hundred feet, then the pilot retracted the flaps and adjusted the engine parameters. He then lost pitch control of the aeroplane after the failure of the elevator pitch-up control cable. The aeroplane dived suddenly and struck the surface of the sea about seven hundred metres from the coastline.

Consequences

	Persons			Equipment
	Fatalities	Injured	Unhurt	
Crew	1	-	-	Destroyed
Passengers	19	-	-	

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[1] All times in this report are UTC, except where otherwise specified. Ten hours should be subtracted to obtain the local time in French Polynesia on the day of the event.

ORGANISATION OF THE INVESTIGATION

The accident occurred on Thursday 9 August at around midday(2). The BEA was informed immediately and, in accordance with Annex 13 to the Convention on International Civil Aviation and the French Civil Aviation Code (Book VII), initiated a safety investigation. A Field Investigator began to collect the factual information.

A team of 4 people, including the Investigator-in-Charge, arrived in Polynesia on the morning of Saturday 11 August.

In accordance with international procedures, a member of the Canadian Transport Safety Board was appointed as Accredited Representative for the State of Design and Manufacture of the aeroplane. Subsequently, since technical information had been requested from United States, the nomination of an American Accredited Representative was accepted.

The wreckage was localised on Sunday 12 August. Recovery operations commenced on 26 August and ended on Monday 3 September.

Three working groups were established in the following areas:

❒ Operation of the aeroplane;

❒ Maintenance and precursors;

❒ Recorders and technical analysis.

All of the operations undertaken on site and on the wreckage were coordinated with those responsible for the judicial investigation.

On 9 October 2007, a safety recommendation was issued to the European Aviation Safety Agency and Transport Canada. An interim report was published in December 2007.

The draft Final Report was sent for comments to the American and Canadian Accredited Representatives. The operator and the French DGAC were also consulted, in in accordance with the French Civil Aviation Code (Book VII).

Comments were received from Canada after the end of the period of consultation, at the time the report was being printed for publication. They are appended.

(2)Local time.

1 - FACTUAL INFORMATION

1.1 History of the Flight

On Thursday 9 August 2007, the DHC6 aeroplane registered F-OIQI was scheduled to fly a public transport flight (QE 1121) between Moorea and Tahiti Faa'a with a pilot and 19 passengers on board. The flight, with an average duration of 7 minutes, is performed under VFR at a planned cruise altitude of 600 feet.

The following information is derived from the on-board audio recording and witness statements.

At 21 h 53 min 22, startup was authorised. The pilot made the safety announcement in English and in French: "Ladies and Gentlemen, hello and welcome on board. Please fasten your seatbelts".

At 21 h 57 min 19, the air traffic controller cleared the aeroplane to taxi towards holding point Bravo on runway 12.

At 21 h 58 min 10, the aeroplane was cleared to line up. It taxied up the runway and lined up at the level of the second taxiway.

At 22 h 00 min 06, the aeroplane was cleared for takeoff. Six seconds later the engines were powered up.

At 22 h 00 min 58, the pilot retracted the flaps.

At 22 h 01 min 07, propeller speed was reduced. At 22 h 01 min 09 the pilot uttered an expression of surprise. Two GPWS warnings sounded, propeller speed increased and four further GPWS warnings sounded. The aeroplane struck the surface of the sea at 22 h 01 min 20.

One minute and eight seconds elapsed between engine power-up and the end of the audio recording.

Fourteen bodies were recovered during the rescue operations. Some aeroplane debris, including parts of the right main gear and seat cushions were recovered by fishermen and the rescue team. Some days later, at a depth of seven hundred metres, a fifteenth body was recovered during operations to recover the flight recorder, both engines, the instrument panel, the front part of the cockpit including engine and flaps controls, the flaps jackscrews and the tail section. It was noted that the rudder and elevator control cables were broken off in their forward parts and that the elevator pitch-up control cable had, in its aft part, a second failure whose appearance was different from that observed on the other failures that were examined.

1.2 Injuries to Persons

Injuries	Crew	Passengers[3]	Other persons
Fatal	1	19	0
Severe	0	0	0
Minor/none	0	0	0

[3] Five bodies were not recovered.

1.3 Damage to Aircraft

The aeroplane was completely destroyed on impact with the sea.

1.4 Other Damage

Not applicable.

1.5 Pilot Information

53 years of age, he had started work with Air Moorea in May 2007.

1.5.1 Licences and ratings

- Commercial pilot license (CPL) with IFR and multi-engine rating n°C387877 issued by Canada 16 October 1992.
- Commercial pilot's license n°18288-97 issued by France 30 May 1997.
- Cessna SET rating valid until 30 September 2008.
- Multi-engine rating issued 6 August 1997 valid until 31 October 2007.
- Multi-engine IR rating n°631/97 issued by France 10 September 1997, valid until 31 may 2008.
- Obtained theory certificates for ATPL 16 June 2000.
- Crew resource management (MCC) obtained 9 February 2001.
- Training instructor for single turbine (CRI) n°F-CRIA000 43067 issued 12 April 2006, valid until 31 March 2009.
- Rating for DHC6 aeroplane valid until 31 May 2008.
- Class 1 medical exam 25 April 2007 valid to 31 October 2007, subject to carrying emergency pair of glasses in case of damage to one pair.

1.5.2 Experience

According to the information in the pilot's logbook, as of 8 August 2007 he had a total of 3,514.5 flight hours of which, on multi-engine aeroplanes:

- 53 in dual command;
- 103.8 as co-pilot;
- 141.6 as Captain.

Before being employed by Air Moorea, he had been employed as a pilot by the airline Finist'air. In this role, he had made many flights between Brest and Ouessant aerodromes.

He began his DHC6 in-flight training on 14 May 2007 and obtained his type rating on 18 May 2007 after 9.3 flying hours. His induction to the airline occurred between 28-30 May through 23 short flights totalling 7.8 flying hours.

Between 30 May 2007 and 8 August 2007, on the Air Moorea DHC6, the pilot completed:

- ☐ 76.8 hours as Captain;
- ☐ 16.4 hours recorded as co-pilot, even though the aeroplane is certified for single pilot operations.

1.5.3 Training and recurrent checks

Between the 22 and the 31 of May 2007 the pilot attended the training modules provided by Air Moorea in:

- ☐ Cockpit Resource Management;
- ☐ Human Factors for single pilot operations;
- ☐ DHC6 specific Safety and Rescue Instructions;
- ☐ Quality Awareness at induction.

A security module at Air Tahiti on 20 June 2007 was also undertaken.

1.6 Aircraft Information

1.6.1 Background

The DHC6 Twin Otter 300 series is a high-wing fixed gear regional transport aeroplane manufactured by De Havilland Canada. It is fitted with two PT6A-27 turbo-prop engines manufactured by Pratt and Whitney Canada. It is certificated for single pilot operations. Its passenger cabin is equipped with 19 seats. Its empty weight is 3,544 kg and the maximum takeoff weight (MTOW) is 5,670 kg.

1.6.2 F-OIQI

- ☐ Serial number: 608
- ☐ First flight: 2 February 1979
- ☐ Certificate of Airworthiness: n°251897 issued 17 November 2006
- ☐ Flying hours as of 8 August 2007: 30,833.51 hours
- ☐ Number of cycles as of 8 August 2007: 55,044 cycles
- ☐ Serial number of left engine: PCE-PG0293
- ☐ Serial number of right engine: PCE-PG0292
- ☐ Total left and right engine hours since manufacture: 841.01 hours and 5,146 cycles.

Note: F-OIQI was the only aeroplane in the Air Moorea DHC6 fleet equipped with stainless steel control cables, all of the others being equipped with carbon steel cables. The cables had been replaced on 11 March 2005. At that time it had flown a total of 29,652 hours and 48,674 cycles.

1.6.3 History

Before coming onto the French register, the aeroplane was registered N228CS in the USA. Owned by DP Acquisitions Inc., it had been used for parachuting operations.

The FAA issued the export Certificate of Airworthiness n°E323329 to French Polynesia on 3 October 2006, the sale certificate being dated 14 November 2006 and the notice of removal from the American register being issued on 16 November 2006.

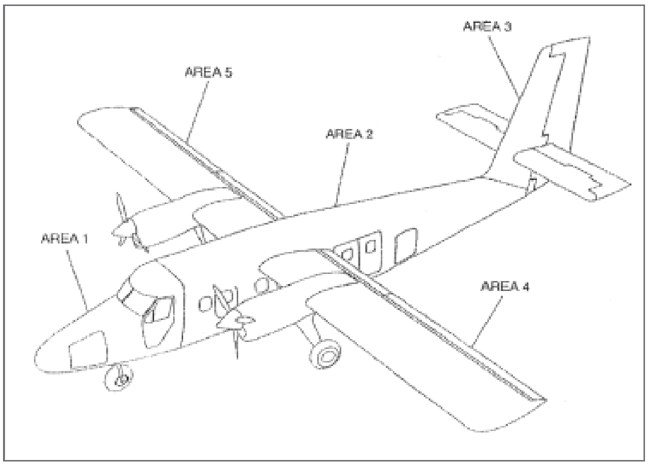
As of the date of export, the aeroplane usage was as follows:

- Fuselage: 30,005.10 hours and 49,898 cycles;
- Left and right engines: 12.6 hours;
- Propellers, time since last overhaul: 606 hours (left), 1,137 hours (right).

1.6.4 Maintenance

The maintenance of the aeroplane was performed by Air Moorea (licensed organisation FR.145.172) using the AM-DHC6 maintenance manual. This manual was approved (DIR/CTFA 06-180183) by the state civil aviation service in French Polynesia on 23 October 2006.

This manual, which was applicable to the entire DHC6 fleet, was intended to provide transition from standard maintenance to an 'EMMA controlled' (Equalized Maintenance for Maximum Availability) maintenance program. This program, proposed by the manufacturer, was based on a maintenance cycle of 6,000 flying hours. It was divided into 48 inspections (EMMA checks) at 125-hour intervals applicable to different areas of the aeroplane. Each inspection was numbered and had a corresponding work card outlining the scope of the inspection.



The aeroplane was separated into 5 areas:
AREA 1:
Interior and exterior of the nose, Cockpit, includes the nose gear.
AREA 2:
Interior and exterior of the cabin and rear of fuselage, includes the main gear and the wing struts.
AREA 3:
Interior and exterior of the tail section.
AREA 4:
Interior and exterior of the left wing includes the engine the propeller and nacelle.
AREA 5:
Interior and exterior of the right wing includes the engine the propeller and nacelle.
The EMMA Controlled check programme covered all of the areas

The maintenance programme calls for an inspection of the elevator cables in areas 2 and 3 during the n°2 check (250 hours), then every thousand hours (checks n°10, 18, 26, 34 and 42). Special checks in the case of operations in a saline atmosphere (SP1-E4 and SP1-E5) or after flights in highly turbulent conditions are also planned.

Before the purchase of the aeroplane by Air Moorea the "EMMA Controlled" maintenance was performed by Fayard Enterprises Inc.

At the time of the purchase, Avia Source Inc., acting as intermediary for the sale, ensured that the aeroplane was delivered to a standard allowing both the Certificate of Airworthiness to be issued and the start of a new maintenance cycle.

To this end, some repair and preparation work was done at Texas Air Services Inc. In particular, new engines were fitted.

The aeroplane was then transported to Canada to Rocky Mountain Aircraft Ltd (EASA-Part 145 approved) where the necessary work was done to allow the issue of the export Certificate of Airworthiness, the renewal of the maintenance cycle, and the installation of new avionic equipment (CVR, GPWS, PA, MFD…) was performed between March and September 2006.

In the course of this work, the control cables were removed, checked and re-installed, with the exception of the aileron cables, which being found to be damaged as a result of a double crossover, had been replaced.

During the aircraft handover to the operator, Air Moorea specified on the parts follow-up documentation that the life of the rudder and elevator cables was limited to one year (operations in saline atmosphere) from 2 October 2006. During the investigation, the Air Moorea management indicated that the aeroplane's documentation was incomplete, specifically that relating to parts follow-up.

Note: The manufacturer's documentation limits the life of carbon steel and stainless steel cables to twelve months in a saline atmosphere. It does not specify if they must be new at the start of such a period of operation.

1.6.4.1 Normal checks on F-OIQI

The aircraft documentation shows that checks 1 to 6 of the EMMA Controlled type and the recurrent checks made mandatory by the Airworthiness Directives had been performed.

Specifically, the checks on the cables had been undertaken as scheduled during the n°2 check on 22 February 2007. At that time, the aeroplane had a total of 30,265 hours and 51,539 cycles.

Note: The calendar limit of five years for the right propeller had been reached on 11 March 2007; the propeller had not been removed. A new calendar limit was included on the equipment follow-up document.

1.6.4.2 Special checks on F-OIQI

1.6.4.2.1 Operations in saline atmosphere

Operating the aeroplane in a saline atmosphere implies inspecting the rudder and elevator cables every four hundred flying hours (SP1-E4) and replacing them every year (SP1-E5).

The maintenance documentation makes mandatory a visual check of the cables, provides information on the detection of traces of corrosion or wear and requires their replacement in case of corrosion or wear.

Note: The manufacturer's maintenance programme makes this mandatory every four hundred flying hours or three calendar months. The Air Moorea programme was amended in October 1998 to eliminate the second limit.

The first SP1-E4 special check should have been performed between the EMMA Controlled checks n°3 and 4, on 4 April 2007 to be exact, 401.82 flying hours after the general overhaul. The aeroplane had stopped flying on that date for a repair on a defective automatic feathering system on one propeller (CRM n°237). The second should have been performed between 3 and 4 August 2007 after 804.32 flying hours.

CRM's n°511 to 515 on these two days had no specific notes on them. The aeroplane log did not mention the application of these checks and no work file was found.

Note: The Air Moorea management told the investigators that these checks had not been performed on the other aeroplanes in the fleet either. The structure of the Air Moorea maintenance manual can lead to this special check being forgotten. In fact, It is mentioned in section IV paragraph 4-5 for operations in a saline atmosphere. This paragraph states the period as four hundred flying hours and refers to sections 3 and 6 for the maintenance instructions. Section 3 (maintenance and utilisation modes and stocking of components and kits) takes into account the life cycle limit for the cables at one year, as mentioned in the SP1-E5 special check. On the other hand, section 6 (maintenance operations) ATA 27 point 4 (rudder, elevator and aileron control cables) makes no reference to the special SP1-E4 check on the state, corrosion, fraying and wear of the cables.

1.6.4.2.2 Flight in highly turbulent conditions

Flight in highly turbulent conditions or with excessive vibrations makes it mandatory to perform a special check based on a declaration made by the pilot on the flight log.

On 2 July 2007, a pilot noted in the flight log (CRM n°407) "very strong turbulence occurred, cabin padding to be replaced". The work performed mentions replacing the cabin padding and a general check on the aeroplane, without any reference to the special check. The aircraft logbook did not mention it and no work sheets were found. It should, however, be noted that the checks on the cables only need to be carried out if the pilot notifies any unusual take-over conditions, which was not the case.

1.6.5 Weight and balance

On departure from Moorea, the load estimate was based on 13 men and six women. Initially, only twelve men were scheduled, a thirteenth getting on board a short time before the doors closed.

For these shuttle flights, the operator uses a standard loading system. The weights of the passengers are applied from standards distinguishing men, women and children. The baggage is weighed before distribution in the hold.

Using standard passenger weights and flight preparation documents for the baggage and fuel weight, the estimated takeoff weight was 5,498 kg. The centre of gravity was 5.46 metres from the reference point. The rearward limit of the centre of gravity is 5.49 metres from the reference point. The aeroplane was thus within weight (see 1.6.1) and centre of gravity limits.

1.6.6 Operations Manual

1.6.6.1 Normal procedures

For the take-off weight of F-OIQI, the parameters and procedures from the operations manual were the following;

Takeoff

- ☐ Moment: 45 PSI
- ☐ Propeller speed (NP): 96%
- ☐ Flaps: 10°
- ☐ VR: 76 kts
- ☐ Initial climb speed: 80 to 90 kts

Normal climb

At 400 feet above ground:

- ☐ Torque: reduction to 40 PSI
- ☐ NP: 85%
- ☐ Flaps: 0°
- ☐ Normal climb speed: 100kts

Note: The minimum height for the flap retraction is 400 feet. The Twin Otter "Pilot Training Manual" calls for retraction of the flaps before adjusting the engine parameters in this phase of flight. The operator called for the reduction in engine RPM before retraction in order to mitigate the pitch-down moment caused by the flap retraction and so that the right hand, after having positioned the flap control lever on 0°, could be placed be placed on the elevator trim in order to reduce the effort on the control column.

The operations manual describes the checks and actions to be performed before takeoff and during taxiing. During this phase, the controls must be CHECKED/FREE. The investigators did not notice this action being performed on the few flights that they took. For the flight on 9 August 2007,the taxiing phase lasted less than three minutes and only the check on the elevator trim was called out.

1.6.6.2 Abnormal and emergency procedures

The operations manual indicates:

If elevator control inputs do not affect the pitch attitude of the aeroplane, longitudinal control can be re-established using the elevator trim control. Engine power can be used to help control vertical speed and flight path.

Note: The CAR 3 regulation, basis of certification for the DHC6, requires a flight test demonstrating the aeroplane's capacity to land using only the elevator trim in the case of failure of the primary longitudinal control of the aeroplane. It does not specify which phases of flight to reproduce during the test.

1.6.6.3 DHC6 type-rating training manual

The DHC6 type-rating training manual requires:

- ☐ A ground phase of 28 hours of courses, plus two hours of tests. During this phase, two hours are devoted to occasional and emergency procedures but the content is not specified.

❒ A 5 h 30 phase of flight, plus one hour in IFR and a practical aptitude test flight. Type ratings n°3 and 4 are respectively devoted to handling various engine failures and to assimilating emergency procedures. The loss of aeroplane primary flight controls is not covered.

Note: Managing the loss of a primary flight control is not covered in training for either private or professional pilots.

1.6.7 Flight controls

1.6.7.1 General

On the Twin Otter, the primary flight controls (ailerons, rudder and elevator) are mechanical, controlled by cable. The cable path is designed to minimise friction. Inspection traps are installed for inspection and maintenance purposes.

Note: To reduce chafing, adjustment of the tension of the cables is a function of the average temperature encountered in the place of operation. For Papeete, this tension is 95 lbs (42.2 daN).

Both types de cables can be installed: carbon steel or stainless steel. These cables are qualified according to the specifications of standard MIL-W-83420. Their normal life span is five years but their utilisation in a saline atmosphere is limited to one year.

Originally, only carbon steel cables were installed on the DHC6. On 7 February 1985, by Engineering Order n°69 053, De Havilland authorised the installation of stainless steel cables. The stainless steel elevator control cables were identified with the references EO 69053-1 to EO 69053-5.

On 22 December 1997, Transport Canada issued supplementary type certificate (STC) n°SA97-124 to Thunder Bay Aviation in relation to replacement of carbon steel or stainless steel control cables on the DHC-6-100,-200,-300, DHC-3 and DHC-2 aeroplanes. This STC allowed the company to sell its cables directly as a replacement for the original De Havilland cables. The Thunder Bay Aviation stainless steel control elevator control cables were identified with the references TB-EO 69053-1 to TB-EO 69053-5.

Notes:

❒ The specifications of standard MIL-W-83420 are identical for carbon steel or stainless steel control cables, the only difference being in the load (resistance) to failure, which are respectively 889 daN and 782,5 daN ;

❒ The extreme load on the elevator control cable taken into account in the certification regulation (CAR 3) is 850 lb (378 daN), thus a limit load[4] of 252 daN.

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[4] The external load is 1.5 times the limit load.

1.6.7.2 Elevator

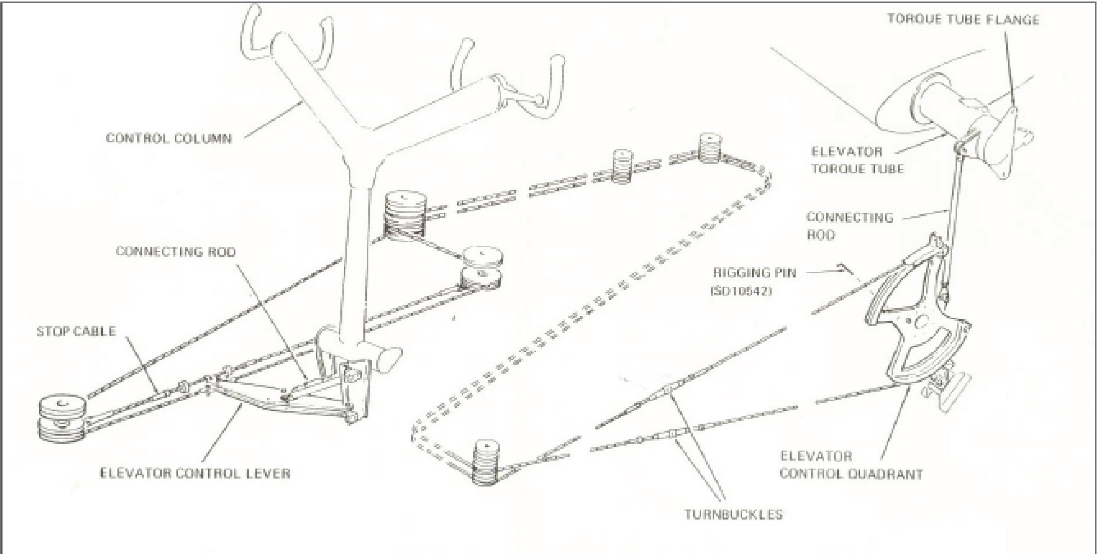


FIGURE 4–23. ELEVATOR SYSTEM – RIGGING

The elevator system on the Twin Otter is composed of two non-interchangeable semi-elevators; the right side elevator is equipped with a flap/elevator interconnect trim tab and the left side elevator with a commanded elevator trim tab.

Column movement is transmitted via a push-pull rod to the elevator control-lever mounted under the floor of the cockpit. The cables which run under the floor of the cabin along the right side of the fuselage transmit movement to the elevator control quadrant, situated in the vertical stabiliser under the attachment of the rear spar, to the horizontal stabiliser. A push-pull rod connects the control quadrant to a lever which integrates the central articulation and the link between both semi-elevators.

Note: Each cable, pitch up and pitch down, of the elevator control system is composed of a forward and aft section, connected by a stretcher situated between stations 421 and 436. These two cables form a closed loop. The failure of one cable makes it impossible to actuate the elevator.

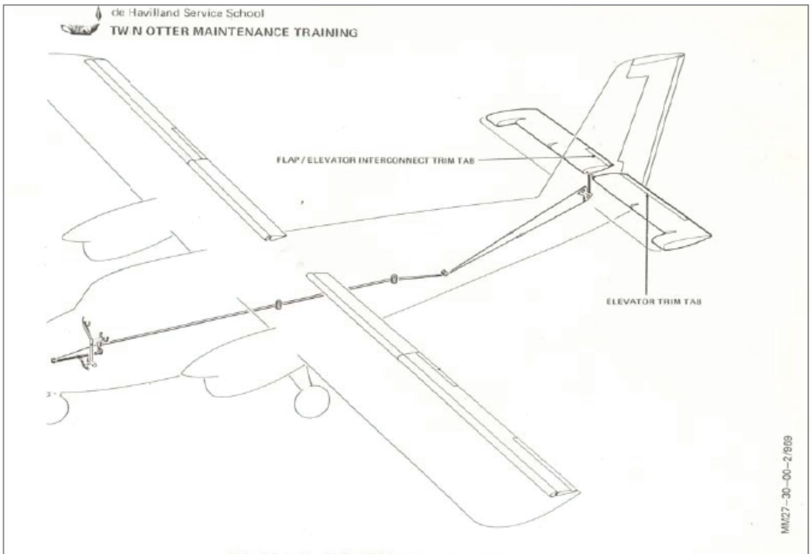


FIGURE 4–22. ELEVATOR CONTROL SYSTEM

On the day of the accident, the elevator cables, reference TBE069053-3 (pitch-down) and TBE069053-4 (pitch-up), totalled 1,181 hours and 6,370 aeroplane cycles.

1.6.7.3 Hydraulic system

The DHC6-300 is fitted with a hydraulic system for controlling the following devices:

- ❐ Flaps;
- ❐ Wheel brakes;
- ❐ Nose wheel steering.

The system pressure (around 1650 PSI) is generated from a pump within the hydraulic generation system. This pump is coupled to an electric motor operating at constant 28V which begins operating when the hydraulic pressure drops by 175 PSI, which in practice is as soon as any hydraulic device is used.

1.7 Meteorological Information

The METAR for 22 h 00 at Tahiti Faa'a aerodrome was:

METAR NTAA 092200Z 24008KT 9999 SCT023 28/21 Q1016 NOSIG=

The same conditions were present at Moorea. The wind was 240°T at 8 knots, visibility was above 10 kilometres, with scattered cloud (cumulus and stratocumulus) at 2,300 feet. The temperature was 28°C and the humidity was 66%.

Between November 2006 and August 2007, maximum wind speeds were always below 75 km/h (40.5 kt).

1.8 Aids to Navigation

For the flight, operated under visual flight rules (VFR), no navigation aids were used by the pilot.

1.9 Telecommunications

Radio communications between F-OIQI and the Moorea Temae control tower consisted only of aeroplane traffic instructions. No distress call was made.

1.10 Aerodrome Information

Moorea Temae is a controlled aerodrome open to public air traffic. It consists of a single tarmac runway, 1,230m in length and 30m wide (see appendix1).

The aerodrome has a RFFS category 4 level 5 rating.

The specific emergency plan for the aerodrome was validated on 25 May 2005 by the Service Navigation Aérienne of the Service D'Etat de l'Aviation Civile in French Polynesia. This plan constitutes a local adaptation of the ORSEC/SATER (search and rescue organisations) procedures, limited to the aerodrome and the immediate surrounding area. This establishes only local measures and, in the case where these are insufficient, guarantees the first response whilst waiting for the SATER plan to take effect.

After the accident, this plan was triggered by the High Commissioner of the Republic.

1.11 Flight Recorders

As the MTOW of the DHC6 is below 5,700kg and the Certificate of Airworthiness was issued before 1 January 1990(5), French law does not require DHC6 aeroplanes to have flight recorders fitted. Air Moorea had nevertheless chosen to install a cockpit voice recorder (CVR) on F-OIQI.

Note: Following the accident to the DHC6-300 registered F-OGES, operated by Caraïbes Air Transport, on 24 March 2001 at Saint-Barthélemy, the BEA recommended to the French and European authorities to make the installation of at least one flight recorder compulsory for aeroplanes carrying more than nine passengers and with a MTOW below 5,700kg, regardless of the date of first certification.

The CVR fitted to F-OIQI was a solid state memory capable of recording the previous 2 hours.

❐ Manufacturer: L3-Communications;
❐ Model: FA2100;
❐ Part number: 2100-1020-00;
❐ Serial Number: 362528.

The recording consisted of four audio channels:

❐ Not utilised;
❐ Pilot radio transmissions and pilot microphone;
❐ Identical to channel 2;
❐ Cockpit Area Microphone (CAM).

The CVR was recovered on 30 August 2007, 21 days after the accident, and was sent to the BEA on the same day.

1.11.1 Readout of CVR

The CVR had scratches and dents on the exterior. As it had been submerged for several days, it was necessary to remove the memory module from the crash protected enclosure and dry it, in order to perform a readout.

The recording recovered was two hours, four minutes and 14 seconds long and was of good quality. It contained both the accident flight and the nine preceding flights.

1.11.2 Analysis of recording

1.11.2.1 Transcription

The recording was synchronised with the UTC time of the radio communications transcript(6) provided by the control tower at Moorea. The complete flight transcript is provided in appendix 3. The most notable points were:

❐ 21 h 57 min 07 Engine start-up;
❐ 22 h 00 min 06 Take-off clearance given;
❐ 22 h 00 min 12 Engine power-up.

(5) Order of 12 May 1997.

(6) The time stated in the transcript is approximate because the recorder stopped between two calls. Due to this, the CVR was synchronised using only the take-off clearance at 22:00:06.

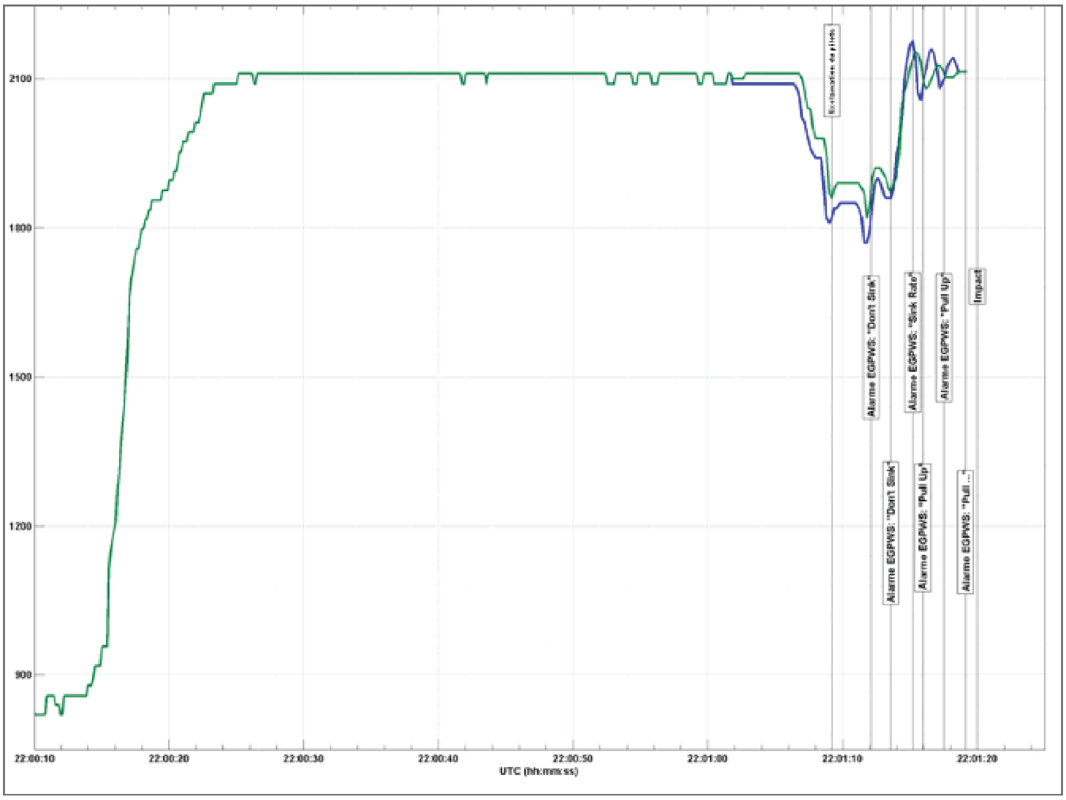
Between 22 h 00 min 58 and 22 h 01 min 06 sounds of hydraulic pump for flap actuation.

- ❐ 22 h 01 min 07 Reduction in propeller speed;
- ❐ 22 h 01 min 09 Exclamation by pilot;
- ❐ 22 h 01 min 12 and 22 h 01 min 13 Two GPWS ‘Don’t Sink’ alerts sounded;
- ❐ 22 h 01 min 14 Increase in propeller speed;
- ❐ Between 22 h 01 min 15 and 22 h 01 min 19, one GPWS alert “Sink rate” and three GPWS “Pull up” alerts;
- ❐ 22 h 01 min 20 End of recording.

1.11.2.2 Spectral analysis

The audio from the CAM was analysed to extract information about the speed of the propellers.

At the time of the take-off roll and the initial climb, both propellers were at 2,100 RPM. Their speed is represented below and associated with certain CVR recorded events.



Propeller rotation speed during the accident flight

1.12 Wreckage and Impact Information

1.12.1 Description of site

The fourteen bodies were recovered outside the lagoon, in an area located at about seven hundred metres from the shore to the south-east of the threshold of runway 30, an area in which the few items of the aeroplane that had not sunk were also recovered. The sea depth in this area reach several hundred metres. The slope of the seabed is about 45% in that area.

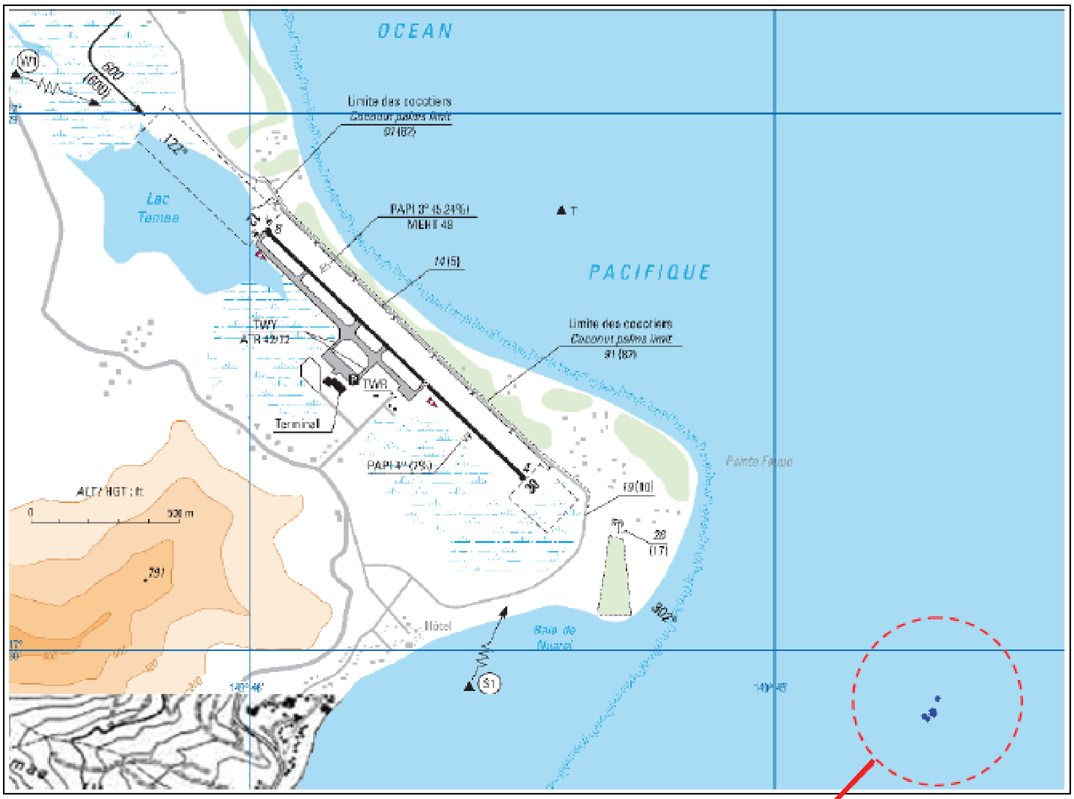
The sea searches (see chapter 1.16) made it possible to position the various elements and to raise those deemed useful for the investigation. During these searches, fifteen bodies were recovered.

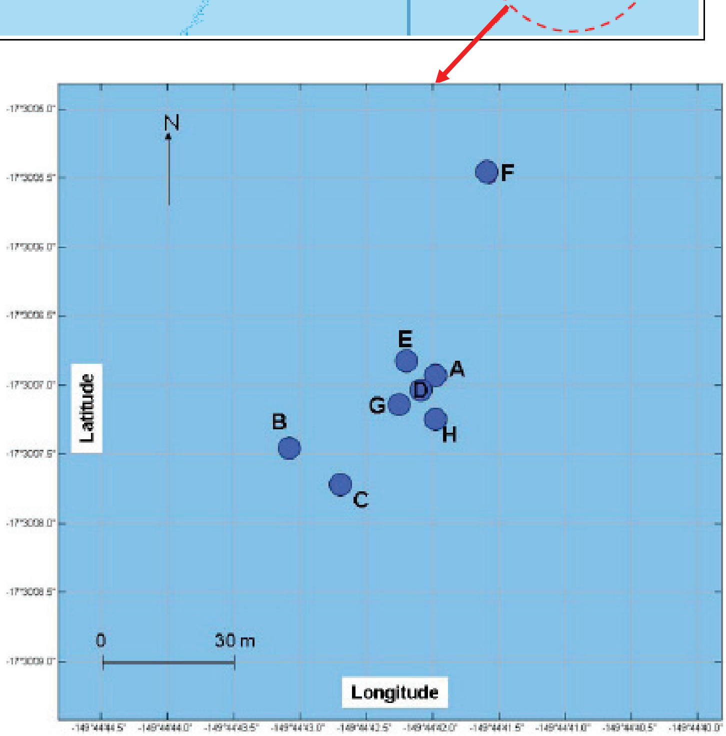
1.12.2 Floating elements

Elements recovered on the sea surface:

- The right main landing gear;
- Fifteen seat cushions;
- Two seat frames;
- One whole seat;
- Several elements of the floor of the passenger cabin;
- The partition walls between the cockpit and the passenger cabin;
- Parts of the forward baggage hold;
- The right and left emergency exits;
- Several life jackets.

1.12.3 Wreckage distribution





A - Tail section and rear section of the fuselage.

B - Right Engine

C - Left engine

D - Front section of the cockpit

E - Part of the right wing, part of the fuselage, part of engine mounting, upper console.

F - Part of the central cabin and left main gear

G - Right wing

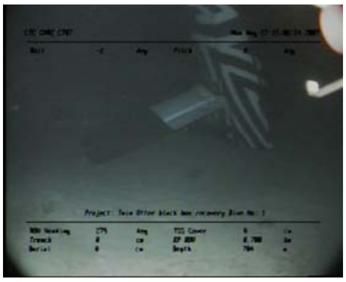
H - Left wing

1.12.4 Recovery of aeroplane parts

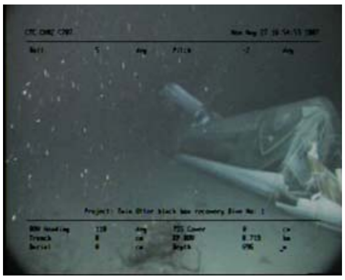
1.12.4.1 Tail and CVR

The rear part of the aeroplane, from the baggage hold to the tail, was in one piece. It was resting on the complete left half fuselage (fixed and mobile parts). A part of the right half of the fuselage was ripped off.

Rear part



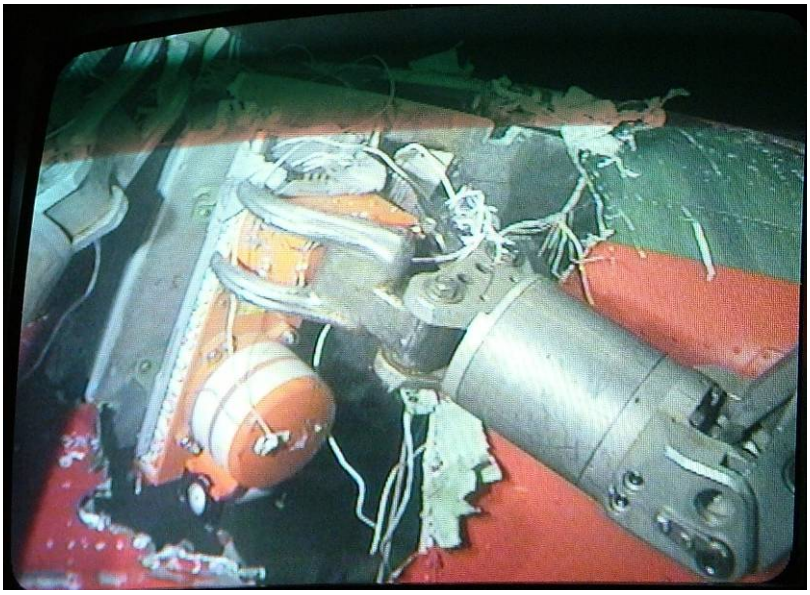
Left side



Right side

An attempt to raise this aft part of the aeroplane was made on Tuesday 28 August. The door of the rear baggage hold and the fuselage were punctured with a metal rod in the shape of a lance. A cable attached to the end of the rod made it possible to attach the part to raise it with the help of a crane. During this manoeuvre, while the part was about fifty metres from the surface, the cable that was holding it cut through the fuselage frame and it all sank back down to the bottom.

A new ROV dive helped to find it, practically vertically below where it had broken free. The tail had separated; the left-side fuselage had broken. In order to ensure that the CVR was recovered, it was then decided to extract it from the seabed. To do this, it was necessary to cut the fuselage on the side to access it and then to tear out the rack on which it was mounted. In addition to the CVR, this rack contained radio-communication boxes. It was raised during the night of 30 August.



Extraction of CVR rack using the ROV arm

The fin, with its associated control surfaces and the elevator control systems, was raised during the night of 31 August and 1st September.

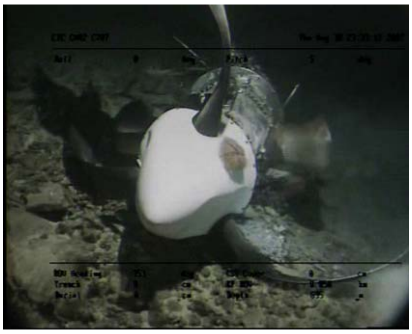
Fin after raising

The two rudder cables and the two elevator control cables were broken: three were about the same length but the fourth, the pitch-up cable, was about 2.5 metres long. On visual examination, one of the failures of this last cable had a different appearance from the others. It was thus decided to examine these parts as a priority.

1.12.4.2 Engines

The right engine was raised during the night of 30 to 31 August.

The left engine was raised during the afternoon of 31 August.

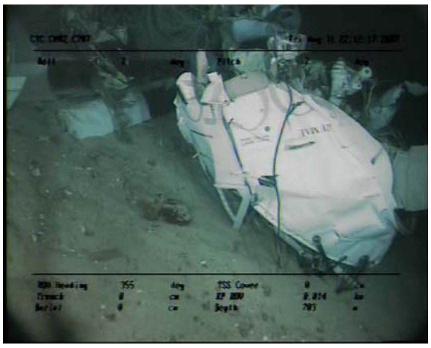


Right engine

Left engine

1.12.4.3 Forward part and cockpit

A piece made up of the nose of the aeroplane, the instrument panel and a part of the control wheel was raised on 1st September. This part was found five metres southwest of the aft part that contained the CVR, 670 metres deep.



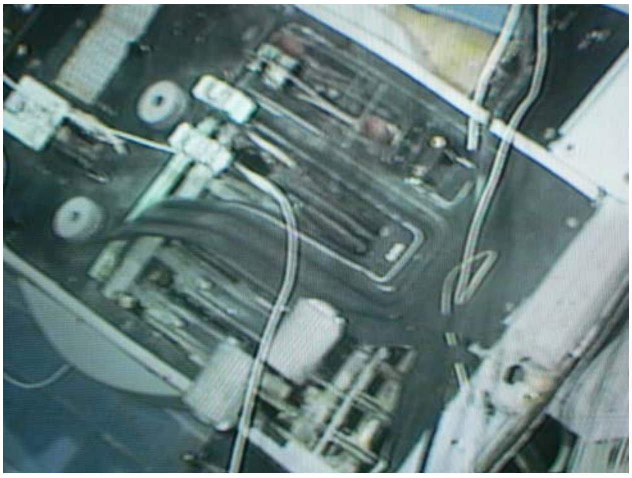
Underwater view

Raised instrument panel

The following information was noted:

❒ HSI and RMI: heading 120°
❒ Left and right VSI: - 3,000 ft/min
❒ Left gauge: 210 lb
❒ Right gauge: 190 lb
❒ Boost pump Aft and Fwd: ON
❒ Right air speed indicator: 100 kt
❒ Tank selectors: Aft and Fwd
❒ Autofeather pushbutton: pressed

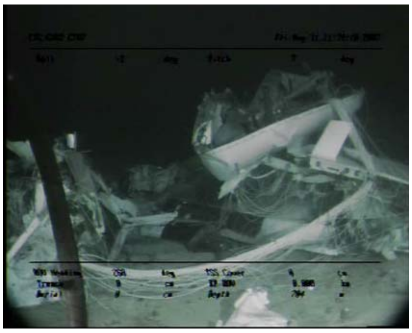
Upper console and flap actuator



The upper console, including among other things the engine thrust levers and the flap control levers, was raised on 2 September.

The flap actuator was also raised on 2 September, and was in the flaps retracted position.

These parts were part of a larger group, that were not raised, that included part of the forward cabin, the right wing and the engine pylon. This group was located eight metres from the piece where the instrument panel was 665 metres deep.



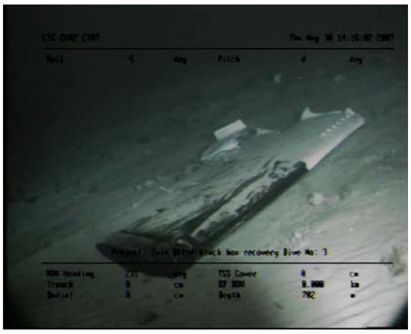
1.12.5 Other parts identified but not raised

1.12.5.1 Part of the central fuselage and left main landing gear

A part of the central fuselage (passenger cabin) with, underneath, the left landing gear, was found forty-five metres north-north-east of the rear part of the aeroplane, 670 metres deep. A detailed examination was made: no bodies were found, and there were no seats in the cabin.

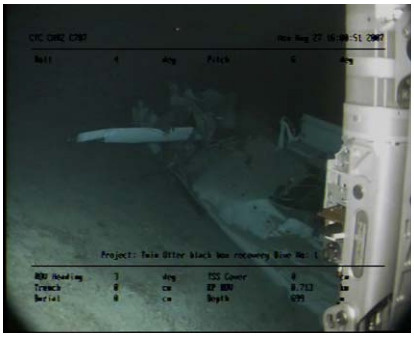
1.12.5.2 Right wing

A part of right wing was found eleven metres southwest of the rear part of the aeroplane, 650 metres deep.



1.12.5.3 Left wing

A part of left wing was found eleven metres to the south of the rear part of the aeroplane, 668 metres deep.



1.13 Medical and Pathological Information

The autopsy of the pilot did not bring to light any anomalies. The biological analyses showed an absence of any medicines, toxic substances or drugs.

The pilot had osteo-articular and visceral lesions that resulted from the violent impact.

1.14 Fire

There was no fire.

1.15 Survival Aspects

The aeroplane parts and the spread dispersion bore witness to the violence of the impact with the surface of the sea. Under such conditions, the accident was not survivable for the occupants.

1.16 Tests and research

1.16.1 Summary and corroboration of testimonies

The controller on duty in Moorea control tower indicated that the F-OIQI had stopped at Bravo taxiway to allow an ATR 72 to land then it had gone up the taxiway to take the penultimate taxiway to runway 12.

The runway employees confirmed that there was no-one in the cockpit seat on the right.

Several people were present at the aeroplane's take-off and initial climb. Some also saw the end of the flight. There were two different groups, people who saw the aeroplane from behind and people who saw the aeroplane from the side.

The first group of people was on the airfield and on the beach. They described a normal take-off and climb, a short stabilisation then a rather pronounced descent. Those who heard the engines added that they were functioning up until impact, though some people noticed a variation in power. Most described a straight trajectory. One did, however, point out that, just before impact, the aeroplane's pitch attitude and bank were at about 45°. A luggage handler who was on the ramp area saw the aeroplane's flight path deflect towards the left during its descent.

The second group was made up of fishermen who were a few hundred metres north of the point of impact. They saw the aeroplane on a slightly pronounced descending trajectory and one of them indicated that it was the front landing gear that first touched the water. They were the first to arrive at the accident zone, saw the rear part of the aeroplane that was sinking rapidly and they smelt a strong smell of kerosene. Three flights, to clarify and corroborate these testimonies, were performed on 16 August 2007 with a Beechcraft of about the same size as the Twin Otter. Some witnesses stood where they were at the time of the accident. The aerology conditions on the day were very close to the ones on the day of the accident.

The flights consisted of a take-off from Moorea airport, a climb to a height of three hundred feet (for two of the flights) and four hundred feet, with a slope close to that of the Twin Otter, that is to say about 10%, then a descent. During the last flight, the aeroplane climbed to three hundred feet and was put into a descent at a 9% slope, with a slight left turn. This trajectory's culmination point coincided with the point of impact. The witnesses considered that this trajectory was close to the one they had seen on the day of the accident.

1.16.2 Localisation of the CVR's underwater locator beacon

The underwater locator beacon fitted to the CVR transmits a 37.5 kHz frequency signal every second as soon as it is submerged. Its regulatory transmission duration is at least thirty days.

The underwater signal localisation operations took place from 11 to 14 August 2007. A DataSonics DPL275A-DHA151 type acoustic beacon locator was used. This is a directional hydrophone with a frequency adjustable amplifier that makes it possible to pick up the signal transmitted by the beacon. The direction of the beacon corresponds to the direction where the signal is heard the loudest. It can be used by an operator on a boat or by a diver under water.

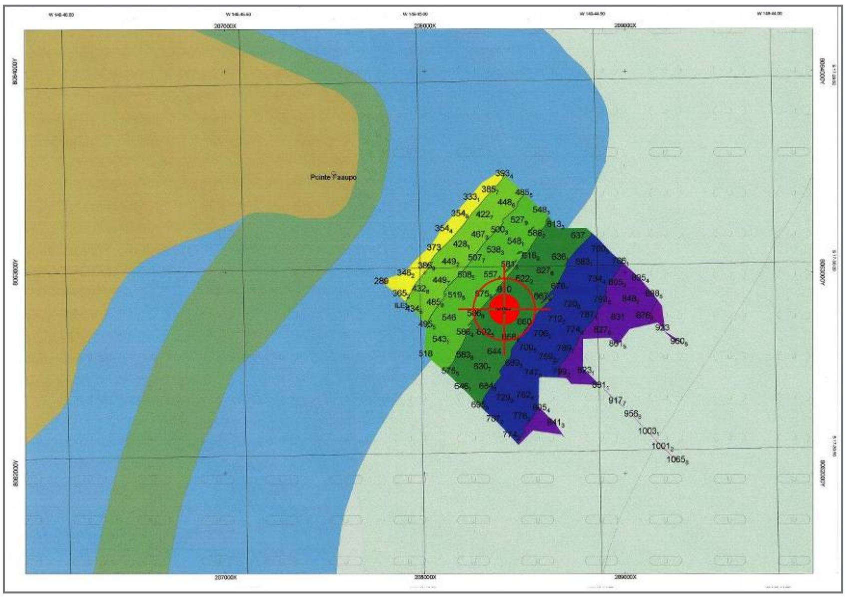
Different measurements of the beacon directions were made at coordinated points measured with a GPS receiver and then transferred to a map. This enabled the CVR to be localised at the junction of the half-rays originating at the measurement points and in the direction of the bearings recorded.

Thirty-two surface measurements and twelve underwater measurements made it possible to define the inside of a circle of 130 metres radius centred on the S17°30'06'' W149°44'46''(7) point as a probable zone where the beacon was located. This calculation was made taking into account the uncertainties related to the different measurements. The sea is in fact a mixed environment, not stationary but noisy, and the spreading of acoustic waves is subject to numerous reflected lines. This leads to measurements with interference that affects localisation accuracy.

(7) The coordinates of the various points used during the mission were based on the WGS84 geodesic system.

Probable zone for the localisation of the CVR's ULB

The French Navy's Hydrographical and Oceanographic Service carried out bathymetric measurements, in preparation for the reading operations, for a zone of a thousand metres by a thousand, centred on the point specified above. Isobaths were traced every one hundred metres. The average slope of the sea bed in this zone was about 45%, the depth varied from three hundred metres to more than nine hundred metres. The depth at the centre of the localisation centre for the CVR beacon was roughly six hundred and fifty metres.



Bathymetric readings

Note: As well as bathymetric readings, some reception of the beacon signal was arranged with a submerged sounding lead tuned at 38 kHz. From two right-angled paths, the position of the beacon could be estimated at the intersection of the perpendiculars with straight lines from the points where the signal was strongest. The position obtained by this method was within the circle of uncertainty previously established by the BEA.

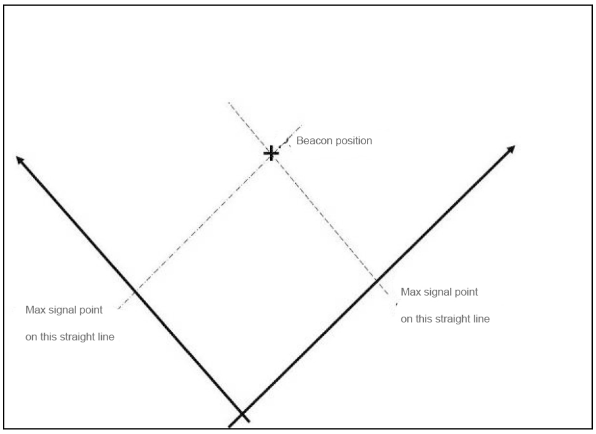


Diagram of the localisation principle

1.16.3 Underwater work

After the accident, the examination and underwater recovery of the Twin Otter components, including the CVR, were deemed indispensible to the investigation, and the necessary means (a ship with dynamic positioning and an ROV[8]) were immediately sought. This task, carried out at French inter-ministerial level, was not easy, as there are not many ships of this type and they are all practically in use at all times. In addition, the time needed for on-site deployment was a significant factor in the decision, given the possibility of worsening weather.

Under these conditions, national solidarity entered into play and Alcatel-Lucent Submarine Networks and Louis Dreyfus Armateurs SAS companies offered the *Ile de Ré* cable laying ship that they own through their subsidiary Alda Marine SAS. The ship was in New Caledonia in the framework of a maintenance contract and the beneficiary, the Office des Postes et Télécommunications de Nouvelle-Calédonie, agreed to an immediate suspension of the contract.

The *Ile de Ré* cable layer

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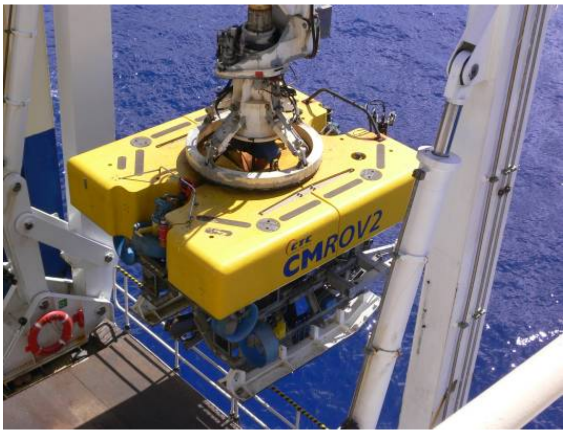
[8] Remote Operated Vehicle

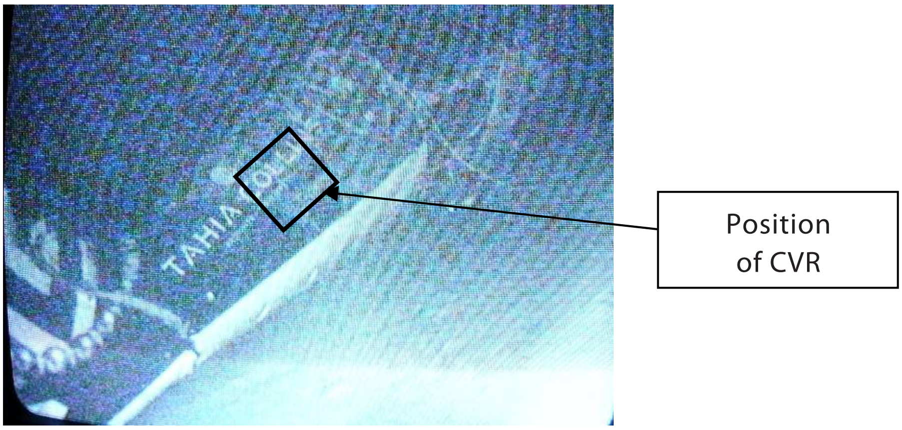
The *Ile de Ré* (see appendix 4) is fitted with a GPS dynamic positioning system that allows it to keep stationary in a precise spot, by countering the effects of wind, current and waves with its engines. It deployed a CMR2 type ROV. This ROV, with two articulated hydraulic arms enabling the handling of objects underwater, can dive to a depth of 2,500 metres; it is remotely-controlled from a cabin onboard the ship to which it is tethered by a cord that transmits the necessary electric power (150 kW) as well as telemetric data and video.



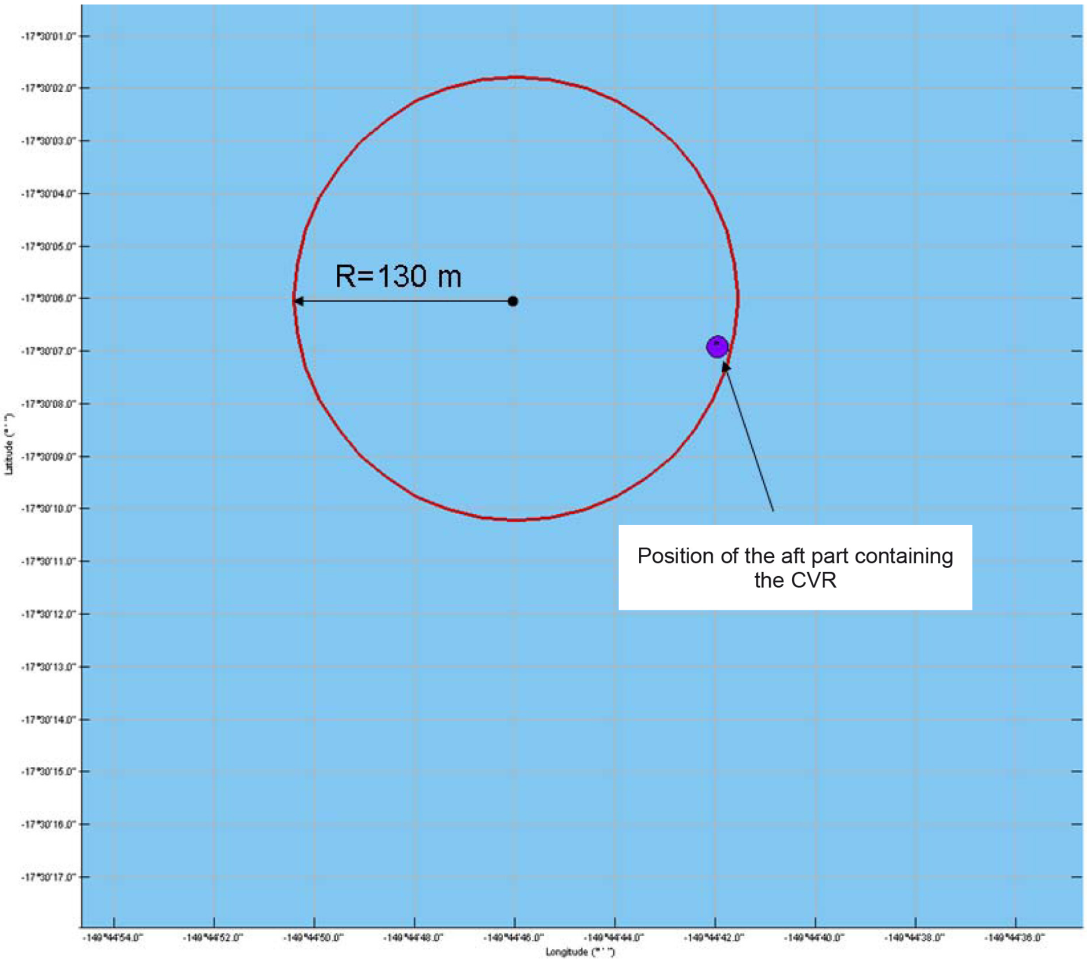
The *Ile de Ré*'s CMR2 ROV

The *Ile de Ré* arrived in Papeete on 26 August. After preparation (in particular, an acoustic detection system for the CVR beacon was installed on the ROV), it was placed on 27 August at the centre of the probable localisation circle and the dynamic positioning was launched. The beacon echo was picked up at about one hundred metres horizontally; the ROV was submerged and directed towards this position.

After a few minutes of searching the ocean bed, the rear section of the aeroplane, where the CVR was placed, was seen at a depth of 666 metres. It was inside the localisation circle, about 120 metres east of the centre.



Position of CVR



The grid pattern location and recovery operations in the area (see paragraph 1.12) were launched. They took place between 25 August and 3 September 2007, monitored by the BEA investigators, in the presence judicial police officers. The ROV operators worked under the investigators' directives, assisted by a specialist from the aeroplane manufacturer. They were systematically filmed and recorded. Despite an ROV breakdown that lasted twenty hours, the planned work programme was followed. Twelve dives were carried out in total.

The *Ile de Ré* set off back to Nouméa on the morning of 6 September.

1.16.4 Examinations

1.16.4.1 The tail assembly

The tail assembly that was recovered was made up of the following parts:

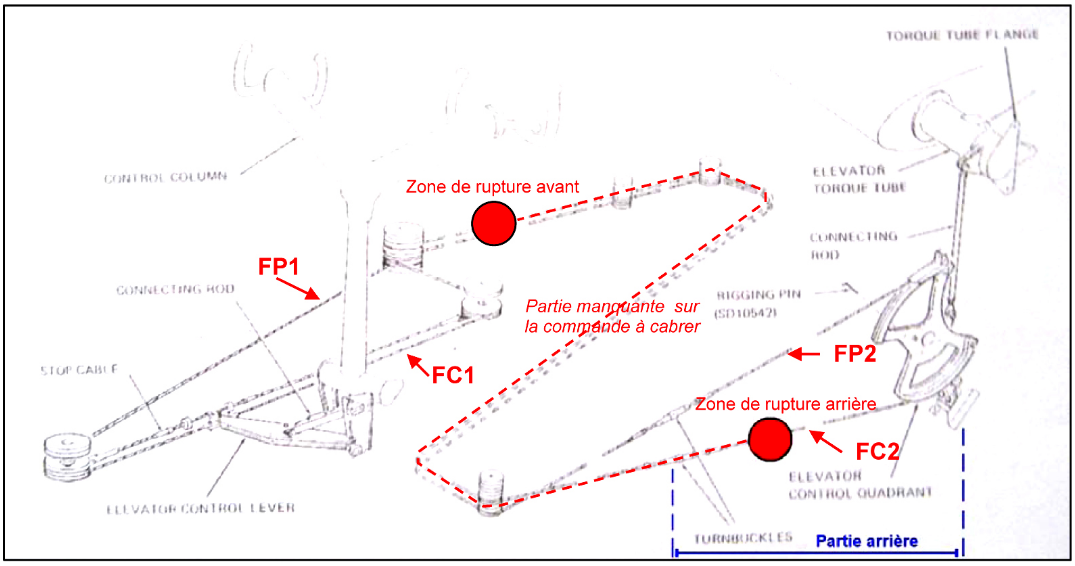
- ❒ the whole vertical stabiliser with tab-fitted rudder;
- ❒ the right horizontal stabiliser, shattered one metre from the tail assembly, with part of the torque tube;
- ❒ the left horizontal stabilizer, shattered twenty centimetres from the tail assembly, with part of the torque tube;
- ❒ the quadrant terminal of the elevator control;
- ❒ the rudder control cables and elevator control cables, broken off;
- ❒ the right elevator torque tube, broken off, as well as the vertical rod broken off to the right of the torque tube joint, but still attached to the quadrant.

The workshop examinations were unable to recreate the fracture sequence but they showed that these components had not been damaged before the accident, except for the control cables (see below). On all the components in the elevator control sequence, the pitch-up control cable was the only one that showed marks and a particular signature.

1.16.4.2 The control cables

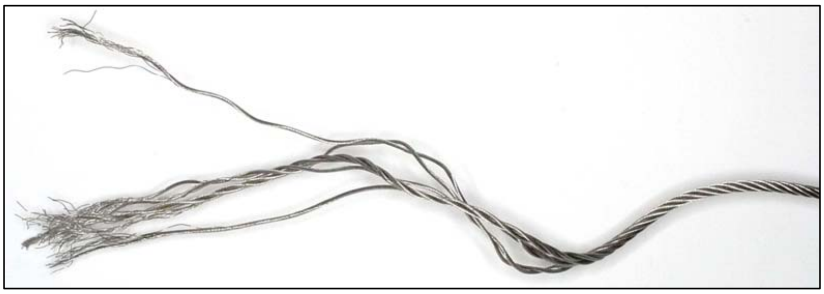
Following the observations made on site, the pieces of control cables brought to the surface were flown to Paris under judicial oversight to be subjected to laboratory analysis.

The two elevator control cables and the two rudder control cables broke off in a zone situated in the forward part of the aeroplane. The pitch-up control cable showed a second failure in the aft part of the aeroplane, with a different appearance to the other failures, and an 8.8-metre long piece of this cable was missing. All of the pitch-down elevator cable was recovered.



FP1 : Fragment of pitch-up cable attached to control column, length 1.55 metres
FP2 : Fragment of pitch-up cable attached to elevator, length 11.25 metres
FC1 : Fragment of pitch-down cable attached to control column, length 0.75 metres
FC2 : Fragment of pitch-down cable attached to elevator, length 2.60 metres
Total length of pitch-up cable = 12.80 metres
Total length of pitch-down cable = 12.15 metres

1.16.4.2.1 Examination of the failures in the forward zone

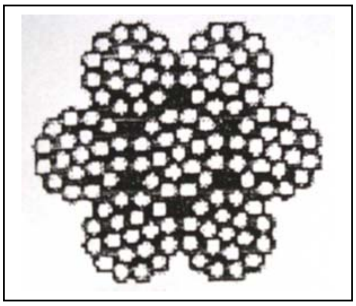


Typical failure of a cable broken off in the forward zone (scale 1:2)

All the failures that occurred in the forward zone were identical, the strands had separated (untwisting) over several centimetres. They were typical of overload failures. No deposit, traces of corrosion or signs of wear were observed in line with the failed areas.

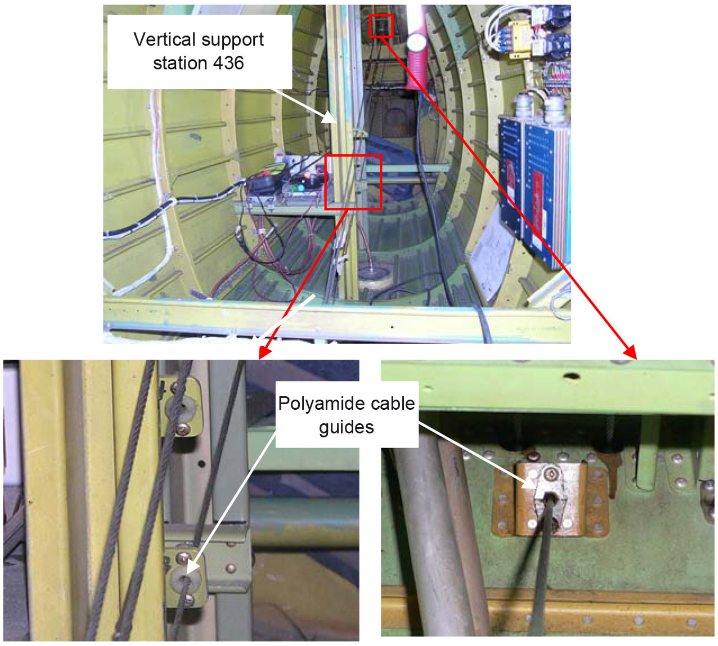
1.16.4.2.2 General examination of the elevator control cables

The elevator control cables were made of stainless steel, they were made up of seven strands of nineteen wires. Six outside strands were spiralled around a central strand with a pitch of about 23 millimetres. Each strand was made up of a core wire around which was plied a first layer of six wires then a second layer of twelve wires. The wires all had the same diameter. The cable's outside diameter was 1/8 inch (roughly 3.2 mm).



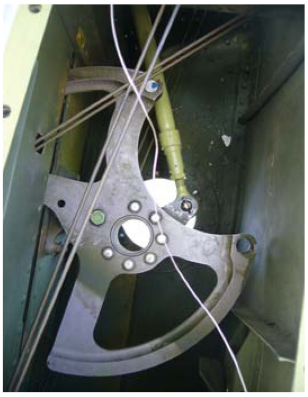
Cross section diagram of cables

The two cables showed several signs of wear in the zones of contact with elements of the aeroplane: the rear quadrant, the rear partition passage and the cable guides attached to a vertical strut at the level of station 436. The formation of flat spots was observed on the section of the cables in contact with these elements and the presence of failed wires.



Cable guide

Rear partition passage



Aft quadrant

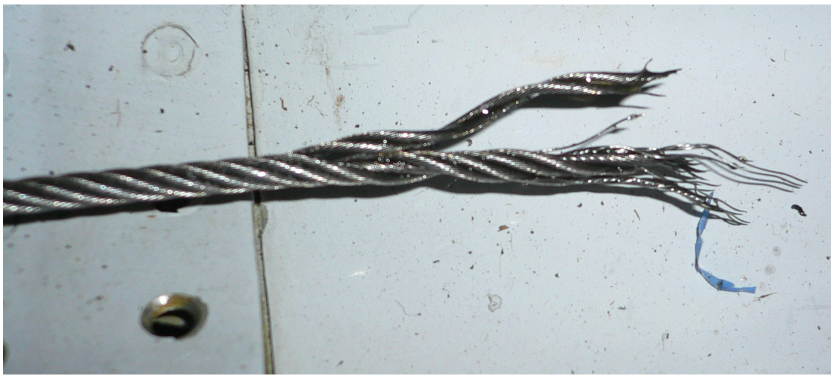
Wear at the metallic quadrant level presented a mat rough aspect relative to the metal on metal chafing. It was characterised by signs of chafing perpendicular to the cables' axis.

The areas of wear at the partition passage level and the cable guides had a shiny "polished" aspect. Their surface showed thin signs of chafing parallel to the cable axis. This wear was representative of chafing with the polyamide bushes located in the ferrules.

The rear failure of the pitch-up control cable was in line with the cable guide.

Note: during the first visual examination of the cables, the signs of wear were not noticed by the investigators.

1.16.4.2.3 Examination of the rear pitch-up control cable



Aft failure of the pitch-up control cable (scale 1:1)

Cable conformity

The cable constitution, its chemical composition and mechanical features were found in accordance with the standard relative to the aeronautical control surface cables used by the manufacturer and approved by the certification authorities.

Examination of the aft failure

The strands stayed grouped on the whole in the aft failure area.

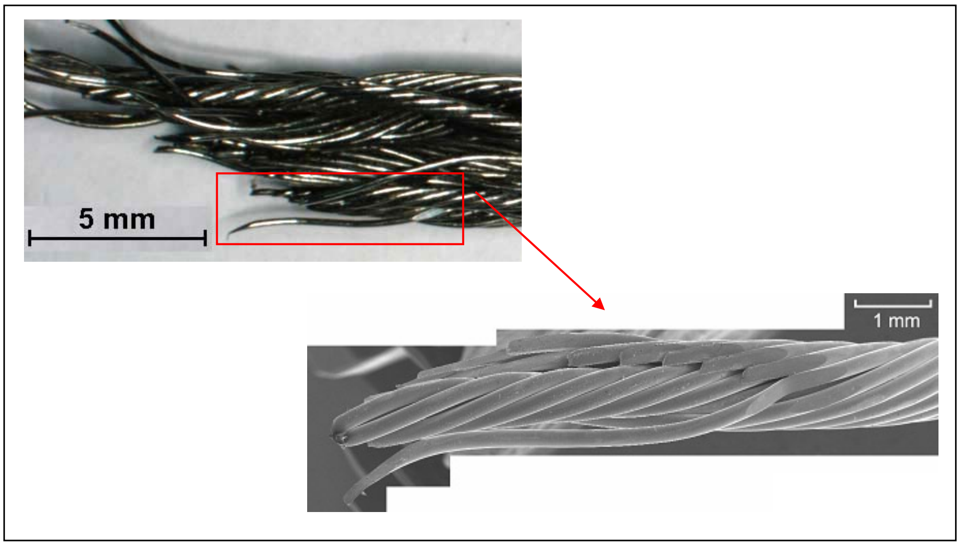
The external wires of the outer strands all failed in line with a range of wear. This represented 72 wires out the 133 that made up the cable. The wear had caused a reduction of the wire cross-section of more than 90% for the majority of them.

Several internal wires of the outer strands showed ranges of wear, indicating that the external wires had been worn through.

The other wires (the outer strands' internal wires and the central strand's wires) had failed in overload. The fractures were characterised by the presence of small cavities over the whole surface.

No sign of corrosion was observed in the failure area.

The specialists who conducted the examinations concluded that this cable had likely failed before hitting the water.



Profile of wear on the outer wires in the failure area

1.16.4.2.4 Aft control cable wear at the cable guides

Wear on the pitch-down and pitch up cables in line with the cable guide was estimated from observation of each wire's profile with a binocular magnifying glass. The plates (appendix 5) show photos of these profiles for each worn wire.

In the absence of a rule or practice for assessing cable wear, the investigators applied the following method:

- each wire with a reduction in cross-section of less than 25% was counted as a non-worn wire;
- each wire with a reduction in cross-section of more than 75% was counted as a worn wire;
- each wire with a reduction in cross-section of between 25 and 75% was counted as a half-worn wire;
- the rate of wear was determined by the ratio of the number of worn wires to the total number of wires making up the cable.

Under these conditions, the rates of wear were reckoned to be:

- 50% for the pitch-up cable;
- 35% for the pitch-down cable.

1.16.4.3 The engines

The aeroplane's two engines were transported to the engine test centre (the CEPr in Saclay). The examinations conducted under the BEA's responsibility showed:

1) for the two GTP's:

- limited signs of contact in rotation on the whole axial flow compressor, centrifuge and core engine turbine;

- limited signs of contact in rotation on the power section.

2) for the two propellers:

- the bending to the rear and twisting of the end of the blades towards the negative pitch on two of the blades of each propeller, the dipping to the front of the third as well as tearing out of the cylinders by extreme rotation of the blades towards the negative pitch. This damage showed the force at the moment of impact.

In conclusion, both engines were rotating at the time of the accident, showed working symmetry and were delivering power. The damage recorded was the consequence of the accident or of corrosion due to a period in sea water.

1.16.4.4 The warning lights panel

Examination of the warning indicators did not reveal anything that could indicate that a warning light was on at the moment of impact.

1.16.5 Aeroplane performance during inputs after take-off

The sound recording showed that the pilot had retracted the flaps then reduced engine power. A partial reconstruction of the accident flight, with the same sequence, was carried out at an altitude of 3,000 ft with a slightly more forward centre of gravity than on the day of the accident. This allowed the team to ascertain the effect of the pitch-down moment at flap retraction from 10° towards 0°. To counter this effect and maintain the aeroplane on its initial trajectory, it was necessary to exert considerable pitch-up effort on the elevator control. If the handle was released, a variation in trim was noticed, moving progressively to twenty-five degrees pitch down, the rate-of-climb indicator rapidly reaching the stop at less than 3,000 ft/min.

1.16.6 Readout of the EGPWS

The aeroplane was equipped with a Honeywell brand MK VI model Extended Ground Proximity Warning System (EGPWS). This on-board system provides the pilot with sound and visual information when flight conditions present a risk of collision with the ground. These warnings are generated for, among others:

- an excessive descent rate (mode 1),
- a loss of altitude after take-off (mode 3).

From the sequence of EGPWS warnings recorded by the CVR, calculations were carried out to determine the flight path vertical profile.

1.16.6.1 Hypotheses and data

The installed EGPWS was considered to be in good working order.

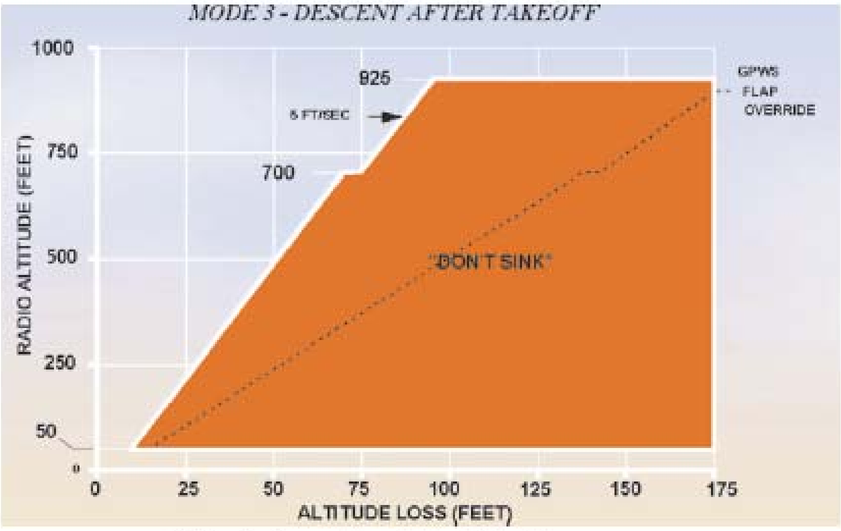
Recorded events used for the calculations:

Time UTC	t (s)	Event
22 h 01 min 08 s	0	
22 h 01 min 09.2 s	1.20	Pilot’s exclamation
22 h 01 min 12.1 s	4.10	EGPWS “Don’t sink“ warning
22 h 01 min 13.55 s	5.55	EGPWS “Don’t sink“ warning
22 h 01 min 15.2 s	7.20	EGPWS “Sink Rate“ warning
22 h 01 min 15.95 s	7.95	EGPWS “Pull up“ warning
22 h 01 min 17.55 s	9.55	EGPWS “Pull up“ warning
22 h 01 min 19.15 s	11.15	EGPWS “Pull“ warning interrupted
22 h 01 min 20 s	12.00	End of recording

- ❐ At t=0, the aeroplane was still assumed to be in normal climb, at a vertical speed of 600 ft/min.

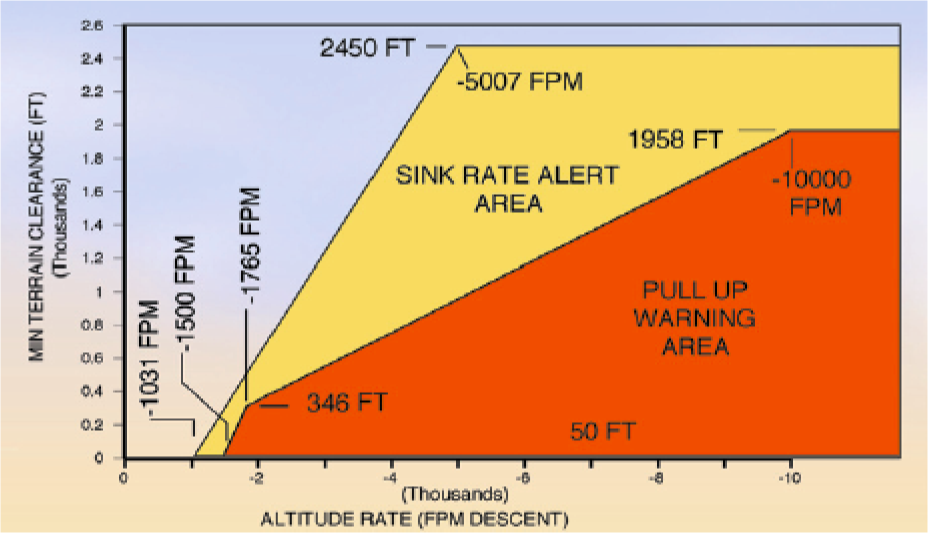
- ❐ Typical EGPWS equations were issued from Honeywell document n°060-4314-000 called “MK VI & MK VIII EGPWS Pilot Guide“, C revision of May 2004.

- ❐ The “Don’t Sink“ warning is the “Mode 3 – Loss of altitude after take-off“ warning. The triggering of this warning depends on the loss of altitude and the aeroplane’s radio altimeter height, as shown below:



Altitude loss after takeoff turboprop

- ❐ The “Sink rate“ and “Pull up“ warnings are “Mode 1 – Excessive descent rate“ warnings. The triggering of these warnings depends on the descent rate and the aeroplane’s radio altimeter height, as shown below:

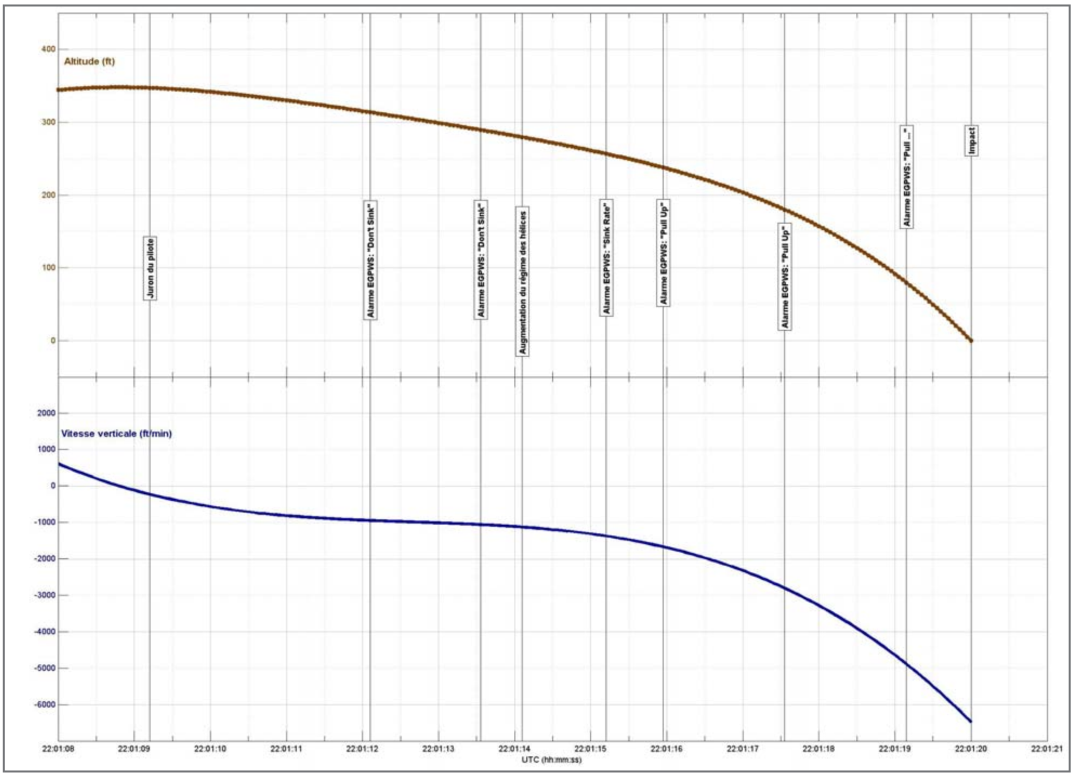


Excessive Descent Rate turboprop

- ❐ The topography of the aeroplane's flight path after take-off from Moorea airport allowed the aeroplane's altitude to be assimilated with its radio altimeter height.

1.16.6.2 Results

From these hypotheses, the establishment of model of the aeroplane's altitude enabled the following vertical profile for the end of the flight to be calculated:



Specifically, the maximum altitude reached at 22 h 01 min 08.8 was about 350 ft. The vertical speed at impact was – 6,500 ft/min.

1.16.7 Flight tests

Flight tests (see details in appendix 6) were carried out at the flight test centre (at Istres) on a DHC6-300. Their aims were:

- ❐ to assess the load increase on the elevator cables when the pilot countered the pitch-down moment at flap retraction,
- ❐ to assess the load increase on the aileron control cables during approach and landing manœuvres,
- ❐ to check the aeroplane's performance in a simulation of elevator control cable failure.

The aeroplane weight used was 5,000 kg (11,020 lb) and its centre of gravity equivalent to that of the F-OIQI the jour of the accident, namely 35.5%.

During the various tests undertaken, it was demonstrated that:

- ❐ maximum load reached was 8 daN on the elevator control, causing an increase in cable tension of 11 daN in its rear section when the pitch-down moment was countered at flap retraction,
- ❐ aileron load with flaps in landing configuration at the last turn increased the load by 8 daN on the control and on the cable,
- ❐ stick free, the flap retraction led to a pitch-down moment varying the aeroplane trim between 20° and 30°, the rate-of-climb indicator going to stop at less than 3,000 ft/min and speed reaching 140 kt in twenty seconds, then the aeroplane recovered on its own in level flight in five seconds, the total loss in height being seven hundred feet,
- ❐ in stick free conditions at flap retraction, if the pitch-down moment was countered by elevator trim within three seconds, the loss of altitude was almost zero.

These tests showed the similarity of the aeroplane's performance in the case of elevator control cable failure with the accident description made by the various witnesses.

Note: The tests were prepared on the ground and conducted by the same team, without any surprise effect. Because of this, any extrapolation in relation to the accident should be made cautiously (see chapter 2.3).

1.16.8 Tests on the cables

Various tests were carried out to understand the performance of a worn cable according to its condition and the load it was subject to. Considering the test conditions (particularly the absence of constraints related to the flight and the impossibility of exactly reproducing the slim structure of wear on the cable involved), it was not appropriate to extrapolate the results obtained, for example to determine each of the F-OIQI worn cable strand's resistance, to establish a correlation between an aeroplane's conditions of use and the real wear of a cable in operation or to try to compare the appearance of the failures.

1.16.8.1 Wear tests

Wear tests were requested from the Ecole Nationale des Ponts and Chaussées. They were carried out, under the same conditions, on two new cables meeting the specifications for the MIL-W-83420 standard, one made of carbon steel and the other of stainless steel. These tests were to compare the wear performance of the two types of cable during cycles of chafing on a polyamide bush.

The bushes used were new and identical to the polyamide bushes installed on the cable guides attached to the station 436 strut.

A range of wear appeared on the stainless steel cable whereas no wear was detectable on the carbon steel cable. These tests confirmed what had been noticed in operation (see 1.18.1). They did not, however, allow a possible cable wear law to be established, if only because calculating the rate of wear by counting wires implied cutting the cable. Because of this, and even if it seemed likely, it was not possible to say if the rhythm of wear accelerated at the same time.

Binocular view of the wear area
on a stainless steel cable
after 150,000 cycles

Binocular view of the wear area
on a carbon steel cable
after 150,000 cycles

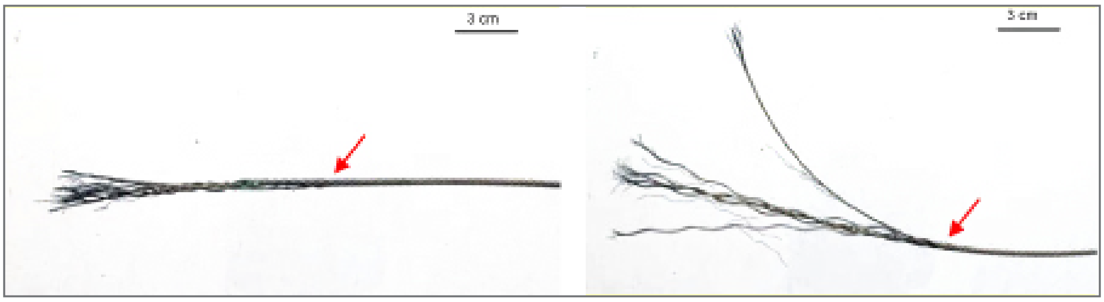
Notes:

- The tendency of stainless steel cables to wear seemed to have been understood in some aeronautical circles. A Special Airworthiness Information Bulletin (SAIB) issued by the FAA on 11 July 2001 recommended that Piper aeroplane owners and operators should carry out stainless steel cable inspections every hundred hours because of their much shorter life expectancy than carbon steel cables.
- Wear of stainless steel cables occurred mainly during control surface deflection; the range of wear on the F-OIQI cables, for example, corresponded to the displacement for normal use of the control surface. Wear was thus linked more to the cycles of use than to the aeroplane's flying hours.
- Unlike corrosion, cable wear was not related to the particular nature of the operating environment, in a saline atmosphere for example.

1.16.8.2 Fatigue tests

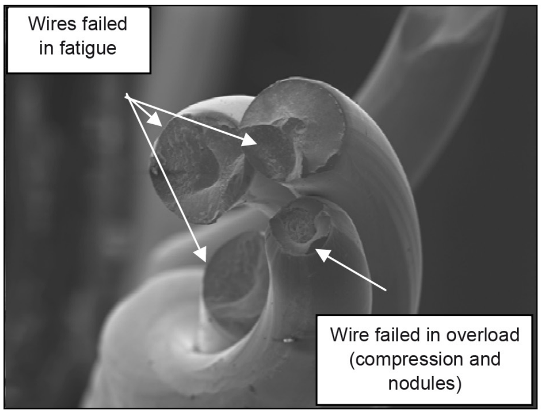
To complete the above tests and to work out the impact of cyclic loads on a worn cable, a fatigue test was carried out at the aeronautical test centre in Toulouse on a stainless steel cable with similar wear to that observed on the F-OIQI's pitch-up cable. This cable was subjected to load cycles of 250 daN representing the maximum certification loads exerted on the cable.

Failure occurred after 58,000 cycles, on the worn spot, with a strong untwisting as far as the fixation zone marked below by red arrows.

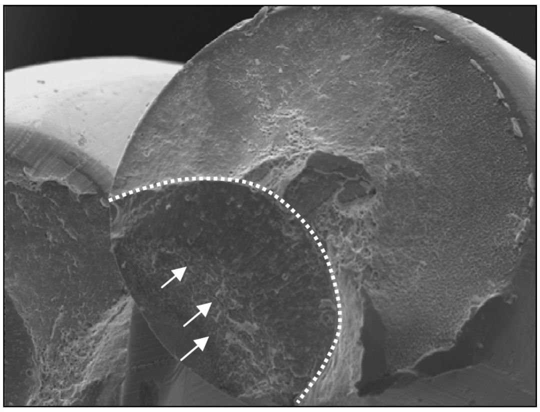


Appearance of the failed cable ends after fatigue test

Several of the outer and central strand wires showed signs of fatigue (see photo below), unlike the F-OIQI's pitch-up cable wires.



Fatigue failures of wires



Overload failure of wire (stress and cups)

1.16.8.3 Tensile tests

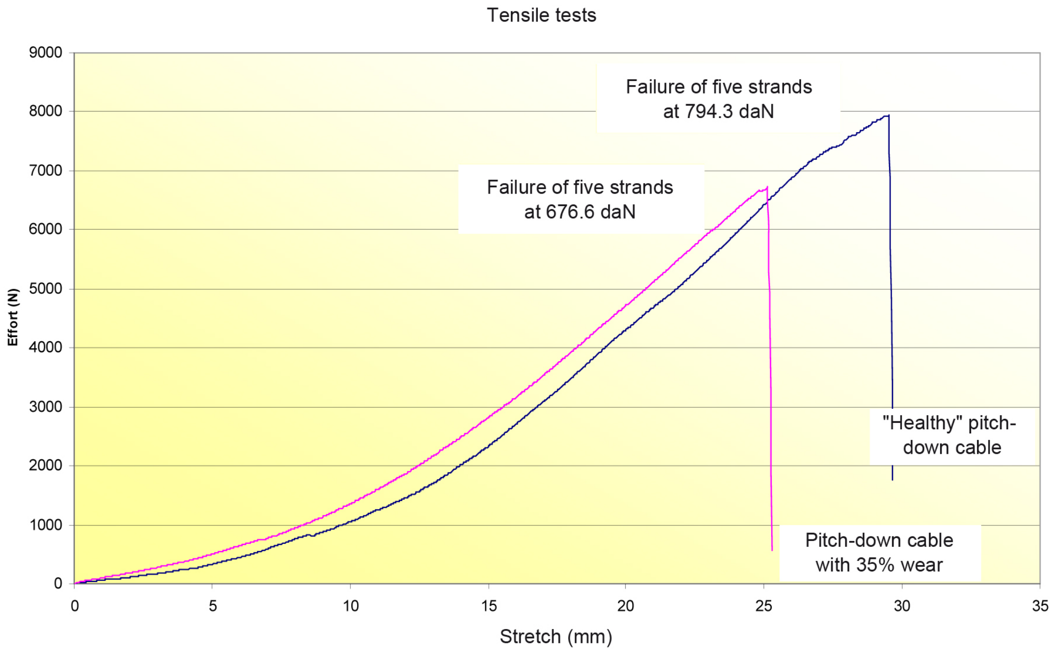
1.16.8.3.1 F-OIQI cables

After the examinations performed on the elevator control cables from F-OIQI (see paragraph 1.16.4.1), some tensile tests were undertaken at the aeronautical test centre (CAE) in Toulouse to assess the residual resistance of the pitch-up cable in the worn failed area in order to compare this to the in-service loads applied on the cable. These in-service loads are the sum of the loads on the control column (see paragraph 1.16.7) and the pre-tensile loads applied in maintenance. They are about 50 daN during flap retraction.

A first test was performed on a healthy area of the aft pitch-up control cable, that's to say with no wear or tears pre- or post-accident.

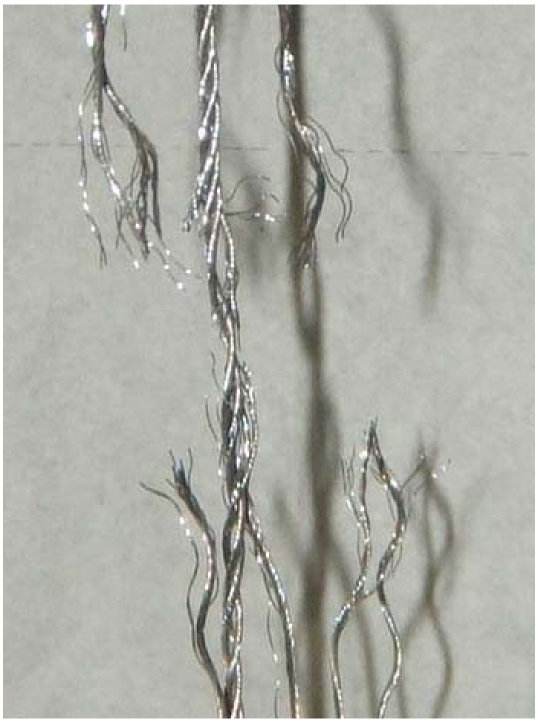
The second test was performed on the aft pitch-down control cable. The loads were centred on the zone located in line with the cable guide whose rate of wear was estimated at 35%.

The tension curves from these tests are presented hereafter as well as the photo of the pitch-down control cable after the test.



Note: For safety reasons, the test stopped when the drop in the load detected by the machine was above 80%. In both cases, two outer strands remained unbroken after the test.

View of pitch-down cable
on traction machine :
high degree of untwisting



Detail of pitch-down-cable
after test : two outer strands
not broken

These tests showed that:

- ❒ the load was not uniformly spread throughout all the strands since they did not all break simultaneously;
- ❒ the failure load of the aft pitch-up control cable in a healthy area, after several hours in service and immersion in sea water for three weeks, was higher than the minimum of the MIL-W-83420 (782,5 daN) standard;
- ❒ the residual resistance of the pitch-down cable in its area worn to 35% and in the same aging conditions was 676,6 daN ;
- ❒ the broken cables showed a high degree of untwisting. The appearance of the failures was similar to that of the failures noted after the accident on the forward parts of the cables; it was different from that of the failure noted at the level of the worn part of the aft pitch-up cable from F-OIQI.

By assessing, through extrapolation of the test results obtained on the pitch-down cable, the residual resistance that the pitch-up cable had in the area worn to 50%, this resistance appears to be much greater than in-service loads: the wear on the cable cannot in itself explain its failure.

Additional tests were also performed in order to better understand cable failure behaviour, in particular with the presence of wear areas.

1.16.8.3.2 Additional tests

Tensile tests were performed on ten new stainless steel cables of the type installed on Twin Otters. More or less significant wear areas that were as representative of those that had been observed on the cables from F-OIQI were prepared specifically on seven of these cables.

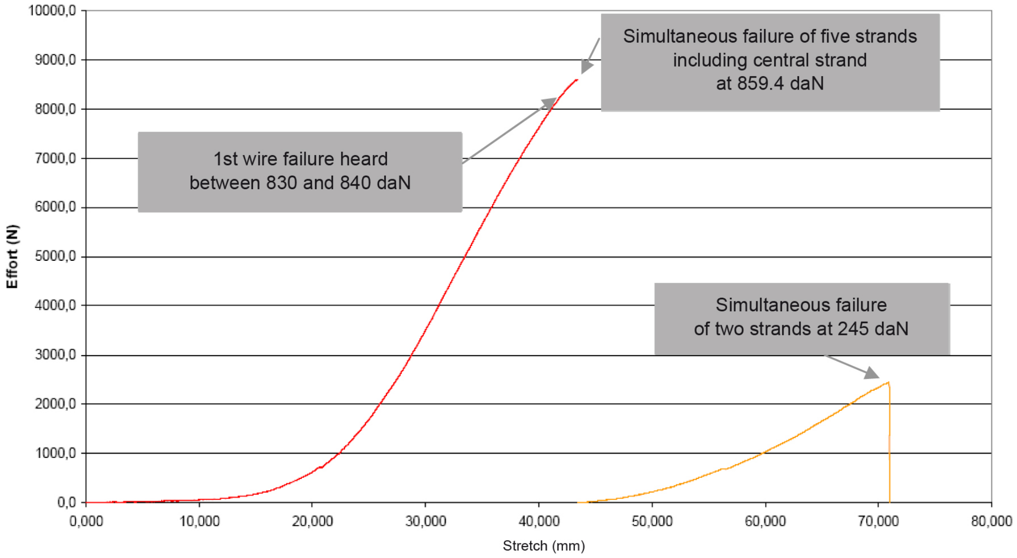
The tests were filmed with a high speed digital camera in order to beak down the failure sequence. An acoustic transmission system was used to detect and record the failures on the wires. These tests were continued up to complete failure of all the strands in the cables.

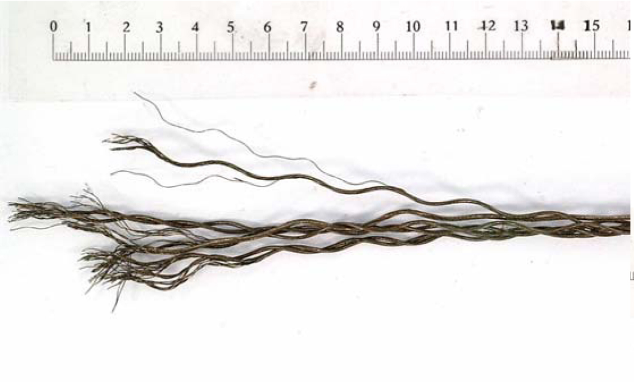
The most representative results are illustrated hereafter. For each test, there is:

- ❒ a photo of the wear area, when there is one;
- ❒ the tension curves showing the load evolution according to the lengthening of the cable;
- ❒ data from the camera or the acoustic transmission system;
- ❒ a photo showing the failure zone.

Tensile test on a new cable

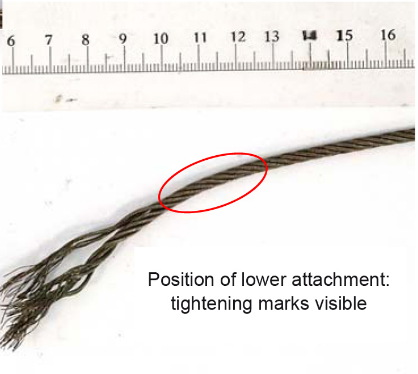
On a new cable, the failure occurred close to the lower attachment system.





Significant untwisting on upper attachment side

No untwisting on lower attachment side

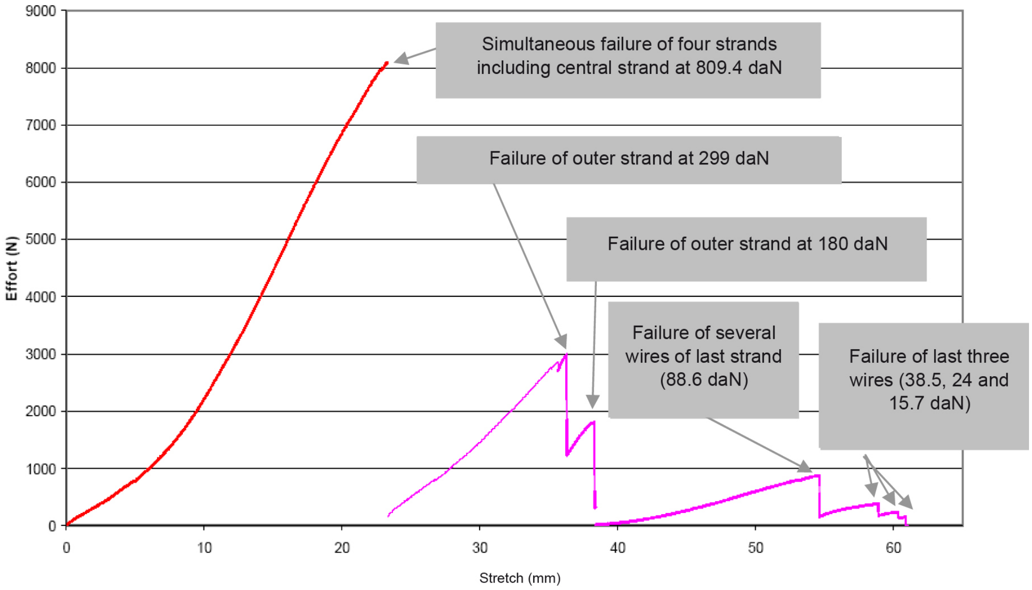


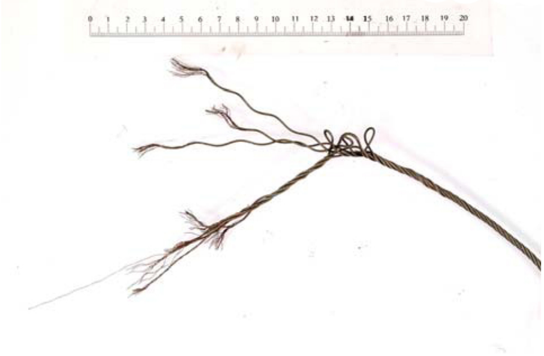
Position of lower attachment: tightening marks visible

Note: The proximity of the attachment system prevented the untwisting of the cable on the lower failed end. Signs of pinching were observed on this cable at the attachment point.

Tensile test on a slightly worn cable

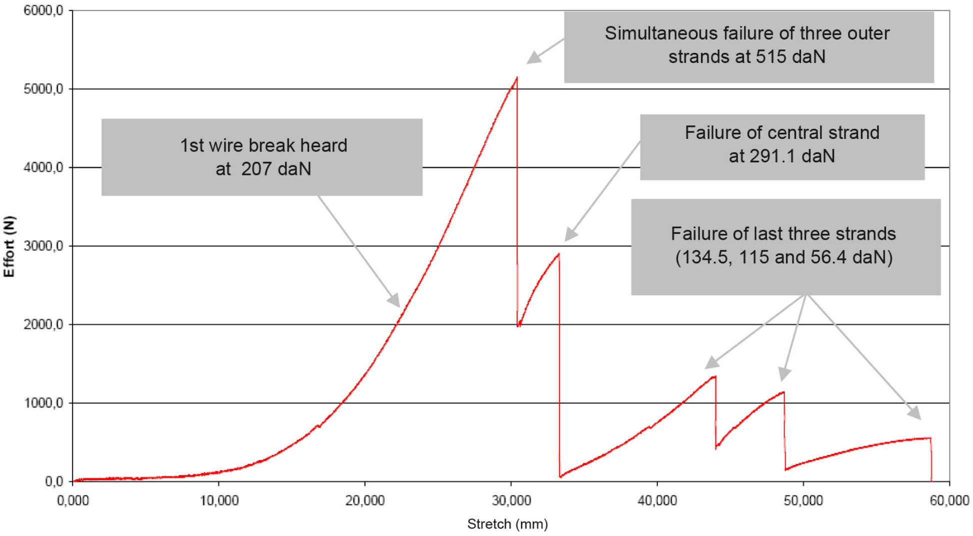
On a slightly worn cable, the failure occurred in the worn area, located in the middle of the section between the attachments.





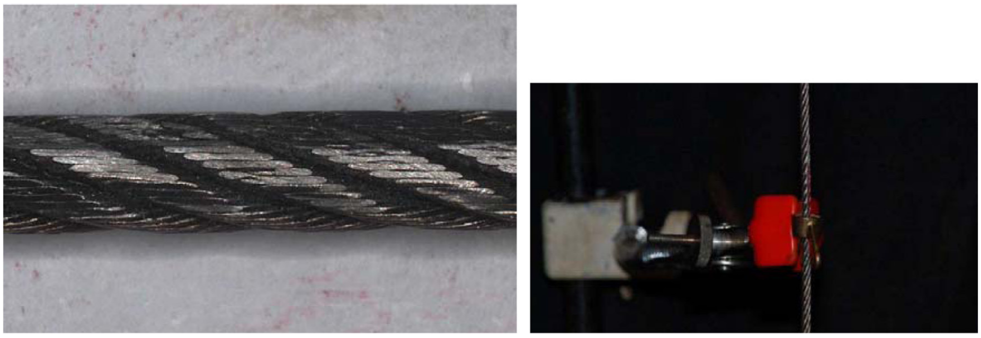
Tensile test on a cable showing similar wear to that of F-OIQI's pitch-up cable

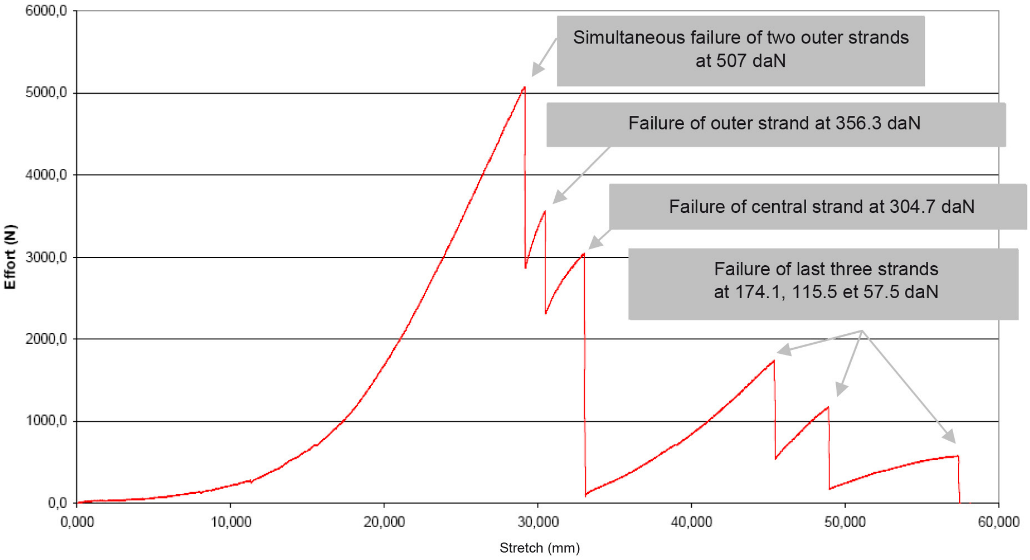
On a cable worn like the F-OIQI aft pitch-up cable, the failure also occurred in the worn area between the attachments.



Tensile test on a cable showing similar wear to that of the F-OIQI's pitch-up cable with a system simulating the presence of the cable guide

In addition to the set-up for the previous test, a system with a diameter, thickness and rigidity all similar to those of the cable guide was placed in contact with the cable in its worn section. The failure occurred at this point.



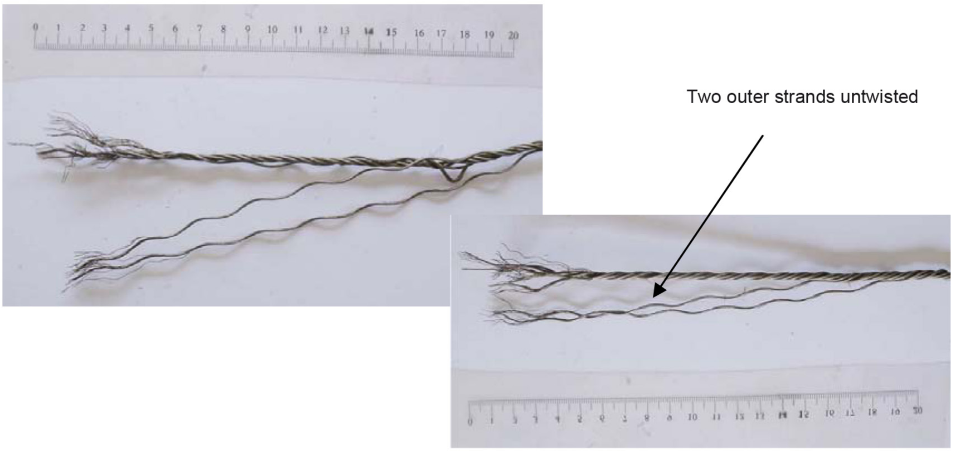


Simultaneous failure of two outer strands at 507 daN

Failure of outer strand at 356.3 daN

Failure of central strand at 304.7 daN

Failure of last three strands at 174.1, 115.5 et 57.5 daN



Two outer strands untwisted

1.16.8.4 Test conclusions

Noting that the tests carried out did not aim to establish a complete model of the wear and failure process of a cable, implying in particular that what follows has no predictive value, we can summarise the behaviour of the cable failures as follows:

For a new cable:

- ❒ The complete failure of the cable took place in several phases:
- ❒ The first wire failures(9) occurred beyond the standard MIL-W-83420 failure load of 80% of this load value.
- ❒ A first simultaneous failure of several strands (between four and six depending on the tests, including the central strand) occurred for a load greater than the standard failure load. This failure was accompanied by an almost total load drop.
- ❒ There followed a phase of re-organisation of the strands that had not failed, accompanied by a global lengthening of the cable and the strands being put under tension.
- ❒ A second failure occurred at a lower load to the previous load, the value of which was according to the number of remaining strands.

The failure was accompanied by considerable generalised untwisting.

For a worn cable:

The presence of a worn area modified the load distribution on the strands making them mixed. The failure sequence counted four, or more, load drops followed by phases of cable lengthening and of putting under tension of the remaining strands. The load drop was complete at the time of the central strand failure.

- ❒ The first wire failures occurred in the worn area, with low loads.
- ❒ The first rupture simultaneous failure of several strands occurred for a load lower than the one noted on a new cable. The value of this failure load lessened when the rate of wear increased.
- ❒ This firsts failure occurred for a cable lengthening that was less than that observed on a new cable.
- ❒ The final failure sequences occurred strand by strand, even wire by wire.

The untwisting is related to the energy released at the time of the failure. The strands that broke off during the first failure were dissociated from the structure of the cable over a considerable length. The others stayed grouped.

For a cable showing similar wear to the F-OIQI pitch-up cable:

- ❒ The failure load of the first wires was in the order of 210 daN.
- ❒ The failure load of the first strands was in the order of 500 daN.
- ❒ The failure load of the last strand was in the order of 55 daN.
- ❒ The lengthening of the cable after the central strand failure was in the order of 35 mm.
- ❒ The lengthening of the cable at the time of the final failure was in the order of 55 mm.

(9)Measured during test.

Influence of the presence of the cable guide.

❒ The presence of the cable guide did not prevent the cable untwisting.
❒ The contact and the bend point brought about could influence the load distribution in the strands and modify the number of load drops.

1.16.9 Effects of blast air on the flight control surfaces

1.16.9.1 Effect of the wind

Considering the significant loads that jet blast air can generate on flight control surfaces, the DHC6 Maintenance Manual, section IV - SPECIAL INSPECTIONS, imposes an inspection before each flight if the aeroplane may have been subject to ground winds exceeding the following conditions:

Without gust lock:

❒ Wind with an average speed equal to or above 30 kt from any direction.
❒ A gust from any direction.

With gust lock:

❒ Wind with an average speed equal to or above 48 kt from a ± 25° sector in relation to the aeroplane's axis.
❒ Wind with an average speed equal to or above 39 kt from a ± 90° sector in relation to the aeroplane's axis.
❒ Wind with an average speed equal to or above 30 kt in all other directions.
❒ A gust in any direction.

The inspection involves, among other things, the flight control cables.

Note: only the speed of the meteorological wind is taken into account. The value of the ground gust taken into account by the certification regulations to determine the limit load on the cables is 88 fps (feet per second) or 96 km/h. However, jet blast on the flight control surfaces from a jet aircraft can also create additional loads on the cables when the gust lock is in place.

1.16.9.2 Locking of flight controls

A system for locking the flight controls is available, when the aeroplane is parked, to avoid flight control surface flapping under the effect of wind gusts.

The rudder is locked in a neutral position by centring the rudder pedals. The locking is done at the level of the rudder control crank under the cockpit floor. The lock control is held in vertical position by a spring pin situated at the lower end of an upright linked to the lock for the aileron and elevator controls.

The aileron and elevator flight control surfaces are locked by means of a device that links the pilot wheel and column to the structure of the flight instrument panel. Originally, the elevator was locked in neutral position. Some flights having taken place with the lock system in place, the manufacturer modified the system so that the elevator control was maintained in maximum forward position (elevator fully pitch-down position). It should be noted that this position does not correspond to the mechanical stop on the elevator; a possible movement or an elongation of up to 34 mm of the cables would be necessary to move the elevator to its stop.

Elevator in locked position

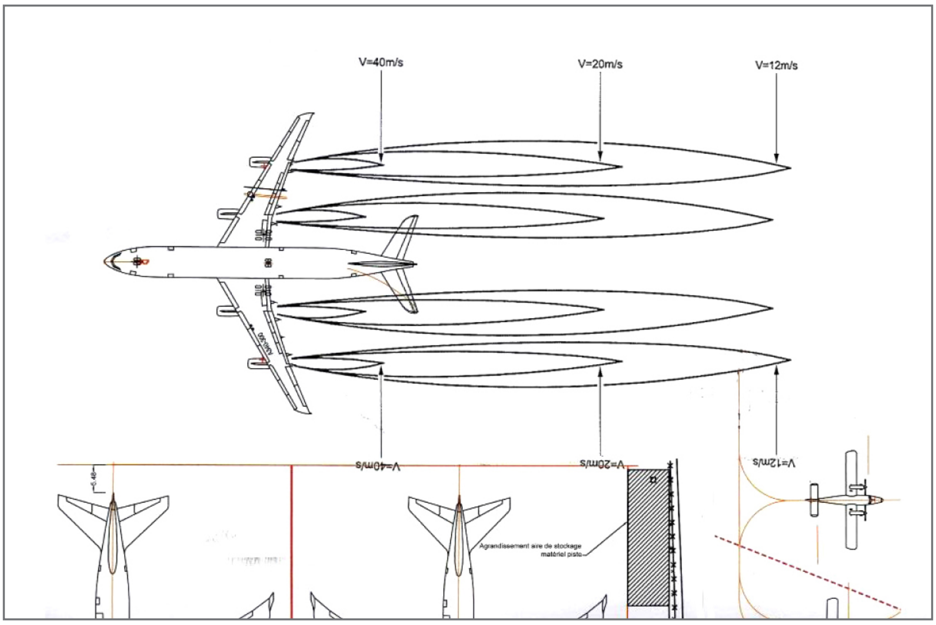
Flight control locking system

As the locking of the flight controls is done in the cockpit, all of the linkages made up of cables and pulleys as well as the mobile flight control surfaces are subject to loads induced by air blast on the flight control surfaces.

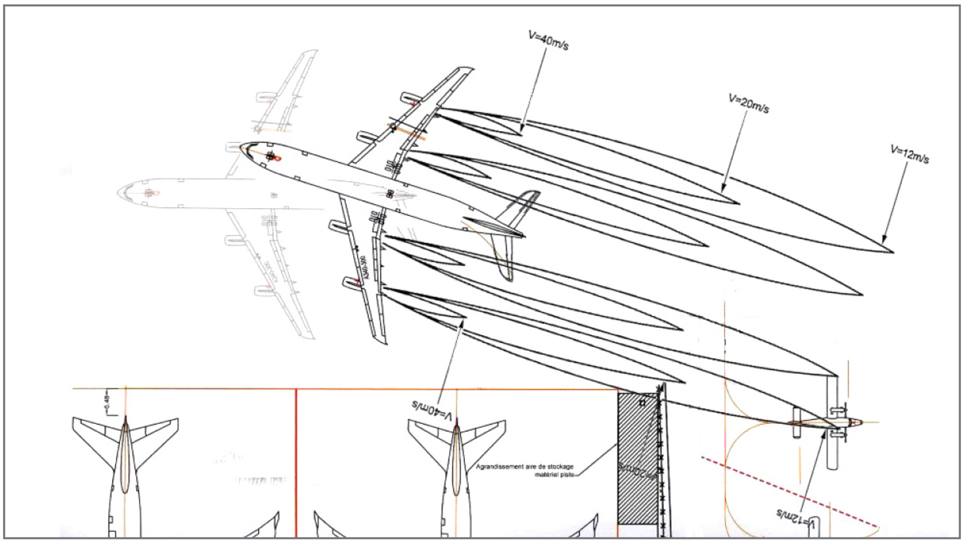
The AIR MOOREA Operations Manual in the section "2- NORMAL PROCEDURES, 2.1- Normal Check-list" specifies locking the controls when there is a prolonged stopover. This is specially the case during parking overnight at Tahiti Faa'a.

1.16.9.3 Parking areas at Tahiti Faa'a

At this aerodrome in fact, the Airbus A340 parked in position P1 can be pushed back either towards the west or towards the east (see appendix 7). These aircraft are thus, during pushback, brought close to the parking areas of the DHC6. Their theoretical relative positions are as shown below:



In the configuration presented, the engines of the A340 are about eighty metres away from the tail of the DHC6. Nevertheless, the above is a only a theoretical drawing. In practice, it is possible that pushback can bring the A340 further to the east; the aeroplane can also be slightly out of line. Thus, for example, if the A340 is turned by about 15° to the north, the DHC6 parked most to the north is touched by the exhaust cone.



Before 2004, jet-blast barriers protected the Golf areas from the effects of jet blast from heavy aircraft pushed back from the B1 parking ramp. The entry into service of the LIMA taxiway, at the end of 2004, was accompanied by the removal of the barriers. An information circular fixed an operational limitation that was repeated in the aerodrome ATC operations manual. Pushback of heavy aeroplanes was authorised only in the absence of traffic on the GOLF area and, conversely, aeroplanes parked at GOLF were not authorised to leave their parking spot while a heavy aeroplane had not begun its turn towards point S. This circular called on Captains to strictly respect clearances from ATC and precise positioning of aeroplanes on pushback at point B1.

This information circular remained in force until March 2006, when the AIP and the operational regulations were updated, showing taxiway LIMA (appendix 7) as well as it use and the rules for pushback for heavy aeroplanes.

It should be noted that the risks of jet blast that might affect aircraft parked at GOLF are not explicitly mentioned.

1.16.9.4 Effect of jet blast

The diagram of the jet exhaust speeds behind the A340 shows that the speed is at its maximum at a height of around four metres. The speed of the exhaust at the level of the horizontal stabiliser of the DHC6, at a height of around three metres, is thus slightly above 12 m/s (about 43 km/h) for a thrust level of the A340 engines corresponding to ground idle, which is the case during pushback.

Around fifteen metres extra pushback is enough for the speed of the exhaust at the level of the DHC6 tail to be near 20 m/s (72 km/h).

To begin taxiing, the thrust of the A340's engines must be increased (breakaway thrust). If this is done, if only exceptionally, when the A340 is in a position to blast the DHC6, the latter's tail will be subject to significantly higher loads.

No data was available on the recommended thrust to move the aeroplane (with N1 around 40%). However, by comparing the data for the A340 with those existing for other aeroplanes, it can be determined that, for such a level of thrust, the speed of the exhaust at the level of the tail of the DHC6 will be more than 45 m/s (162 km/h).

As the estimated speed at the level of the tail of the DHC6 can vary between 40 and 160 km/h, the effect of the jet blast corresponds to a load factor on the elevator control cable of between 0.2 and 2.8 times the limit load, that's to say 50 to 710 daN. As an indication, the load of 515 daN measured during the tests (see paragraph 1.16.8.3.2) would correspond to jet blast of around 135 km/h.

1.16.9.5 Known events

On 17 August 2005, a Saab 2000, at the ramp, with controls locked, was subjected to jet blast of around 126 kt (233 km/h) from a passing B747. This resulted in the bending of the left aileron control pushrod, causing it to fail at the time of takeoff. The crew had to make an emergency landing. Calculations showed that the flight controls had been subjected to a load four times higher than the regulatory limit (see appendix 8).

Another case of bending of an aileron control pushrod, also on a Saab 2000, occurred in 1998 when a B737 passed. The jet blast having been noticed, the flight had been cancelled to allow checks to be undertaken.

1.17 Information on Organisations and Management

1.17.1 The operator

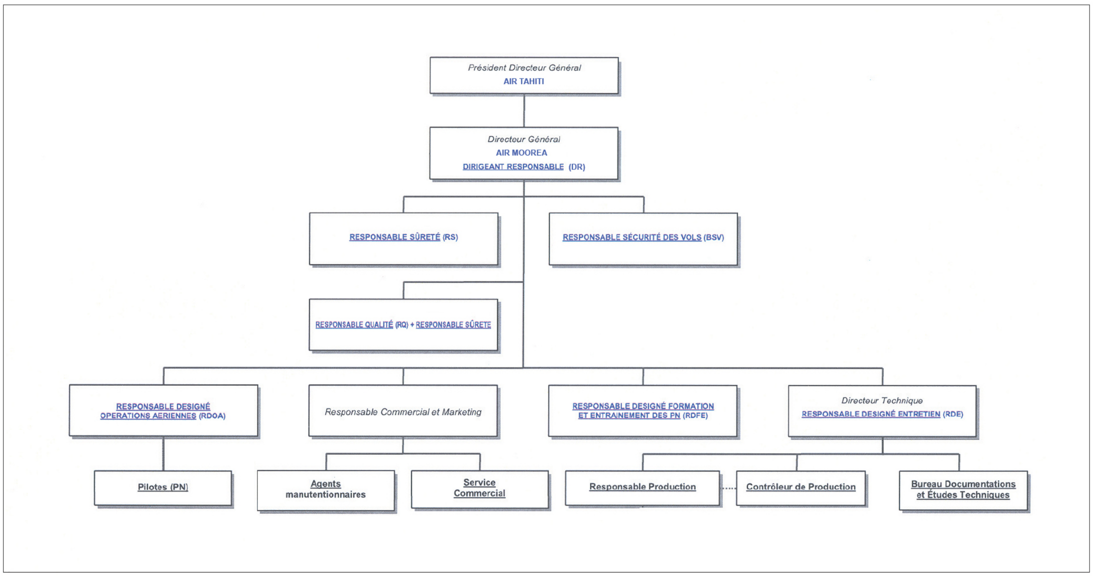
Founded 35 years ago, Air Moorea became a subsidiary of the domestic airline Air Tahiti. It mainly undertakes regular air transport flights, up to forty flights a day, between Tahiti Faa'a and Moorea Temae airports. In addition it carries out charter flights to various airports in the Tahiti region.

Before the accident the company had three Twin Otters. A fourth, acquired by the Territory, is operated by Air Moorea for Air Tahiti for the inter-Marquises service.

Note: The ATC service (DGAC) monitoring report in December 2006 referred to: "Specific operation causing numerous infringements with regard to context: Nothing to report".

1.17.2 Operator's organisation

1.17.2.1 Organisation chart



1.17.2.2 Tahiti Faa'a – Moorea Temae shuttle flights

Given the operational conditions peculiar to shuttle flights (VFR in ATC control zone, frequency and flight duration), adapted flight preparation and follow-up procedures were developed by the operator and featured in its Operations Manual. In particular:

- No flight plan was submitted.
- The weight and balancing breakdown was carried out with tables prepared for each aeroplane and for each shuttle journey. The pilot made sure that the passengers were placed with respect to balancing and the restraints related to cabin safety (emergency exits).
- A quantity of fuel was defined to allow four rotations to be carried out. The pilot made sure that the amount of fuel used on each leg complied with the allocated amounts.
- To allow the pilot to focus on outside monitoring during these very short legs, no navigation log was written in flight. Only the CRM, the fuel check and the number of passengers among others, was recorded after landing.

The meteorological protection file was consulted on a terminal, a service provided by Météo France.

1.17.2.3 Maintenance organisation

1.17.2.3.1 Background

Air Moorea had held a maintenance approval (approval certificate FR.145.172) since 22 December 1993. The number of staff allowed for in the maintenance organisation's specifications manual is in the order of thirty people.

The approval allowed it to undertake the following maintenance:

- DHC-6, Beech 200, PA-23, PA-28, PA-31, PA-31T, PA38 type aeroplanes.
- Pratt & Whitney PT6A-27/28/41/42 engines for Hot Section Inspection (HSI) and borescope.
- Lycoming O-235-L2A, O-320-E2A, O-360-A4M,IO-540-C4B5,IO-360-C1C6, TIO-540-J2BD, LTIO-540-J2BD engines for borescope and removal/reinstallation of cylinders.
- Communication and navigation equipment (defined list).
- Aeroplane batteries (defined list), for inspection and test only.
- Landing gear equipment (defined list) for inspection, test and repairs only.

Air Moorea maintains its own aeroplanes, Air Archipels' aeroplanes and the High Commission's aeroplane.

The maintenance organisation's organisation chart and staff distribution is in Appendix 9.

1.17.2.3.2 Oversight

In the approval framework, the Groupement pour the Sécurité de l'Aviation Civile (Civil Aviation Safety Group) undertakes oversight operations. The last oversight operation performed on 6 March 2007 (CR n°00001042/06/07 and n°00001042/07/07) showed only level 3 deviations.

Note: Level 3 is an observation with no reference to the non-fulfilment of a regulatory requirement. The maintenance organisation's quality system must take level 3 deviations into account and correct them when they judge it to be necessary. Through polling during its subsequent audits, the Authority ensures level 3 deviation processing. In comparison, levels 1 and 2 correspond to significant non-compliance with regulatory requirements lowering the aircraft's safety level (seriously affected for level 1, possibly affected for 2).

The last oversight operations did not then reveal any dysfunctions likely to affect flight safety.

After the accident, the DGAC and GSAC's inspection of the Air Moorea workshops brought to light non-compliance in continuing airworthiness and aeroplane maintenance. Workshop approval was suspended on 13 September 2007. This suspension was lifted on 20 September 2007.

Note: The non-compliance that was noted had no link with the accident.

1.18 Additional information

1.18.1 Condition of the Twin Otter fleet

Viking Air Limited, the manufacturer, having taken over Twin Otter aeroplane type certificates on 31 January 2006 and being responsible for their continuing airworthiness, carried out a survey among operators, at the BEA's request, specifically among those with a high cycle/hours ratio, in order to obtain additional information on the cable checking procedure (appendix 10).

A message was sent to twenty-seven DHC6 operators in December 2007. Nine responses, representing sixty-five aeroplanes, were received.

The information received came from four operators using forty-nine aeroplanes in a saline atmosphere and in a tropical zone, with cycle/hour ratios ranging from 2.1 to 4.1, and from five operators using sixteen aeroplanes outside tropical zones, with ratios between 1.6 and 2.8.

Of the sixty-five aeroplanes, twenty-three, operated in a saline atmosphere and fitted with stainless steel cables, had the time period between inspections shortened to 125 hours with forecast cable replacements. The inspections were even reduced to every fifty hours on twenty-two other aeroplanes, yet still with traces of wear or broken wires observed. One aeroplane kept to inspections every 400 hours.

Of the nineteen aeroplanes fitted with carbon steel cables, no wear was noticed, even for those with 60-month replacement intervals. In addition to this investigation, the same observation was made on the three Air Moorea aeroplanes fitted with carbon steel cables. The cables were replaced every twelve months in a good-as-new condition, according to the flight mechanics.

To summarize, this survey showed that:

- ❐ Carbon cables did not seem sensitive to operational wear, unlike stainless steel cables.
- ❐ Several operators introduced stainless steel cable inspection cycles that were much more restrictive than those required by the manufacturer.

The manufacturer concluded that, even if stainless steel cables are more sensitive to wear, this had never led to a dangerous situation.

It should be noted that without an examination of the recovered worn cables, it was not possible to specify the extent of their wear and the risks run. Yet there was no requirement or checking measure for removed cables, even for those identified as being damaged.

1.18.2 Continuing airworthiness

For continuing airworthiness, according to the maintenance organisation's material, the conditions requiring fault notification to the Authority, the manufacturer and the operator are restricted to:

- ❐ significant cracks,
- ❐ corrosion or primary structure failing,
- ❐ report of burning,

❒ electric arc,
❒ significant fuel or hydraulic leakage,
❒ safety system or total system failure,
❒ out-of-date airworthiness directive,
❒ faults discovered during the aeroplane's programmed maintenance.

An "Unfit to fly report" is filled in by the controller and formalized by the technical director. It is sent to the Authority, the manufacturer and the operator within three days.

There is no provision for notification relating to cable wear.

1.18.3 Previous events

In 1994, a DHC6 crashed into a lake after take-off from Port Hardy (Canada). At the time of flap retraction, at about one hundred feet, the flight crew lost pitch control. One of the cables, made of carbon steel, from the elevator control had been recovered broken off after corrosion. In the investigation report published at that time, it was noted that stainless steel was more sensitive to wear than carbon steel.

On 22 March 2005, the DHC6-300 registered F-OIJL was undertaking a freight flight between Cayenne Rochambeau and Maripasoula (see appendix 11). During the last turn, at a height of four hundred feet, the pilot had observed that he no longer had control of the right aileron. He had interrupted his manœuvre and performed a go-around, brushing some trees and had then been able to land. On the ground, mechanics had observed a fracture in the upper right aileron cable and considerable wear, with the fracture of two strands, of the lower right aileron cable in the same area, to the right of a cable-guide. The cables controlling the left aileron showed signs of less significant wear. Signs of wear had also been observed on the elevator control cable where it passed through a pulley. The mechanic had reported that he carried out these inspections alone: because of this he could not monitor all the cables, especially the parts in contact with the pulley.

The standard inspection (operations in a non-saline atmosphere) of F-OIJL's roll control cables had been carried out 656 hours before the failure, and inspection of the elevator control cable was performed 166 hours previously. After the incident, during roll control cable replacement, it was noted that the cables chafed abnormally on the guide-cable polyamide bushes on the right aileron side. The possibility of faulty assembly was proposed to explain the wear. The work carried out during this investigation, in liaison with the Canadian authorities and the manufacturer, was not able to confirm the assembly anomaly or to determine the causes of wear. Neither was it possible to determine if the cable's probable wear at the time of the programmed annual inspection had been detected by the mechanic or if he had omitted to check the condition of the right side cables.

Examinations of the F-OIJL roll control cables, compared to the F-OIQI elevator control cables, showed that:

❒ The cables had the same configuration, the same chemical composition and the same mechanical features.

❒ The cables on F-OIJL were installed new in February 2003. They had a total of 2,081 flying hours for roughly 3,000 cycles compared to 1,181 hours and 6,370 cycles for F-OIQI.

- ❐ The type of wear observed was the same on all the cables: flats caused by the cables chafing against the bush in the longitudinal direction.
- ❐ The wear observed was over the whole circumference (360°) of the cable from F-OIJL, unlike that of F-OIQI, worn only over 180°.
- ❐ The wear on the failed cable on F-OIJL was roughly 80%.
- ❐ The stress loads that led to the F-OIJL roll cable failure were of the same order as those exerted on the pitch-up cable at flap retraction.

Note: Following this incident, the Swiss workshop that maintained Air Guyane's aeroplanes, decided not to install stainless steel cables any more on any of the aeroplanes for which it carried out maintenance work.

2 - ANALYSIS

2.1 The Loss of Control

During the first weeks of the investigation, observations made on the parts of the wreckage that were recovered as well as study of the CVR recording and the witness testimony, associated with the reconstitution of the airplane's flight path, led the investigators to focus their efforts on the elevator control cables.

On the one hand, there was a failure of the elevator pitch-up control cable at the aft in an area that was worn, in line with a cable guide, a failure whose appearance and position differed from those of the other failures observed. On the other hand, the available information made it possible to eliminate the other potential causes that could have led to the flight path observed, namely damage to the elevator, a poorly managed engine failure, pilot incapacitation or passenger interference.

The in-flight tests that were carried out confirmed that the failure of the pitch-up cable at the moment when the flaps were retracted was indeed the cause of the loss of pitch control of the airplane. This failure did, however, have to be explained.

2.2 Pitch-up Control Cable Failure Scenario

In flight, the loads on the cable are at their greatest when it is necessary to counter the pitch moment induced by the retraction of the flaps. It should be noted that it was during this phase of flight that a cable failure occurred that caused the accident in Canada in 1994. However, as the investigation confirmed, the input of around 50 daN is low in relation to the minimum resistance of a new cable, which is 782.5 daN.

The wear on the cable where it failed was due to its chafing on the polyamide bush located in the cable guide. This wear was significant: due to the structure of the cable it had affected all of the strands except the central strand, and had led to the failure or the almost total reduction in cross-section of 72 wires out of the 132 that made up the cable.

This wear did not however, make it possible to explain the failure of the cable when the flaps were retracted on initial climb. The first tests in fact showed that the residual resistance of a cable with this wear rate was markedly higher than the loads encountered in flight.

Additional tensile tests showed that the presence of a worn area modified the behaviour of the cable. It both reduced the failure stress of the first strands as well as the elongation of the cable, and, by modifying the load distribution in the strands, it tended to dissociate their failures, as well as that of the wires.

These tests, since they were limited to the objectives set by the investigation, did not make it possible to establish a law for the failure of a worn cable. They did, however, clarify the previous result by showing that, for a cable with average wear, the failure stress of the first strands remains greater than the maximum in-service loads specified for certification and, further, than in-flight loads. Only in the case of an almost complete wear-through, such as that noted at Cayenne, can an in-flight failure of the cable occur.

To arrive at the failure in the case of F-OIQI, it was thus necessary for some additional phenomenon to occur that aggravated the cable's weakness. The cable was in compliance with the specifications and, apart from the wear, no damage previous to the accident had been observed. The effect of fatigue could also be eliminated, since none of the wires on the broken cable showed any signs of fatigue. However, if the fatigue test performed on a worn cable clearly showed that it could fail with the application of cyclic loads, of the kind that can be encountered in service, after a relatively low number of cycles, it also confirmed the appearance in such a case of signs of fatigue. The additional phenomenon could thus only be external to the airplane.

The failure of the worn cable thus necessarily occurred in two stages, with the initial failure of several strands, including the central strand, under the effect of the external phenomenon, then the failure of the last strands under the effect of the in-service load. The nature of the tests and the elements available made it impossible to go any further with this description, even though, during the tests, the failure stress on the worn last strand was of the order of the load exerted on the cable to counter the pitch moment on flap retraction. The absence of any indications of fatigue on the fracture surfaces of the wires, despite strong turbulence encountered about a month before the accident, shows that the successive episodes in the failure of the cable occurred over a relatively short period.

The phenomenon that caused the failure of the first strands must have induced high load on the pitch-up cable, around 500 daN if reference is made to the figure obtained during the tests. It is possible to eliminate a violent impact on the elevator, since it bore no signs of damage. It is also possible to eliminate the effect of the wind on the control surfaces since the wind speeds recorded during operation of F-OIQI never reached the maximum certification value (96 km/h) that results in loads of 252 daN. However, inputs on the elevator, when it is locked – as has been seen, it is locked in the pitch-down position in this case – lead to loads on the pitch-up cable that are only limited by the resistance of the latter.

It has been shown, on another airplane type, that jet blast on the control surfaces from powerful jet engines caused excessive stress on the locked flight controls, leading to rod buckling, to the point where the latter could break under the strain of the first actuation in flight.

F-OIQI was parked near A340 type wide-body airplanes. Calculations showed that the jet blast from the engines of these airplanes could result in a load above the stress failure level for a worn cable, on the elevator control cable on the Twin Otter in the parking position. More precisely, this would lead to the application of excess loads on the pitch-up control cable until the elevator arrived at the low stop position, that is to say until a cable extension of 35 mm.

Since, in addition, a single exposure is enough to start the process of cable destruction, this cause appears, by a process of elimination, to be the explanation for the event.

2.3 Could the Accident Have Been Avoided?

2.3.1. Management of the malfunction

The malfunction occurred at the top of the initial climb, passing through 350 feet, when the pilot retracted the flaps then adjusted the engine parameters. While he was adjusting the parameters with his right hand, he was holding the wheel with his left hand while pulling back to counter the pitch-down moment and stabilise the airplane on its flight path. It was only at the end of this process, which lasted nine seconds, that he would adjust the trim. It should be noted that the pilot was applying the procedure recommended by the manufacturer; the operator had reversed the sequence.

The pilot was suddenly confronted with an event never encountered during repetitive flights and which he had apparently never heard mentioned: during the adjustment of the parameters, the control column moved freely in pitch as a result of the failure of the elevator control cable and the airplane started to dive. At that moment, his right hand was certainly still on the engine controls located on the overhead panel.

The flight tests showed that during flap retraction, when pitch control is free, the airplane dives with a high pitch angle. At this height in the flight, only immediate action on the trim located on the centre pedestal would make it possible to recover the airplane. The test also showed that from level flight it takes about three seconds for a pilot trained for and prepared for this exercise to recover the airplane.

The highly dynamic nature of the events following the failure must be emphasized here. Eleven seconds passed between the pilot's exclamation and the impact. This only left a short time for the pilot to analyse the situation and apply a solution that he had to improvise. In addition, the stress associated with the airplane's attitude and the difficulty in estimating his height, in the conditions on the day, in relation to the surface of the water, certainly affected his powers of analysis. The pilot was not trained or prepared, either during his training or during type rating, as indeed most pilots aren't, to react to a loss of pitch control. Only a reflex action could thus have allowed him to recover the airplane before the impact.

The increase in the engine RPM recorded on the CVR may have two explanations, both of which tend to suggest that the pilot had not identified the nature of the malfunction. It is possible that he attempted to modify the airplane's attitude by using the secondary effects of the engines or, despairingly, that he tried to cancel the phenomenon by going back on his most recent actions.

2.3.2 Maintenance of F-OIQI

When F-OIQI arrived, Air Moorea, which was not made aware of the specific characteristics of the stainless steel cable, or even informed of these specific characteristics, had not been informed of the installation of stainless steel cables, the only mention in the dossier being a different reference. In addition, even this was not done in such a way as to draw particular attention to it, carbon steel and stainless steel cables being interchangeable, so that the maintenance of F-OIQI was thus undertaken in the same way as that of the rest of the fleet.

The standard checks on the airplane had been performed in accordance with the registered and approved programme. No doubt can be cast on the quality of these checks, the maintenance organisation having been subject to an oversight inspection in March 2007 that had not led to any significant comments. It should of course be noted, as the DGAC did during the inspection in September 2007, that follow-up on the documentation was not carried out as strictly as could be expected. This does not, however, imply that the maintenance operations themselves were not carried out seriously and competently.

On the other hand, the special cable inspections linked to use in saline conditions do not appear to have been deliberately ignored but rather fallen into disuse on the Air Moorea fleet well before the arrival of F-OIQI. Before any other considerations, three factors may explain this evolution:

❐ these special checks did not coincide with the scheduled checks (400 hours is not a multiple of 125 hours);

❐ the structure of the Maintenance Manual does not facilitate these checks;

❐ finally, the maintenance organisation had never noticed any deterioration, either through corrosion or wear, during the annual replacement of the carbon steel cables that it was used to.

It is difficult to say whether the mandatory checks would have made it possible to detect the wear on the cable. In fact, this wear is very difficult to detect on an installed cable, especially if one has not previously been confronted with this phenomenon.

It should be noted that the special checks are only planned by the manufacturer in the case of use in a saline atmosphere, which means that they are intended to detect a deterioration of the cables linked to this atmosphere. However, nothing establishes a link between the wear noted on the cables on F-OIQI to use in a saline atmosphere, so that this wear would apparently have been identical in a terrestrial use, for which the special checks not performed by Air Moorea would not have been required.

2.3.3 Continuing airworthiness of the cables

The installation of stainless steel cables had been decided on in order to counter the corrosion problems on the carbon steel cables, in addition to the measures such as annual replacement and checks that had been put in place. No specific measures had been established on this occasion, although the two different types of cables, made of different material, are no affected by the same effects. Specifically, it is astonishing that the instructions for terrestrial operations were not adapted for the stainless steel cable and replacement only every five years had been maintained, with only one check programmed every thousand flying hours, as if their wear had never really been taken into account.

Thus, a certain amount of ambiguity remains today since both cables are considered as interchangeable and can be installed according to the operator’s choice, the check and replacement intervals being exactly the same. The investigation showed that, according to the type of cable selected, the maintenance programmes cannot be identical. Even where the time between checks, according to intervals based on length of use, whether calendar or flying hours, is suitable for problems of corrosion, it is not well adapted to wear phenomena where the number of cycles is the primary consideration.

In parallel, no awareness campaign for operators has been undertaken on the risks of wear. It was on the basis of their own experience that some operators reduced the intervals between special checks down to fifty hours, and very likely informed their oversight authority. This indicates the speed at which the wear can appear and propagate. It is surprising, to say the least, that these disparities in maintenance did not alert the manufacturer and the authorities.

Finally, no follow-up on the condition of cables removed was put in place. In the course of the investigation it was revealed that anomalies had been discovered on several occasions but that the operators simply changed the cables without informing the manufacturer. As there is no process for follow-up on in-service events for this equipment, there is no established procedure for systematically researching the causes of a failure and determining the corrective measures to take.

To summarize, it is clear today that this wear phenomenon had been known for a long time but that no study appeared to have ever been conducted to understand the process (appearance, speed, evolution in resistance), nor to determine what the consequences could be.

2.4 The Phenomenon of Jet Blast

The investigation once again emphasized the importance of the phenomenon of jet blast for safety. In fact, if an individual aware of the phenomenon does not witness it, the damage caused by jet blast on an airplane is for the most part undetectable during the pre-flight inspection.

Today, certification standards based on average meteorological phenomena are far from taking into account the blast speed of new generation jet engines. The cases listed showed that it is possible to multiply by four the maximum loads calculated in certification applied to the flight control surfaces and to their control systems.

Equally, it appears imperative that jet blast should be taken into account completely in the design of parking aprons and in the procedures for ground operation of jet airplanes and that all personnel involved in the operation of airplanes and aerodromes should be made aware of the risks induced by this phenomenon.

3 - CONCLUSION

3.1 Findings

- ☐ The pilot possessed the licenses and ratings required to undertake the flight.
- ☐ The meteorological conditions were good.
- ☐ After a normal takeoff, the flaps were retracted at around 350 feet. The pilot then lost pitch control of the aeroplane, which adopted a steep nose-down attitude.
- ☐ The DHC6 Twin Otter has significant pitch-down moment when the flaps are retracted.
- ☐ The failure of the elevator control cable leads to a loss of aeroplane pitch control.
- ☐ The certification regulations specify that the airplane be recoverable in case of a failure of an elevator control cable. However, pilots are neither prepared for this situation during training nor trained to deal with it.
- ☐ Just before the impact with the water, the propeller speed increased.
- ☐ The elevator control cables were made of stainless steel and had been installed new on 11 March 2005. They had been removed, checked and re-installed in October 2006, before delivery of the airplane to Air Moorea.
- ☐ The airplane had flown 6,260 cycles (for 1,100 flying hours) since the installation of the new cables, of which 5,150 cycles for Air Moorea (for 841 flying hours) since its entry into service at Air Moorea.
- ☐ One of the failures on the elevator control cables, noted after the accident, was in a wear area.
- ☐ The failure in the aft part of the pitch-up cable was different from the other failures observed on the cables.
- ☐ The external wires of the six outer strands had failed due to wear in this area, which represented 72 of the 133 wires that made up the cable.
- ☐ Other worn areas were found on the elevator control cables.
- ☐ Several cables of this type were found with worn areas at other operators.
- ☐ Twin Otter cables can be made of carbon steel or stainless steel. These two types of cables are interchangeable on the airplane. Their inspection and replacement programmes are the same although their behaviour is different: carbon steel cables are more sensitive to corrosion, stainless steel to wear.
- ☐ F-OIQI was the only airplane in the Air Moorea fleet equipped with stainless steel cables. The operator was not aware of this characteristic, which was only apparent through a reference.
- ☐ The checks required by the manufacturer are based on the number of flying hours performed or on the calendar and not on a number of cycles. This inspection rhythm is well adapted for the phenomenon of corrosion but not for that of wear.
- ☐ There is no follow-up on the condition of stainless steel cables removed nor of unprogrammed removals.

❒ No special inspection or reduction in potential service life for stainless steel cables was recommended for operations outside of maritime areas.

❒ No influence of the saline atmosphere on the wear of stainless steel cables was identified.

❒ Several operators had adopted special inspection intervals closer together than those mandated by the manufacturer.

❒ The follow-up documentation for limited-life parts on F-OIQI contained some errors on the installation and replacement dates.

❒ The propeller on the right engine should have been removed in March 2007.

❒ The airplane had been subjected to strong turbulence in July 2007. No mention was made in the aeroplane log of any problem affecting the flight controls, only the reinstallation of cabin upholstery being mentioned.

❒ No trace was found of special cable checks programmed for the saline atmosphere.

❒ The last oversight operation carried out on 6 March 2007 did not bring to light any dysfunction in the maintenance organisation that could endanger the safety of flights.

❒ After the accident, an inspection led by the DGAC did not reveal any irregularities with any link to the accident.

❒ The failure of the pitch-up cable in the area with 50% wear cannot be explained only by the loads on the elevator control during operations.

❒ F-OIQI was parked at night with the controls locked.

❒ An external phenomenon, most likely jet blast, caused the failure of several strands in the worn area. The final strands failed as a result of the in-flight loads on the elevator control.

❒ The failure of the first strands was accompanied by a stretching of the cable that moved the elevator to its mechanical stop.

❒ The last strands failed due to the in-flight loads on the elevator control.

❒ The process of cable failure occurred over a short period of time. No signs of fatigue appeared on the failed wires.

3.2 Causes

The accident was caused by the loss of airplane pitch control following the failure, at a low height, of the elevator pitch-up control cable at the time the flaps were retracted.

This failure was due to the following series of phenomena:

❒ Significant wear on the cable in line with a cable guide;

❒ An external phenomenon, most likely jet blast, which caused the failure of several strands;

❒ The failure of the last strand or strands under in-flight loads on the elevator control system.

The following factors may have contributed to the accident:

- ❐ The absence of information and training for pilots on a loss of pitch control;
- ❐ The operator's failure to carry out some special inspections;
- ❐ The failure by the manufacturer and the airworthiness authority to fully take into account the wear phenomenon;
- ❐ The failure by the airworthiness authorities, airport authorities and operators to fully take into account the risks associated with jet blast;
- ❐ The rules for replacement of stainless steel cables on a calendar basis, without taking into account the activity of the airplane in relation to its type of operation.

4 - RECOMMENDATIONS

4.1

Examination of the parts recovered from the wreckage revealed significant worn areas on the aft part of the elevator control cables and the aft pitch-up cable that was found to be broken at the level of a worn area located in line with a cable guide. The BEA recommended, on 9 October 2007, that Transport Canada and the European Aviation Safety Agency:

- **require operators to perform an inspection as soon as possible on stainless steel elevator control cables installed on DHC-6 Twin Otter airplanes, with particular attention being paid to chafing areas in contact with cable guides;**

- **consider extending these inspections to carbon steel cables that may also be installed on the elevator control system of this airplane.**

The BEA also asked that any cables found to be worn should be sent to it in the context of this investigation. Transport Canada and EASA issued the BEA's recommendation, Transport Canada specifying erroneously that there had been no failure in the worn area. Following this recommendation, Transport Canada subsequently issued a service alert bulletin for those operating and maintaining Twin Otters. This bulletin reminded them of the necessity of being informed of and applying the instructions relating to inspection and replacement of cables and also specified that any other defects or any other events of this type should be notified to it in the context of the service report programme.

For its part, EASA asked operators under its oversight to inspect, as rapidly as possible, cables made of stainless steel and carbon steel and report the conclusions of their inspections to their national authorities and to Viking, holder of the Twin Otter airworthiness type certificate.

At the time of publication of this report, no information on the inspections that may have been performed, nor on any possible wear detected, has been supplied to the BEA.

4.2

Stainless steel cables' sensitivity to wear has been established, even though cables of this type are installed on the primary controls of many airplanes. Further, the investigation showed both that the characteristics of the cable in relation to tensile failure were greatly modified by wear and that the process of wear itself, in particular its speed of propagation, was little known (thus, several operators of DHC6's significantly reduced the cable inspection intervals recommended by the manufacturer). As a result, given the current state of knowledge, no wear on a control surface cable can be accepted without risking safety.

Consequently, the BEA recommends to EASA and to Transport Canada:

- **That stainless steel control surface cables be forbidden on the DHC6, at least until improved knowledge on their behaviour makes it possible to determine new regulatory requirements and to establish appropriate maintenance procedures;**

- **That a review be undertaken, in the light of the lessons learned in this investigation, of the design and in-service experience of other aircraft on which stainless steel cables are used for the primary controls so as to determine the measures that may prove useful to safety.**

4.3

The installation of stainless steel cables has been authorised since 1985. Even though it was rapidly noted that these cables were subject to wear, it was left to the initiative of operators to adopt, alone, the preventive measures to check this phenomenon, and no risk evaluation was performed. The cables correspond to a technical standard but, once installed on an airplane, only the operator can describe their condition and the manufacturer ensure any follow-up. It has been noted in the course of this investigation that anomalies had been discovered on several occasions, but that the operators had been satisfied to change the cables without informing the manufacturer about it. Since there is no process for following up events during operations for this equipment, there is no established procedure to systematically search for the causes of any failures and determine the corrective measures. This phenomenon is certainly not restricted to cables alone.

Consequently, the BEA recommends that:

- **DGAC encourage operators to transmit to manufacturers all information on technical anomalies detected that are not included in the maintenance documentation.**

4.4

On many airplanes manufactured and certificated according to the CAR 3 or FAR/JAR 23 that, like the DHC 6, undertake public transport of passengers, the failure of a primary flight control can lead to a loss of control. The investigation showed that a pilot, confronted with the loss of a primary flight control, risked not being able to handle it, given that he/she is neither prepared nor trained for it.

Consequently, the BEA recommends that:

- **DGAC modify in-flight training programmes to obtain the PPL or CPL license so that they include awareness training for flying an airplane in case of a failure of one of the primary flight controls.**

4.5

The consequences of jet blast on an airplane are difficult to detect during a normal pre-flight inspection. Jet blast can by far exceed meteorological wind speeds. However, this phenomenon is rarely taken into account, whether in the design and operation of aerodromes or in the certification of aircraft. What is more, only those people aware of the risks that jet blast can cause and who witness the phenomenon can take the appropriate decisions.

Consequently, the BEA recommends that:

- **DGAC organise an information campaign among aerodrome and aircraft operators so as to make them aware of the risks associated with jet blast from airplanes;**

- **EASA consider the appropriateness of taking jet blast into account in the process of aircraft certification.**

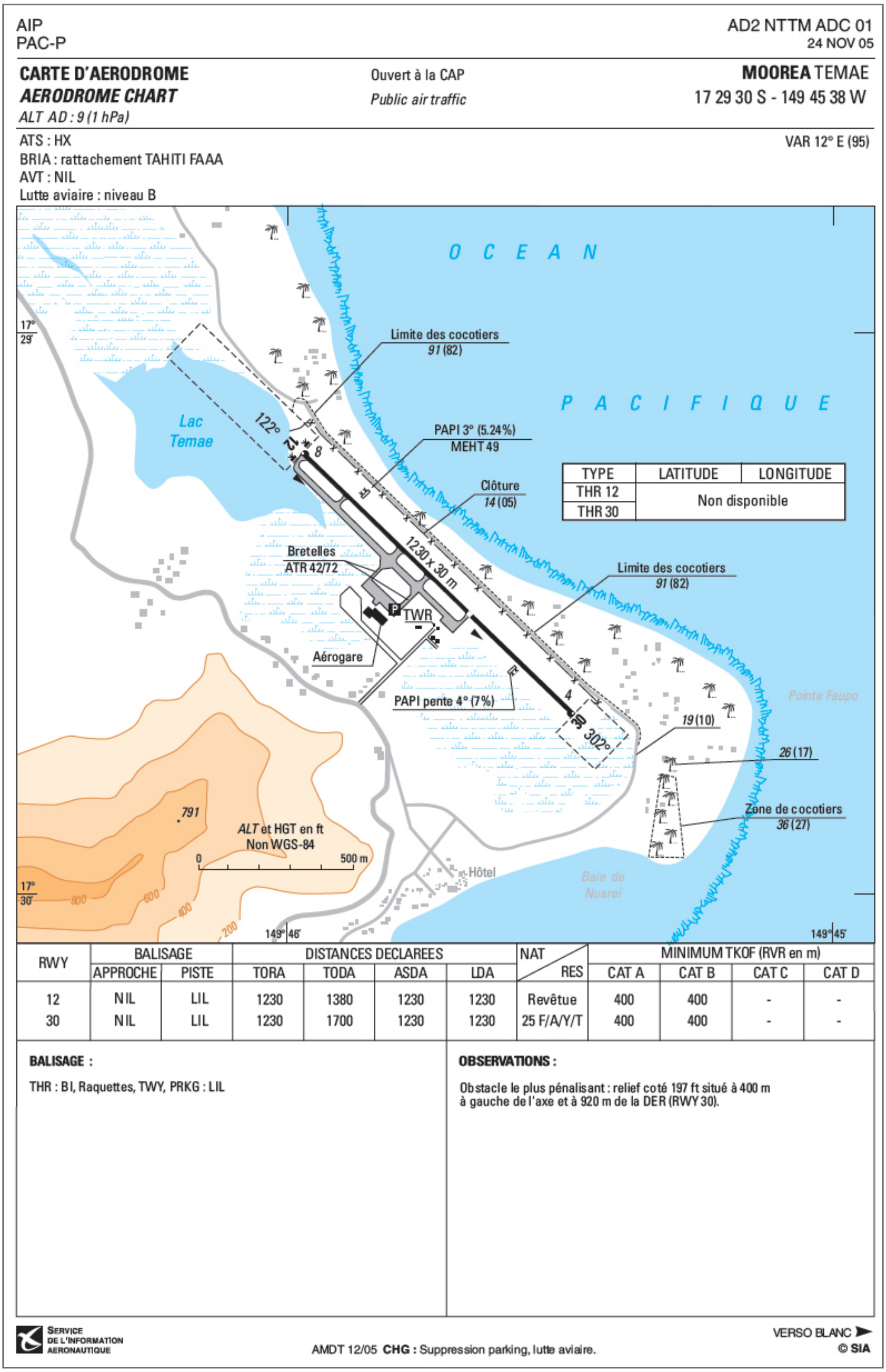
4.6 Reminder of a Recommendation

F-OIQI was equipped with a cockpit voice recorder, even though the regulations do not require it. However, without this equipment it would have been practically impossible to find the wreckage and, above all, to obtain information relevant to the investigation. The BEA hereby issues a reminder that following the accident on 24 March 2001 at Saint-Barthélemy (971) to the DHC6 300 registered F-OGES operated by Caraïbes Air Transport, it recommended to the French and European authorities to make mandatory the installation of at least one flight recorder on board public transport aircraft with more than nine passengers and whose maximum certified takeoff weight is less than or equal to 5,700 kg, whatever the date of initial certification might be.

List of Appendices

Appendix 1

Moorea VAC chart



AIP
PAC-P

AD2 NTTM ADC 01
24 NOV 05

CARTE D'AERODROME
AERODROME CHART
ALT AD : 9 (1 hPa)

Ouvert à la CAP
Public air traffic

MOOREA TEMAE
17 29 30 S - 149 45 38 W

ATS : HX
BRIA : rattachement TAHITI FAAA
AVT : NIL
Lutte aviaire : niveau B

VAR 12° E (95)

TYPE	LATITUDE	LONGITUDE
THR 12	Non disponible	
THR 30		

RWY	BALISAGE		DISTANCES DECLAREES				NAT	MINIMUM TKOF (RVR en m)			
	APPROCHE	PISTE	TORA	TODA	ASDA	LDA	RES	CAT A	CAT B	CAT C	CAT D
12	NIL	LIL	1230	1380	1230	1230	Revêtue 25 F/A/Y/T	400	400	-	-
30	NIL	LIL	1230	1700	1230	1230		400	400	-	-

BALISAGE :

THR : BI, Raquettes, TWY, PRKG : LIL

OBSERVATIONS :

Obstacle le plus pénalisant : relief coté 197 ft situé à 400 m à gauche de l'axe et à 920 m de la DER (RWY 30).

SERVICE DE L'INFORMATION AERONAUTIQUE

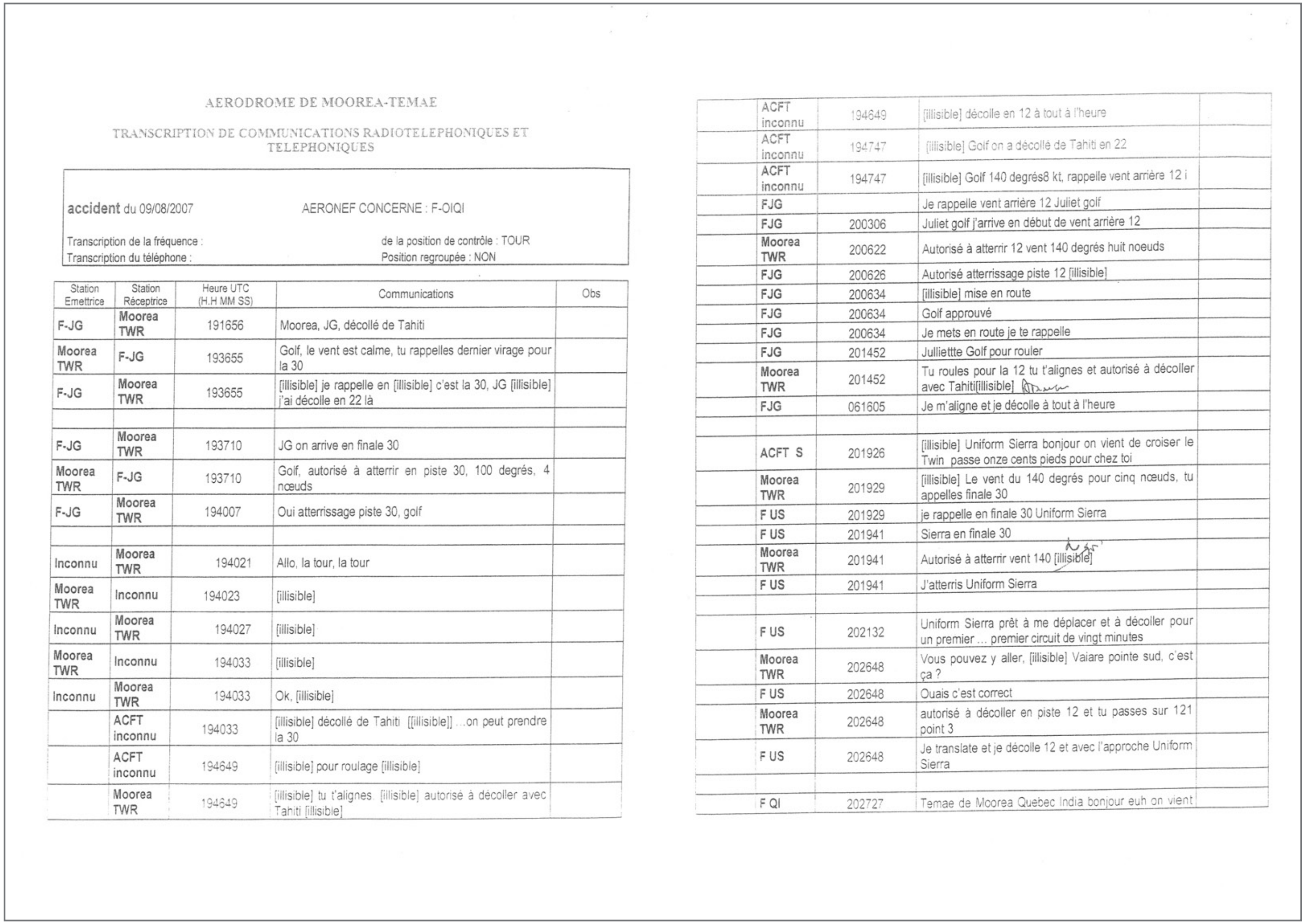
AMDT 12/05 **CHG :** Suppression parking, lutte aviaire.

VERSO BLANC ►

© SIA

Appendix 2

Transcript of radio-telephone communications



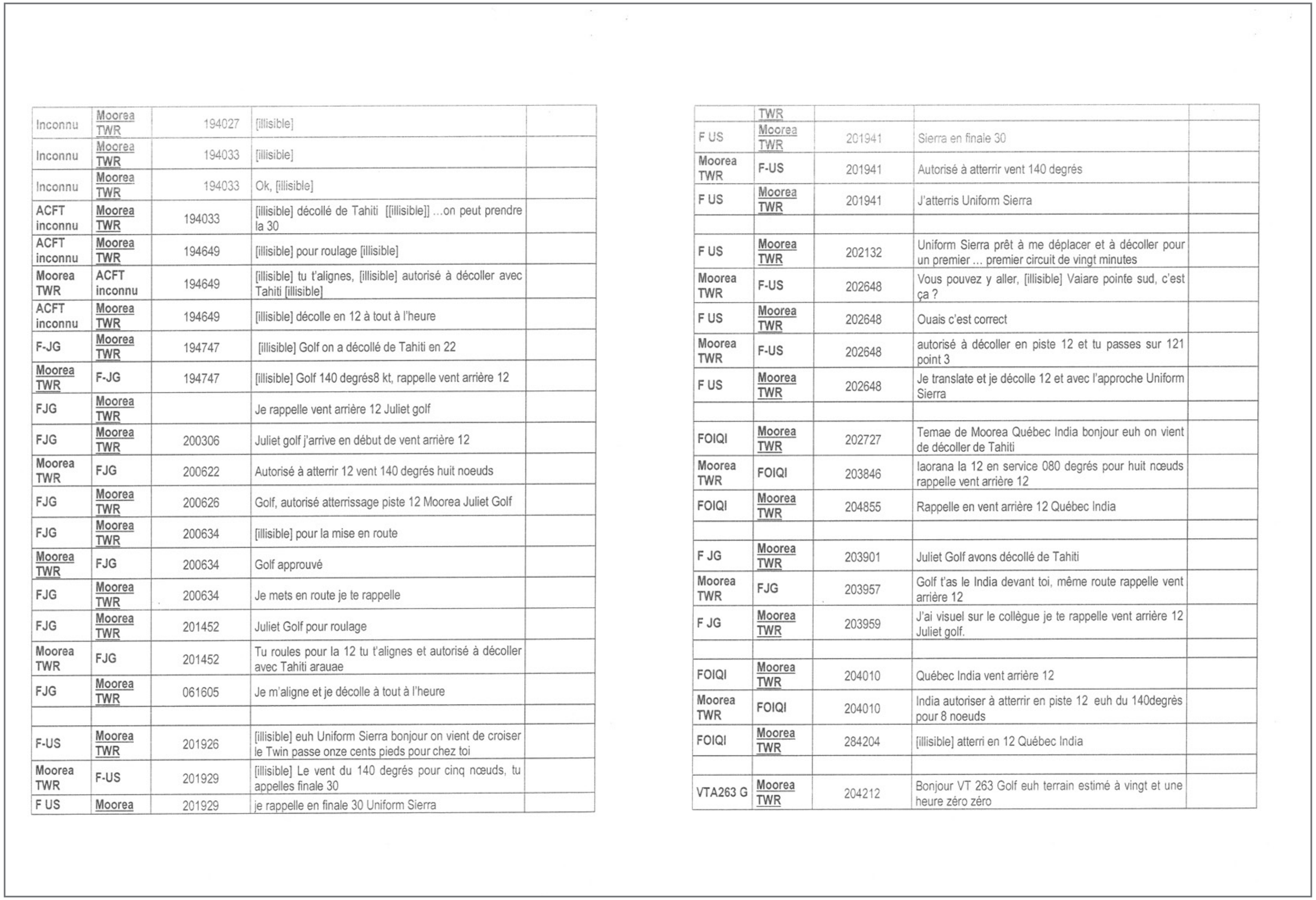
AERODROME DE MOOREA-TEMAE

TRANSCRIPTION DE COMMUNICATIONS RADIOTELEPHONIQUES ET TELEPHONIQUES

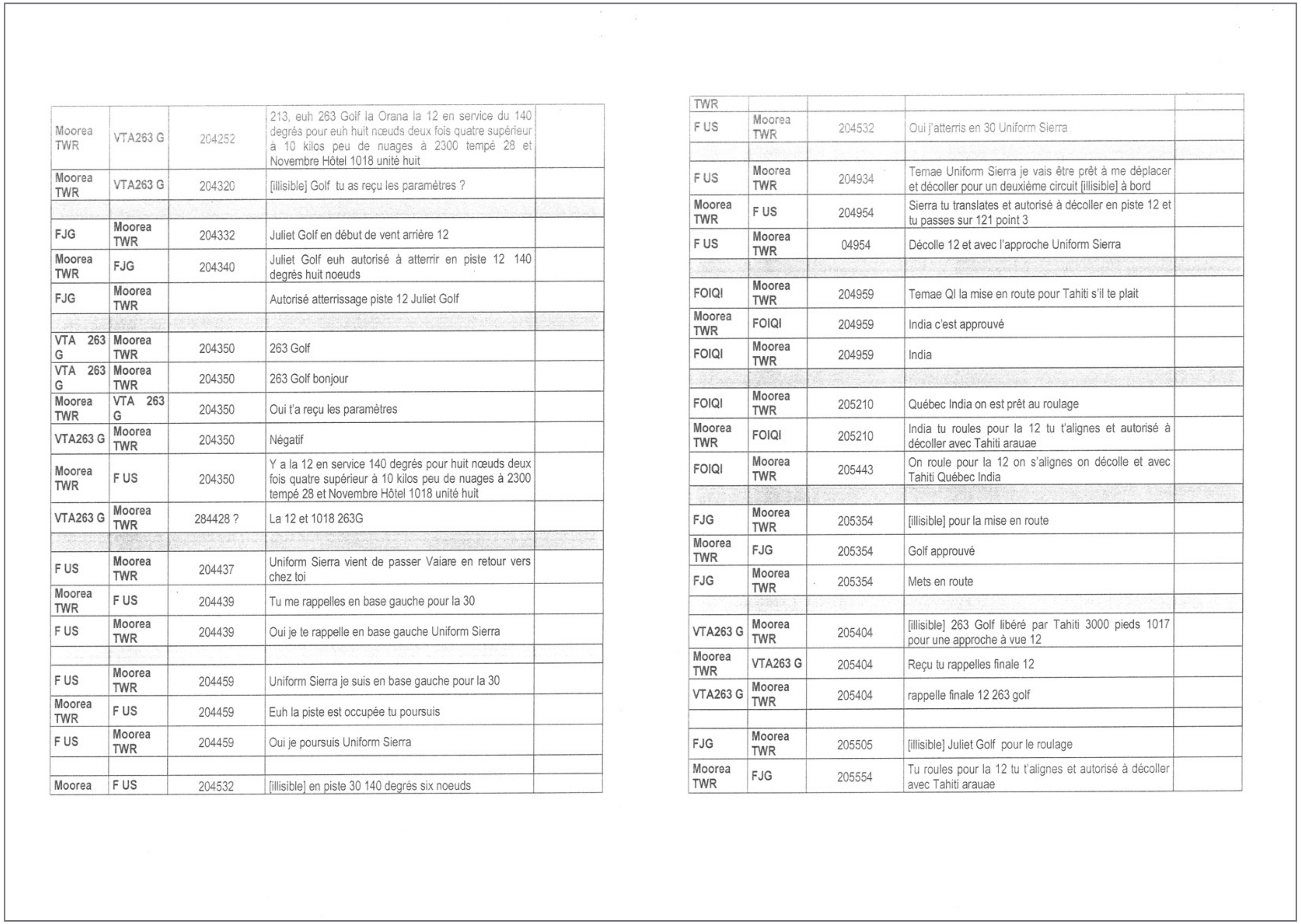
accident du 09/08/2007 AERONEF CONCERNE : F-OIQI

Transcription de la fréquence : de la position de contrôle : TOUR
Transcription du téléphone : Position regroupée : NON

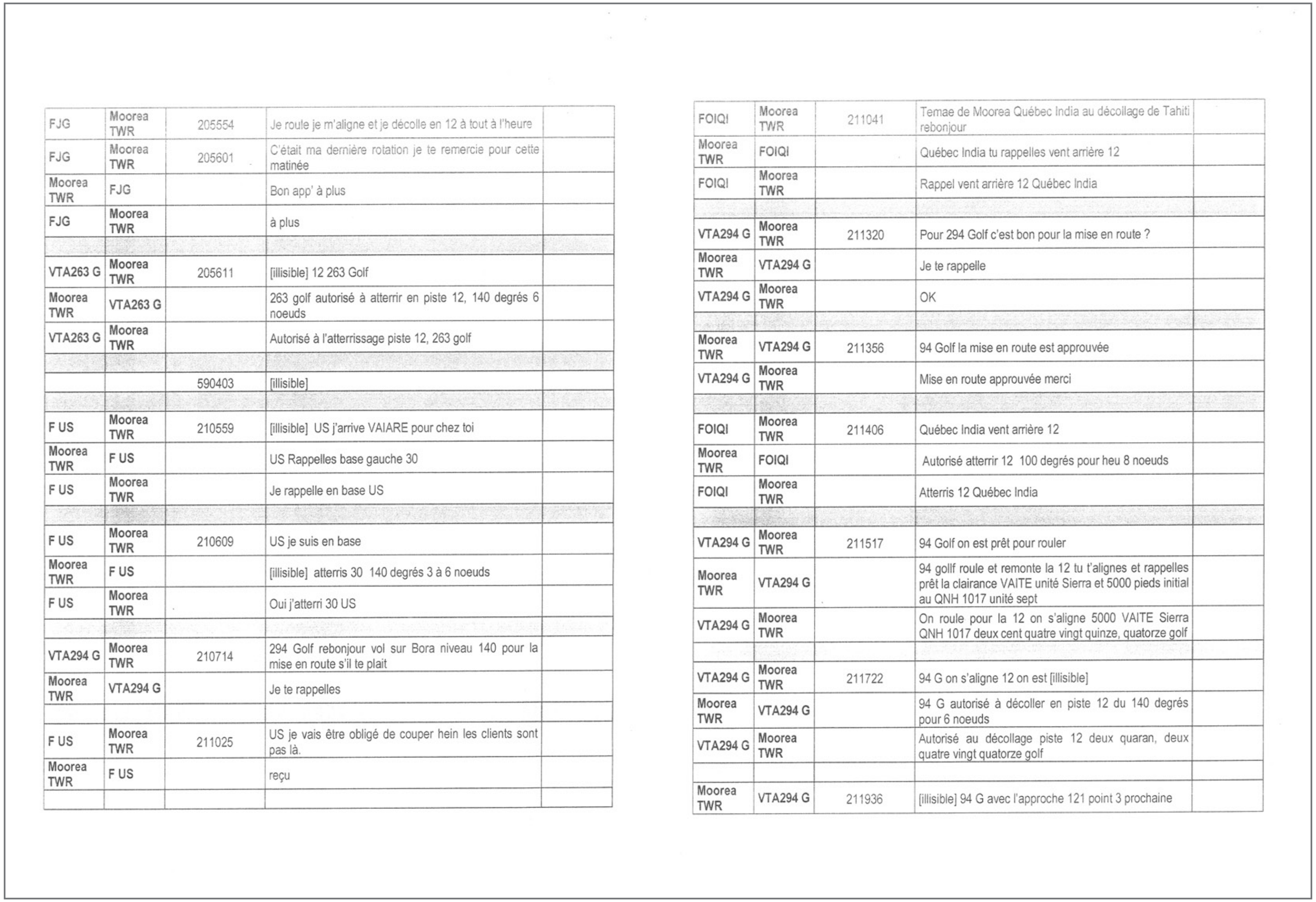
Station Emettrice	Station Réceptrice	Heure UTC (H.H MM SS)	Communications	Obs
F-JG	**Moorea TWR**	191656	Moorea, JG, décollé de Tahiti	
Moorea TWR	**F-JG**	193655	Golf, le vent est calme, tu rappelles dernier virage pour la 30	
F-JG	**Moorea TWR**	193655	[illisible] je rappelle en [illisible] c'est la 30, JG [illisible] j'ai décolle en 22 là	
F-JG	**Moorea TWR**	193710	JG on arrive en finale 30	
Moorea TWR	**F-JG**	193710	Golf, autorisé à atterrir en piste 30, 100 degrés, 4 nœuds	
F-JG	**Moorea TWR**	194007	Oui atterrissage piste 30, golf	
Inconnu	**Moorea TWR**	194021	Allo, la tour, la tour	
Moorea TWR	**Inconnu**	194023	[illisible]	
Inconnu	**Moorea TWR**	194027	[illisible]	
Moorea TWR	**Inconnu**	194033	[illisible]	
Inconnu	**Moorea TWR**	194033	Ok, [illisible]	
	ACFT inconnu	194033	[illisible] décollé de Tahiti [[illisible]] ...on peut prendre la 30	
	ACFT inconnu	194649	[illisible] pour roulage [illisible]	
	Moorea TWR	194649	[illisible] tu t'alignes [illisible] autorisé à décoller avec Tahiti [illisible]	
	ACFT inconnu	194649	[illisible] décolle en 12 à tout à l'heure	
	ACFT inconnu	194747	[illisible] Golf on a décollé de Tahiti en 22	
	ACFT inconnu	194747	[illisible] Golf 140 degrés8 kt, rappelle vent arrière 12 i	
	FJG		Je rappelle vent arrière 12 Juliet golf	
	FJG	200306	Juliet golf j'arrive en début de vent arrière 12	
	Moorea TWR	200622	Autorisé à atterrir 12 vent 140 degrés huit noeuds	
	FJG	200626	Autorisé atterrissage piste 12 [illisible]	
	FJG	200634	[illisible] mise en route	
	FJG	200634	Golf approuvé	
	FJG	200634	Je mets en route je te rappelle	
	FJG	201452	Julliettte Golf pour rouler	
	Moorea TWR	201452	Tu roules pour la 12 tu t'alignes et autorisé à décoller avec Tahiti[illisible]	
	FJG	061605	Je m'aligne et je décolle à tout à l'heure	
	ACFT S	201926	[illisible] Uniform Sierra bonjour on vient de croiser le Twin passe onze cents pieds pour chez toi	
	Moorea TWR	201929	[illisible] Le vent du 140 degrés pour cinq nœuds, tu appelles finale 30	
	F US	201929	je rappelle en finale 30 Uniform Sierra	
	F US	201941	Sierra en finale 30	
	Moorea TWR	201941	Autorisé à atterrir vent 140 [illisible]	
	F US	201941	J'atterris Uniform Sierra	
	F US	202132	Uniform Sierra prêt à me déplacer et à décoller pour un premier ... premier circuit de vingt minutes	
	Moorea TWR	202648	Vous pouvez y aller, [illisible] Vaiare pointe sud, c'est ça ?	
	F US	202648	Ouais c'est correct	
	Moorea TWR	202648	autorisé à décoller en piste 12 et tu passes sur 121 point 3	
	F US	202648	Je translate et je décolle 12 et avec l'approche Uniform Sierra	
	F QI	202727	Temae de Moorea Quebec India bonjour euh on vient	



Inconnu	Moorea TWR	194027	[illisible]	
Inconnu	Moorea TWR	194033	[illisible]	
Inconnu	Moorea TWR	194033	Ok, [illisible]	
ACFT inconnu	Moorea TWR	194033	[illisible] décollé de Tahiti [[illisible]] …on peut prendre la 30	
ACFT inconnu	Moorea TWR	194649	[illisible] pour roulage [illisible]	
Moorea TWR	ACFT inconnu	194649	[illisible] tu t'alignes, [illisible] autorisé à décoller avec Tahiti [illisible]	
ACFT inconnu	Moorea TWR	194649	[illisible] décolle en 12 à tout à l'heure	
F-JG	Moorea TWR	194747	[illisible] Golf on a décollé de Tahiti en 22	
Moorea TWR	F-JG	194747	[illisible] Golf 140 degrés8 kt, rappelle vent arrière 12	
FJG	Moorea TWR		Je rappelle vent arrière 12 Juliet golf	
FJG	Moorea TWR	200306	Juliet golf j'arrive en début de vent arrière 12	
Moorea TWR	FJG	200622	Autorisé à atterrir 12 vent 140 degrés huit noeuds	
FJG	Moorea TWR	200626	Golf, autorisé atterrissage piste 12 Moorea Juliet Golf	
FJG	Moorea TWR	200634	[illisible] pour la mise en route	
Moorea TWR	FJG	200634	Golf approuvé	
FJG	Moorea TWR	200634	Je mets en route je te rappelle	
FJG	Moorea TWR	201452	Juliet Golf pour roulage	
Moorea TWR	FJG	201452	Tu roules pour la 12 tu t'alignes et autorisé à décoller avec Tahiti arauae	
FJG	Moorea TWR	061605	Je m'aligne et je décolle à tout à l'heure	
F-US	Moorea TWR	201926	[illisible] euh Uniform Sierra bonjour on vient de croiser le Twin passe onze cents pieds pour chez toi	
Moorea TWR	F-US	201929	[illisible] Le vent du 140 degrés pour cinq nœuds, tu appelles finale 30	
F US	Moorea TWR	201929	je rappelle en finale 30 Uniform Sierra	
F US	Moorea TWR	201941	Sierra en finale 30	
Moorea TWR	F-US	201941	Autorisé à atterrir vent 140 degrés	
F US	Moorea TWR	201941	J'atterris Uniform Sierra	
F US	Moorea TWR	202132	Uniform Sierra prêt à me déplacer et à décoller pour un premier … premier circuit de vingt minutes	
Moorea TWR	F-US	202648	Vous pouvez y aller, [illisible] Vaiare pointe sud, c'est ça ?	
F US	Moorea TWR	202648	Ouais c'est correct	
Moorea TWR	F-US	202648	autorisé à décoller en piste 12 et tu passes sur 121 point 3	
F US	Moorea TWR	202648	Je translate et je décolle 12 et avec l'approche Uniform Sierra	
FOIQI	Moorea TWR	202727	Temae de Moorea Québec India bonjour euh on vient de décoller de Tahiti	
Moorea TWR	FOIQI	203846	Iaorana la 12 en service 080 degrés pour huit nœuds rappelle vent arrière 12	
FOIQI	Moorea TWR	204855	Rappelle en vent arrière 12 Québec India	
F JG	Moorea TWR	203901	Juliet Golf avons décollé de Tahiti	
Moorea TWR	FJG	203957	Golf t'as le India devant toi, même route rappelle vent arrière 12	
F JG	Moorea TWR	203959	J'ai visuel sur le collègue je te rappelle vent arrière 12 Juliet golf.	
FOIQI	Moorea TWR	204010	Québec India vent arrière 12	
Moorea TWR	FOIQI	204010	India autoriser à atterrir en piste 12 euh du 140degrés pour 8 noeuds	
FOIQI	Moorea TWR	284204	[illisible] atterri en 12 Québec India	
VTA263 G	Moorea TWR	204212	Bonjour VT 263 Golf euh terrain estimé à vingt et une heure zéro zéro	

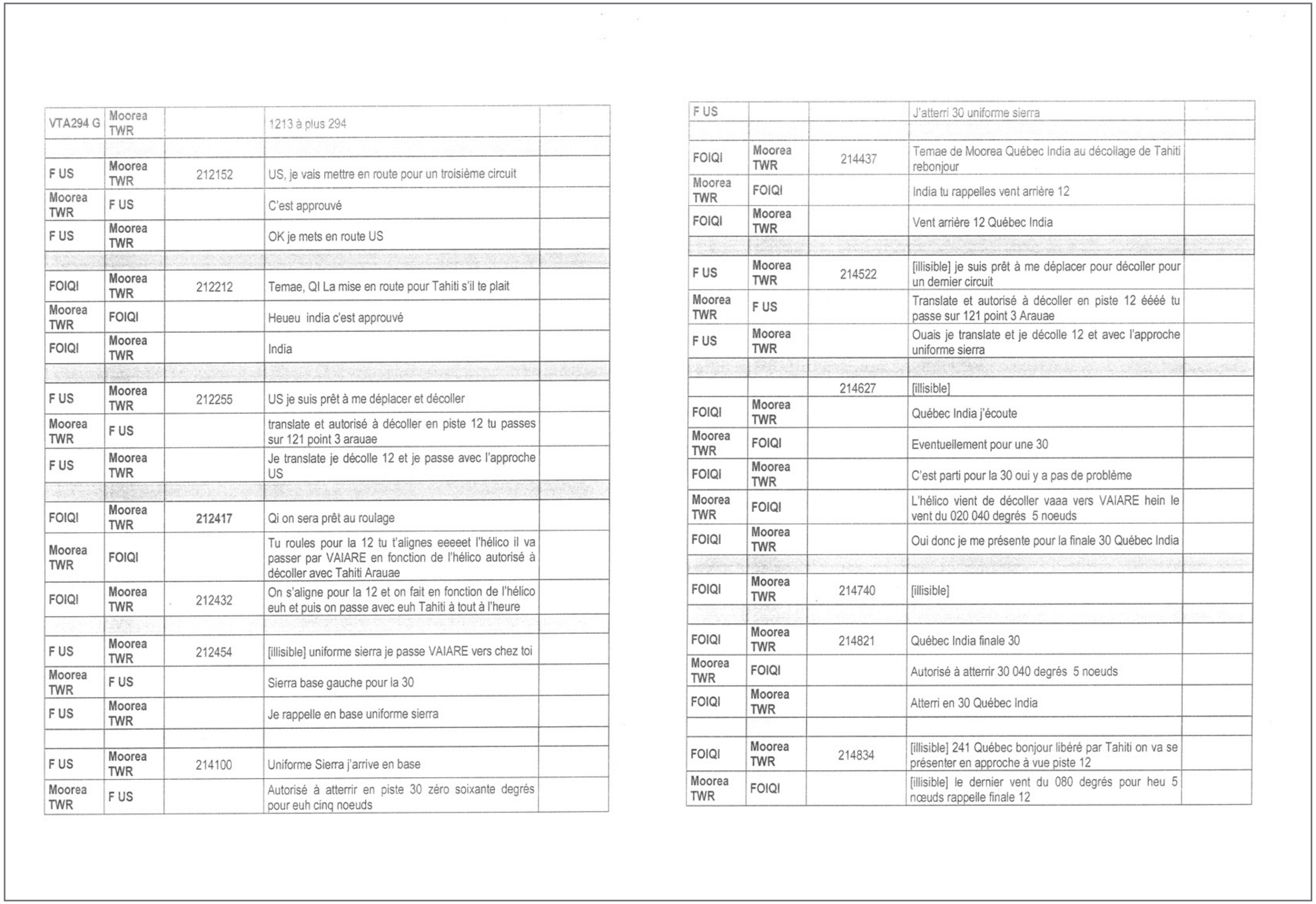


Moorea TWR	VTA263 G	204252	213, euh 263 Golf la Orana la 12 en service du 140 degrés pour euh huit nœuds deux fois quatre supérieur à 10 kilos peu de nuages à 2300 tempé 28 et Novembre Hôtel 1018 unité huit	
Moorea TWR	VTA263 G	204320	[illisible] Golf tu as reçu les paramètres ?	
FJG	Moorea TWR	204332	Juliet Golf en début de vent arrière 12	
Moorea TWR	FJG	204340	Juliet Golf euh autorisé à atterrir en piste 12 140 degrés huit noeuds	
FJG	Moorea TWR		Autorisé atterrissage piste 12 Juliet Golf	
VTA 263 G	Moorea TWR	204350	263 Golf	
VTA 263 G	Moorea TWR	204350	263 Golf bonjour	
Moorea TWR	VTA 263 G	204350	Oui t'a reçu les paramètres	
VTA263 G	Moorea TWR	204350	Négatif	
Moorea TWR	F US	204350	Y a la 12 en service 140 degrés pour huit nœuds deux fois quatre supérieur à 10 kilos peu de nuages à 2300 tempé 28 et Novembre Hôtel 1018 unité huit	
VTA263 G	Moorea TWR	284428 ?	La 12 et 1018 263G	
F US	Moorea TWR	204437	Uniform Sierra vient de passer Vaiare en retour vers chez toi	
Moorea TWR	F US	204439	Tu me rappelles en base gauche pour la 30	
F US	Moorea TWR	204439	Oui je te rappelle en base gauche Uniform Sierra	
F US	Moorea TWR	204459	Uniform Sierra je suis en base gauche pour la 30	
Moorea TWR	F US	204459	Euh la piste est occupée tu poursuis	
F US	Moorea TWR	204459	Oui je poursuis Uniform Sierra	
Moorea TWR	F US	204532	[illisible] en piste 30 140 degrés six noeuds	
F US	Moorea TWR	204532	Oui j'atterris en 30 Uniform Sierra	
F US	Moorea TWR	204934	Temae Uniform Sierra je vais être prêt à me déplacer et décoller pour un deuxième circuit [illisible] à bord	
Moorea TWR	F US	204954	Sierra tu translates et autorisé à décoller en piste 12 et tu passes sur 121 point 3	
F US	Moorea TWR	04954	Décolle 12 et avec l'approche Uniform Sierra	
FOIQI	Moorea TWR	204959	Temae QI la mise en route pour Tahiti s'il te plait	
Moorea TWR	FOIQI	204959	India c'est approuvé	
FOIQI	Moorea TWR	204959	India	
FOIQI	Moorea TWR	205210	Québec India on est prêt au roulage	
Moorea TWR	FOIQI	205210	India tu roules pour la 12 tu t'alignes et autorisé à décoller avec Tahiti arauae	
FOIQI	Moorea TWR	205443	On roule pour la 12 on s'alignes on décolle et avec Tahiti Québec India	
FJG	Moorea TWR	205354	[illisible] pour la mise en route	
Moorea TWR	FJG	205354	Golf approuvé	
FJG	Moorea TWR	205354	Mets en route	
VTA263 G	Moorea TWR	205404	[illisible] 263 Golf libéré par Tahiti 3000 pieds 1017 pour une approche à vue 12	
Moorea TWR	VTA263 G	205404	Reçu tu rappelles finale 12	
VTA263 G	Moorea TWR	205404	rappelle finale 12 263 golf	
FJG	Moorea TWR	205505	[illisible] Juliet Golf pour le roulage	
Moorea TWR	FJG	205554	Tu roules pour la 12 tu t'alignes et autorisé à décoller avec Tahiti arauae	

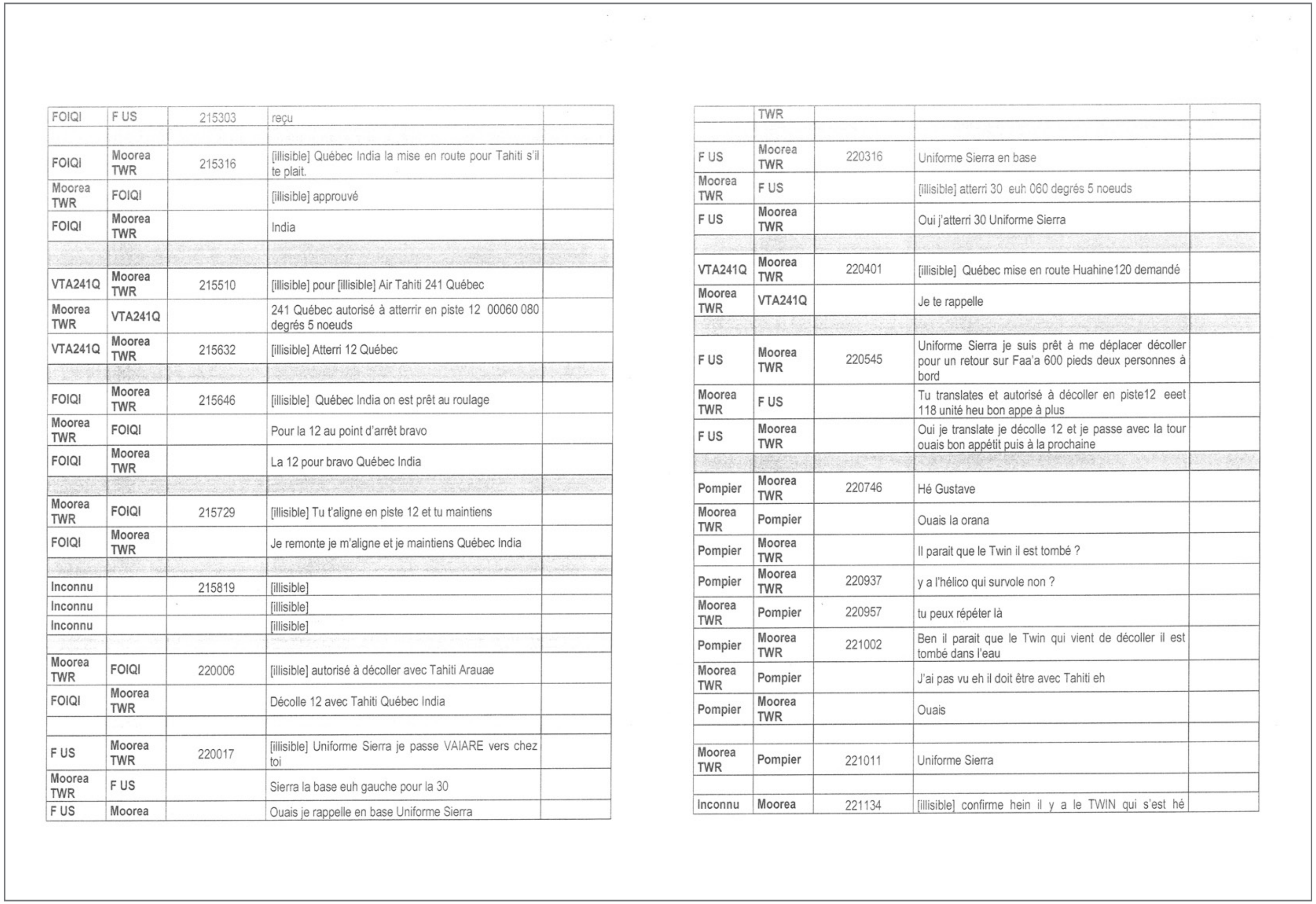


FJG	Moorea TWR	205554	Je roule je m'aligne et je décolle en 12 à tout à l'heure	
FJG	Moorea TWR	205601	C'était ma dernière rotation je te remercie pour cette matinée	
Moorea TWR	FJG		Bon app' à plus	
FJG	Moorea TWR		à plus	
VTA263 G	Moorea TWR	205611	[illisible] 12 263 Golf	
Moorea TWR	VTA263 G		263 golf autorisé à atterrir en piste 12, 140 degrés 6 noeuds	
VTA263 G	Moorea TWR		Autorisé à l'atterrissage piste 12, 263 golf	
		590403	[illisible]	
F US	Moorea TWR	210559	[illisible] US j'arrive VAIARE pour chez toi	
Moorea TWR	F US		US Rappelles base gauche 30	
F US	Moorea TWR		Je rappelle en base US	
F US	Moorea TWR	210609	US je suis en base	
Moorea TWR	F US		[illisible] atterris 30 140 degrés 3 à 6 noeuds	
F US	Moorea TWR		Oui j'atterri 30 US	
VTA294 G	Moorea TWR	210714	294 Golf rebonjour vol sur Bora niveau 140 pour la mise en route s'il te plait	
Moorea TWR	VTA294 G		Je te rappelles	
F US	Moorea TWR	211025	US je vais être obligé de couper hein les clients sont pas là.	
Moorea TWR	F US		reçu	

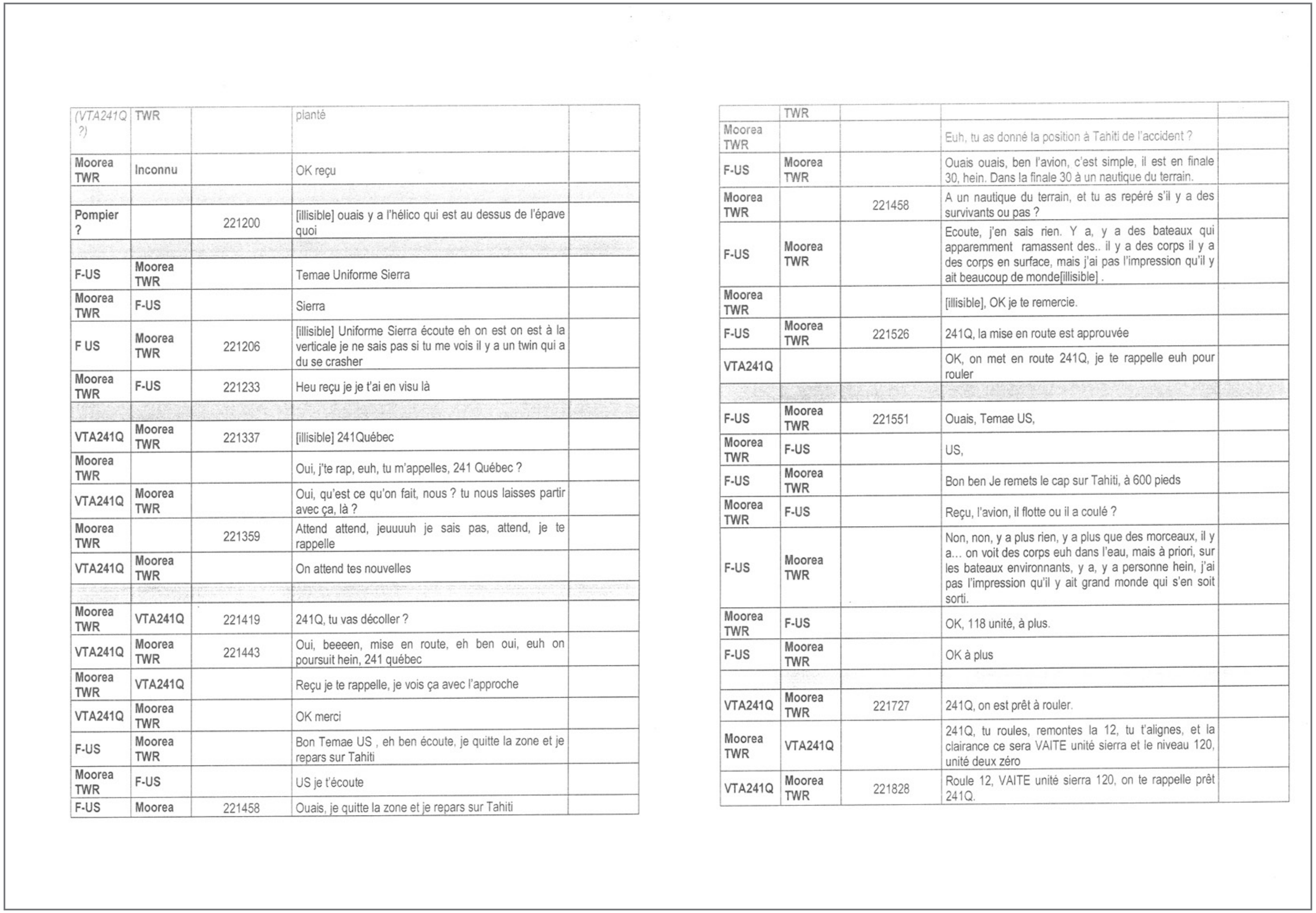
FOIQI	Moorea TWR	211041	Temae de Moorea Québec India au décollage de Tahiti rebonjour	
Moorea TWR	FOIQI		Québec India tu rappelles vent arrière 12	
FOIQI	Moorea TWR		Rappel vent arrière 12 Québec India	
VTA294 G	Moorea TWR	211320	Pour 294 Golf c'est bon pour la mise en route ?	
Moorea TWR	VTA294 G		Je te rappelle	
VTA294 G	Moorea TWR		OK	
Moorea TWR	VTA294 G	211356	94 Golf la mise en route est approuvée	
VTA294 G	Moorea TWR		Mise en route approuvée merci	
FOIQI	Moorea TWR	211406	Québec India vent arrière 12	
Moorea TWR	FOIQI		Autorisé atterrir 12 100 degrés pour heu 8 noeuds	
FOIQI	Moorea TWR		Atterris 12 Québec India	
VTA294 G	Moorea TWR	211517	94 Golf on est prêt pour rouler	
Moorea TWR	VTA294 G		94 gollf roule et remonte la 12 tu t'alignes et rappelles prêt la clairance VAITE unité Sierra et 5000 pieds initial au QNH 1017 unité sept	
VTA294 G	Moorea TWR		On roule pour la 12 on s'aligne 5000 VAITE Sierra QNH 1017 deux cent quatre vingt quinze, quatorze golf	
VTA294 G	Moorea TWR	211722	94 G on s'aligne 12 on est [illisible]	
Moorea TWR	VTA294 G		94 G autorisé à décoller en piste 12 du 140 degrés pour 6 noeuds	
VTA294 G	Moorea TWR		Autorisé au décollage piste 12 deux quaran, deux quatre vingt quatorze golf	
Moorea TWR	VTA294 G	211936	[illisible] 94 G avec l'approche 121 point 3 prochaine	



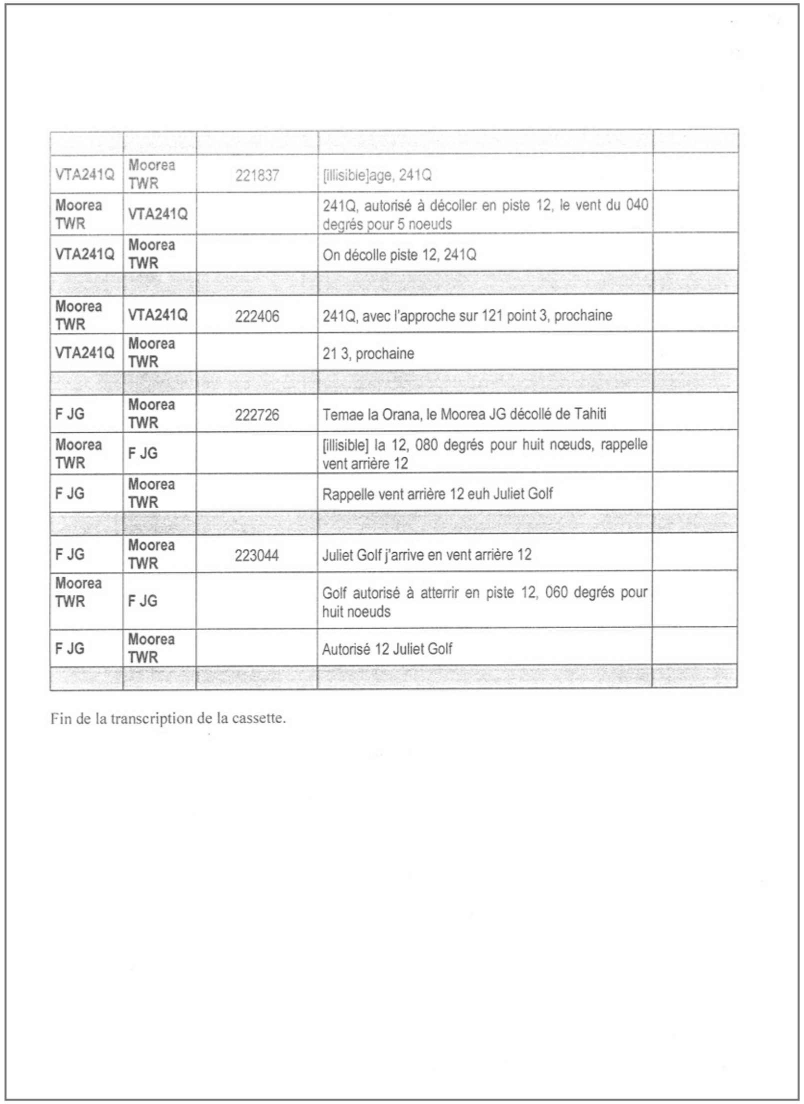
VTA294 G	Moorea TWR		1213 à plus 294	
F US	Moorea TWR	212152	US, je vais mettre en route pour un troisiéme circuit	
Moorea TWR	F US		C'est approuvé	
F US	Moorea TWR		OK je mets en route US	
FOIQI	Moorea TWR	212212	Temae, QI La mise en route pour Tahiti s'il te plait	
Moorea TWR	FOIQI		Heueu india c'est approuvé	
FOIQI	Moorea TWR		India	
F US	Moorea TWR	212255	US je suis prêt à me déplacer et décoller	
Moorea TWR	F US		translate et autorisé à décoller en piste 12 tu passes sur 121 point 3 arauae	
F US	Moorea TWR		Je translate je décolle 12 et je passe avec l'approche US	
FOIQI	Moorea TWR	212417	Qi on sera prêt au roulage	
Moorea TWR	FOIQI		Tu roules pour la 12 tu t'alignes eeeeet l'hélico il va passer par VAIARE en fonction de l'hélico autorisé à décoller avec Tahiti Arauae	
FOIQI	Moorea TWR	212432	On s'aligne pour la 12 et on fait en fonction de l'hélico euh et puis on passe avec euh Tahiti à tout à l'heure	
F US	Moorea TWR	212454	[illisible] uniforme sierra je passe VAIARE vers chez toi	
Moorea TWR	F US		Sierra base gauche pour la 30	
F US	Moorea TWR		Je rappelle en base uniforme sierra	
F US	Moorea TWR	214100	Uniforme Sierra j'arrive en base	
Moorea TWR	F US		Autorisé à atterrir en piste 30 zéro soixante degrés pour euh cinq noeuds	
F US			J'atterri 30 uniforme sierra	
FOIQI	Moorea TWR	214437	Temae de Moorea Québec India au décollage de Tahiti rebonjour	
Moorea TWR	FOIQI		India tu rappelles vent arrière 12	
FOIQI	Moorea TWR		Vent arrière 12 Québec India	
F US	Moorea TWR	214522	[illisible] je suis prêt à me déplacer pour décoller pour un dernier circuit	
Moorea TWR	F US		Translate et autorisé à décoller en piste 12 éééé tu passe sur 121 point 3 Arauae	
F US	Moorea TWR		Ouais je translate et je décolle 12 et avec l'approche uniforme sierra	
		214627	[illisible]	
FOIQI	Moorea TWR		Québec India j'écoute	
Moorea TWR	FOIQI		Eventuellement pour une 30	
FOIQI	Moorea TWR		C'est parti pour la 30 oui y a pas de problème	
Moorea TWR	FOIQI		L'hélico vient de décoller vaaa vers VAIARE hein le vent du 020 040 degrés 5 noeuds	
FOIQI	Moorea TWR		Oui donc je me présente pour la finale 30 Québec India	
FOIQI	Moorea TWR	214740	[illisible]	
FOIQI	Moorea TWR	214821	Québec India finale 30	
Moorea TWR	FOIQI		Autorisé à atterrir 30 040 degrés 5 noeuds	
FOIQI	Moorea TWR		Atterri en 30 Québec India	
FOIQI	Moorea TWR	214834	[illisible] 241 Québec bonjour libéré par Tahiti on va se présenter en approche à vue piste 12	
Moorea TWR	FOIQI		[illisible] le dernier vent du 080 degrés pour heu 5 nœuds rappelle finale 12	



FOIQI	F US	215303	reçu	
FOIQI	Moorea TWR	215316	[illisible] Québec India la mise en route pour Tahiti s'il te plait.	
Moorea TWR	FOIQI		[illisible] approuvé	
FOIQI	Moorea TWR		India	
VTA241Q	Moorea TWR	215510	[illisible] pour [illisible] Air Tahiti 241 Québec	
Moorea TWR	VTA241Q		241 Québec autorisé à atterrir en piste 12 00060 080 degrés 5 noeuds	
VTA241Q	Moorea TWR	215632	[illisible] Atterri 12 Québec	
FOIQI	Moorea TWR	215646	[illisible] Québec India on est prêt au roulage	
Moorea TWR	FOIQI		Pour la 12 au point d'arrêt bravo	
FOIQI	Moorea TWR		La 12 pour bravo Québec India	
Moorea TWR	FOIQI	215729	[illisible] Tu t'aligne en piste 12 et tu maintiens	
FOIQI	Moorea TWR		Je remonte je m'aligne et je maintiens Québec India	
Inconnu		215819	[illisible]	
Inconnu			[illisible]	
Inconnu			[illisible]	
Moorea TWR	FOIQI	220006	[illisible] autorisé à décoller avec Tahiti Arauae	
FOIQI	Moorea TWR		Décolle 12 avec Tahiti Québec India	
F US	Moorea TWR	220017	[illisible] Uniforme Sierra je passe VAIARE vers chez toi	
Moorea TWR	F US		Sierra la base euh gauche pour la 30	
F US	Moorea		Ouais je rappelle en base Uniforme Sierra	
	TWR			
F US	Moorea TWR	220316	Uniforme Sierra en base	
Moorea TWR	F US		[illisible] atterri 30 euh 060 degrés 5 noeuds	
F US	Moorea TWR		Oui j'atterri 30 Uniforme Sierra	
VTA241Q	Moorea TWR	220401	[illisible] Québec mise en route Huahine120 demandé	
Moorea TWR	VTA241Q		Je te rappelle	
F US	Moorea TWR	220545	Uniforme Sierra je suis prêt à me déplacer décoller pour un retour sur Faa'a 600 pieds deux personnes à bord	
Moorea TWR	F US		Tu translates et autorisé à décoller en piste12 eeet 118 unité heu bon appe à plus	
F US	Moorea TWR		Oui je translate je décolle 12 et je passe avec la tour ouais bon appétit puis à la prochaine	
Pompier	Moorea TWR	220746	Hé Gustave	
Moorea TWR	Pompier		Ouais la orana	
Pompier	Moorea TWR		Il parait que le Twin il est tombé ?	
Pompier	Moorea TWR	220937	y a l'hélico qui survole non ?	
Moorea TWR	Pompier	220957	tu peux répéter là	
Pompier	Moorea TWR	221002	Ben il parait que le Twin qui vient de décoller il est tombé dans l'eau	
Moorea TWR	Pompier		J'ai pas vu eh il doit être avec Tahiti eh	
Pompier	Moorea TWR		Ouais	
Moorea TWR	Pompier	221011	Uniforme Sierra	
Inconnu	Moorea	221134	[illisible] confirme hein il y a le TWIN qui s'est hé	



(VTA241Q ?)	TWR		planté	
Moorea TWR	Inconnu		OK reçu	
Pompier ?		221200	[illisible] ouais y a l'hélico qui est au dessus de l'épave quoi	
F-US	Moorea TWR		Temae Uniforme Sierra	
Moorea TWR	F-US		Sierra	
F US	Moorea TWR	221206	[illisible] Uniforme Sierra écoute eh on est on est à la verticale je ne sais pas si tu me vois il y a un twin qui a du se crasher	
Moorea TWR	F-US	221233	Heu reçu je je t'ai en visu là	
VTA241Q	Moorea TWR	221337	[illisible] 241Québec	
Moorea TWR			Oui, j'te rap, euh, tu m'appelles, 241 Québec ?	
VTA241Q	Moorea TWR		Oui, qu'est ce qu'on fait, nous ? tu nous laisses partir avec ça, là ?	
Moorea TWR		221359	Attend attend, jeuuuuh je sais pas, attend, je te rappelle	
VTA241Q	Moorea TWR		On attend tes nouvelles	
Moorea TWR	VTA241Q	221419	241Q, tu vas décoller ?	
VTA241Q	Moorea TWR	221443	Oui, beeeen, mise en route, eh ben oui, euh on poursuit hein, 241 québec	
Moorea TWR	VTA241Q		Reçu je te rappelle, je vois ça avec l'approche	
VTA241Q	Moorea TWR		OK merci	
F-US	Moorea TWR		Bon Temae US , eh ben écoute, je quitte la zone et je repars sur Tahiti	
Moorea TWR	F-US		US je t'écoute	
F-US	Moorea	221458	Ouais, je quitte la zone et je repars sur Tahiti	
	TWR			
Moorea TWR			Euh, tu as donné la position à Tahiti de l'accident ?	
F-US	Moorea TWR		Ouais ouais, ben l'avion, c'est simple, il est en finale 30, hein. Dans la finale 30 à un nautique du terrain.	
Moorea TWR		221458	A un nautique du terrain, et tu as repéré s'il y a des survivants ou pas ?	
F-US	Moorea TWR		Ecoute, j'en sais rien. Y a, y a des bateaux qui apparemment ramassent des.. il y a des corps il y a des corps en surface, mais j'ai pas l'impression qu'il y ait beaucoup de monde[illisible] .	
Moorea TWR			[illisible], OK je te remercie.	
F-US	Moorea TWR	221526	241Q, la mise en route est approuvée	
VTA241Q			OK, on met en route 241Q, je te rappelle euh pour rouler	
F-US	Moorea TWR	221551	Ouais, Temae US,	
Moorea TWR	F-US		US,	
F-US	Moorea TWR		Bon ben Je remets le cap sur Tahiti, à 600 pieds	
Moorea TWR	F-US		Reçu, l'avion, il flotte ou il a coulé ?	
F-US	Moorea TWR		Non, non, y a plus rien, y a plus que des morceaux, il y a… on voit des corps euh dans l'eau, mais à priori, sur les bateaux environnants, y a, y a personne hein, j'ai pas l'impression qu'il y ait grand monde qui s'en soit sorti.	
Moorea TWR	F-US		OK, 118 unité, à plus.	
F-US	Moorea TWR		OK à plus	
VTA241Q	Moorea TWR	221727	241Q, on est prêt à rouler.	
Moorea TWR	VTA241Q		241Q, tu roules, remontes la 12, tu t'alignes, et la clairance ce sera VAITE unité sierra et le niveau 120, unité deux zéro	
VTA241Q	Moorea TWR	221828	Roule 12, VAITE unité sierra 120, on te rappelle prêt 241Q.	

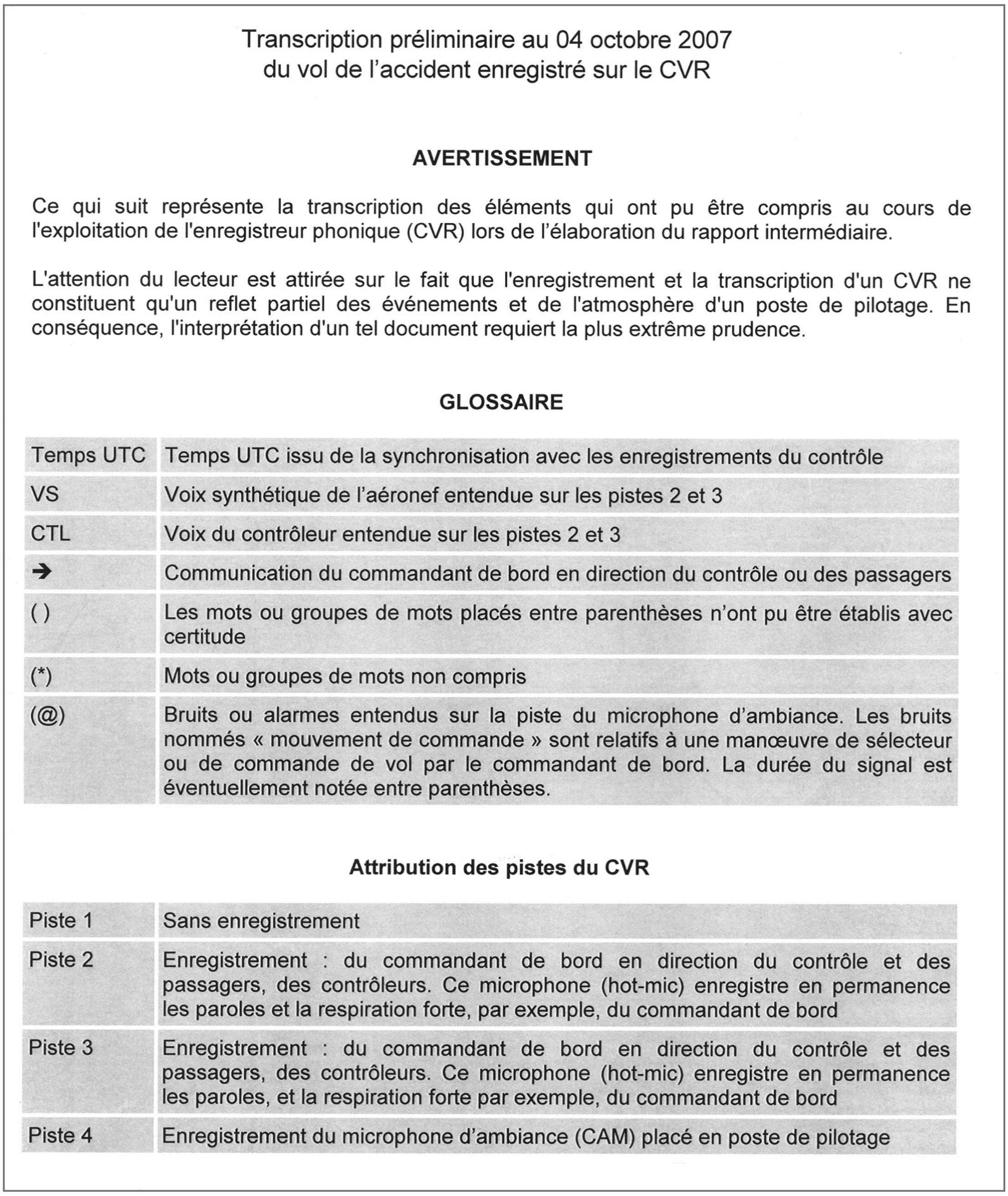


VTA241Q	Moorea TWR	221837	[illisible]age, 241Q	
Moorea TWR	**VTA241Q**		241Q, autorisé à décoller en piste 12, le vent du 040 degrés pour 5 noeuds	
VTA241Q	**Moorea TWR**		On décolle piste 12, 241Q	
Moorea TWR	**VTA241Q**	222406	241Q, avec l'approche sur 121 point 3, prochaine	
VTA241Q	**Moorea TWR**		21 3, prochaine	
F JG	**Moorea TWR**	222726	Temae la Orana, le Moorea JG décollé de Tahiti	
Moorea TWR	**F JG**		[illisible] la 12, 080 degrés pour huit nœuds, rappelle vent arrière 12	
F JG	**Moorea TWR**		Rappelle vent arrière 12 euh Juliet Golf	
F JG	**Moorea TWR**	223044	Juliet Golf j'arrive en vent arrière 12	
Moorea TWR	**F JG**		Golf autorisé à atterrir en piste 12, 060 degrés pour huit noeuds	
F JG	**Moorea TWR**		Autorisé 12 Juliet Golf	

Fin de la transcription de la cassette.

Appendix 3

CVR Transcript



Transcription préliminaire au 04 octobre 2007
du vol de l'accident enregistré sur le CVR

AVERTISSEMENT

Ce qui suit représente la transcription des éléments qui ont pu être compris au cours de l'exploitation de l'enregistreur phonique (CVR) lors de l'élaboration du rapport intermédiaire.

L'attention du lecteur est attirée sur le fait que l'enregistrement et la transcription d'un CVR ne constituent qu'un reflet partiel des événements et de l'atmosphère d'un poste de pilotage. En conséquence, l'interprétation d'un tel document requiert la plus extrême prudence.

GLOSSAIRE

Temps UTC	Temps UTC issu de la synchronisation avec les enregistrements du contrôle
VS	Voix synthétique de l'aéronef entendue sur les pistes 2 et 3
CTL	Voix du contrôleur entendue sur les pistes 2 et 3
➔	Communication du commandant de bord en direction du contrôle ou des passagers
( )	Les mots ou groupes de mots placés entre parenthèses n'ont pu être établis avec certitude
(*)	Mots ou groupes de mots non compris
(@)	Bruits ou alarmes entendus sur la piste du microphone d'ambiance. Les bruits nommés « mouvement de commande » sont relatifs à une manœuvre de sélecteur ou de commande de vol par le commandant de bord. La durée du signal est éventuellement notée entre parenthèses.

Attribution des pistes du CVR

Piste 1	Sans enregistrement
Piste 2	Enregistrement : du commandant de bord en direction du contrôle et des passagers, des contrôleurs. Ce microphone (hot-mic) enregistre en permanence les paroles et la respiration forte, par exemple, du commandant de bord
Piste 3	Enregistrement : du commandant de bord en direction du contrôle et des passagers, des contrôleurs. Ce microphone (hot-mic) enregistre en permanence les paroles, et la respiration forte par exemple, du commandant de bord
Piste 4	Enregistrement du microphone d'ambiance (CAM) placé en poste de pilotage

Temps UTC	Commandant de bord, contrôleur ou voix synthétique	Remarques, bruits
21 h 49 min 03 s		Arrêt des moteurs du vol précédent Bruits en cabine passagers pendant les prochaines minutes
49 min 17 s	CdB : Bonne journée messieurs dames au revoir	
49 min 20 s		Arrêt des bruits en poste
21 h 50 min 03 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (600ms)
50 min 49 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (500ms)
21 h 51 min 34 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (500ms)
21 h 52 min 17 s		Début des bruits en poste de pilotage, (ceinture, …)
21 h 52 min 18 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
21 h 53 min 03 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
53 min 08 s		Bruits de mouvement du casque avec microphone
53 min 12 s		Soufflement dans le microphone de casque
53 min 16 s	➔ Témaé de Moorea Québec India la mise en route pour Tahiti s'il te plaît	
53 min 22 s	CTL : India approuvé	
53 min 23 s	➔ India	
53 min 39 s		Début de bruit de conditionnement d'air
53 min 45 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
21 h 54 min 02 s	➔ Mesdames messieurs bonjour bienvenu à bord veuillez attacher vos ceintures s'il vous plaît merci ➔ Ladies and gentlemen welcome on board fasten your seat belts thank you	
21 h 57 min 07 s		Coupure d'enregistrement. L'enregistrement est maintenant continu jusqu'à la fin du vol. Les hélices sont en rotation.

Temps UTC	Commandant de bord, contrôleur ou voix synthétique	Remarques, bruits
57 min 10 s		Augmentation régime moteur
57 min 16 s	➔ Témaé de Québec India on est prêt au roulage	
57 min 19 s	CTL : (Pour) la douze au point d'arrêt Bravo	
57 min 21 s	➔ La douze pour Bravo Québec India	
57 min 23 s		(@) Bruit de mouvement de commande
57 min 24 s		Augmentation régime moteur
57 min 26 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
57 min 27 s		(@) Signal sonore (828 Hz 800 ms)
57 min 28 s		Diminution du régime moteur
57 min 30 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (600ms)
57 min 36 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (700ms)
57 min 37 s		Discussion en bruit de fond du CAM
57 min 39 s		Augmentation régime moteur
57 min 41 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (700ms)
57 min 45 s		Diminution du régime moteur
57 min 48 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (700ms)
57 min 55 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (500ms)
57 min 57 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms) suivi d'un bruit strident (250 ms 6500 Hz)
21 h 58 min 01 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (700ms)
58 min 04 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (500ms)
58 min 06 s	CTL : India tu t'alignes en piste douze et tu maintiens	
58 min 08 s		Augmentation régime moteur
58 min 10 s	➔ Je remonte je m'aligne et je maintiens Québec India	

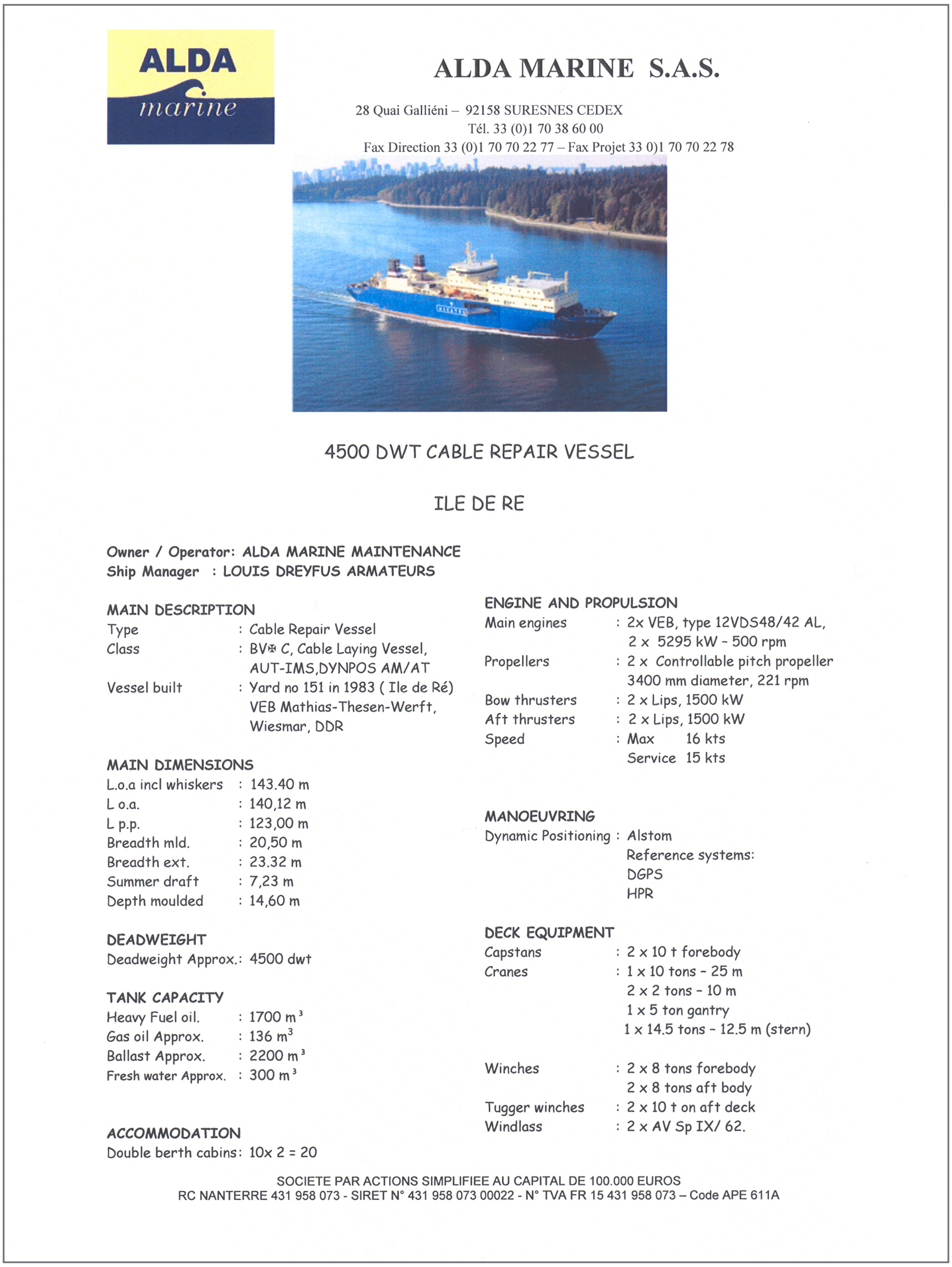
Temps UTC	Commandant de bord, contrôleur ou voix synthétique	Remarques, bruits
58 min 13 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (600ms)
58 min 15 s		Diminution du régime moteur
58 min 17 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
58 min 20 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (800ms)
58 min 23 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
58 min 24 s		Diminution du régime moteur
58 min 27 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
58 min 29 s	CdB : (*) trim est réglé (*)	
58 min 33 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (500ms)
58 min 48 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (600ms)
58 min 52 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (600ms)
58 min 54 s		(@) Bruit de mouvement de commande
58 min 55 s		Augmentation régime moteur
58 min 56 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
21 h 59 min 00 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (700ms)
59 min 01 s		(@) Diminution du régime moteur
59 min 04 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
59 min 05 s		Augmentation régime moteur
59 min 07 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (500ms)
59 min 11 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (800ms)
59 min 13 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (700ms) suivi d'un bruit strident (100 ms 6500 Hz)
59 min 17 s		Diminution du régime moteur
59 min 36 s		(@) Bruit non identifié

Temps UTC	Commandant de bord, contrôleur ou voix synthétique	Remarques, bruits
59 min 41 s		Trois communications entre l'ATC et le Novembre X-ray sur les pistes 2 et 3
59 min 54 s		Quatre messages radio non compris sur la piste 3 avec le Québec India
22 h 00 min 00 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
00 min 06 s	CTL : India autorisé à décoller avec Tahiti Air Moorea	
00 min 09 s	➔ Décolle douze avec Tahiti (Air) Québec India	
00 min 12 s		Mise en puissance
00 min 13 s		Augmentation de la vitesse de rotation des hélices
00 min 22 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
00 min 35 s		(@) Bruit non identifié
00 min 40 s		(@) Signal sonore strident (100ms 6500Hz)
00 min 58 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (500ms)
00 min 02 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
22 h 01 min 06 s		(@) Bruit similaire au fonctionnement de la pompe hydraulique (500ms)
01 min 07 s 400		Réduction de la vitesse de rotation des hélices
01 min 09 s 200	CdB : Ah putain	
01 min 11 s 450		(@) Bruit de mouvement de commande
01 min 12 s 100	VS : Don't sink	
01 min 12 s 500		(@) Bruit non identifié
01 min 13 s 280		(@) Bruit similaire au fonctionnement de la pompe hydraulique (400ms)
01 min 13 s 550	VS : Don't sink	
01 min 13 s 900		(@) Bruit de mouvement de commande
01 min 14 s 100		Augmentation de la vitesse de rotation des hélices
01 min 14 s 600		(@) Bruit non identifié
01 min 15 s 200	VS : Sink rate	
01 min 15 s 950	VS : Pull up	

Temps UTC	Commandant de bord, contrôleur ou voix synthétique	Remarques, bruits
01 min 17 s 550	VS : Pull up	
01 min 19 s 150	VS : Pull	
01 min 19 s 950		(@) Signal sonore sur la piste 1
22 h 01 min 20 s 000		Fin du signal sur la piste CAM et fin d'enregistrement

Appendix 4

Description of the “*Ile de Ré*“



ALDA MARINE S.A.S.

28 Quai Galliéni – 92158 SURESNES CEDEX
Tél. 33 (0)1 70 38 60 00
Fax Direction 33 (0)1 70 70 22 77 – Fax Projet 33 0)1 70 70 22 78

4500 DWT CABLE REPAIR VESSEL

ILE DE RE

Owner / Operator: ALDA MARINE MAINTENANCE
Ship Manager : LOUIS DREYFUS ARMATEURS

MAIN DESCRIPTION
Type : Cable Repair Vessel
Class : BV✠ C, Cable Laying Vessel, AUT-IMS,DYNPOS AM/AT
Vessel built : Yard no 151 in 1983 (Ile de Ré) VEB Mathias-Thesen-Werft, Wiesmar, DDR

MAIN DIMENSIONS
L.o.a incl whiskers : 143.40 m
L o.a. : 140,12 m
L p.p. : 123,00 m
Breadth mld. : 20,50 m
Breadth ext. : 23.32 m
Summer draft : 7,23 m
Depth moulded : 14,60 m

DEADWEIGHT
Deadweight Approx.: 4500 dwt

TANK CAPACITY
Heavy Fuel oil. : 1700 m^3
Gas oil Approx. : 136 m^3
Ballast Approx. : 2200 m^3
Fresh water Approx. : 300 m^3

ACCOMMODATION
Double berth cabins: 10x 2 = 20

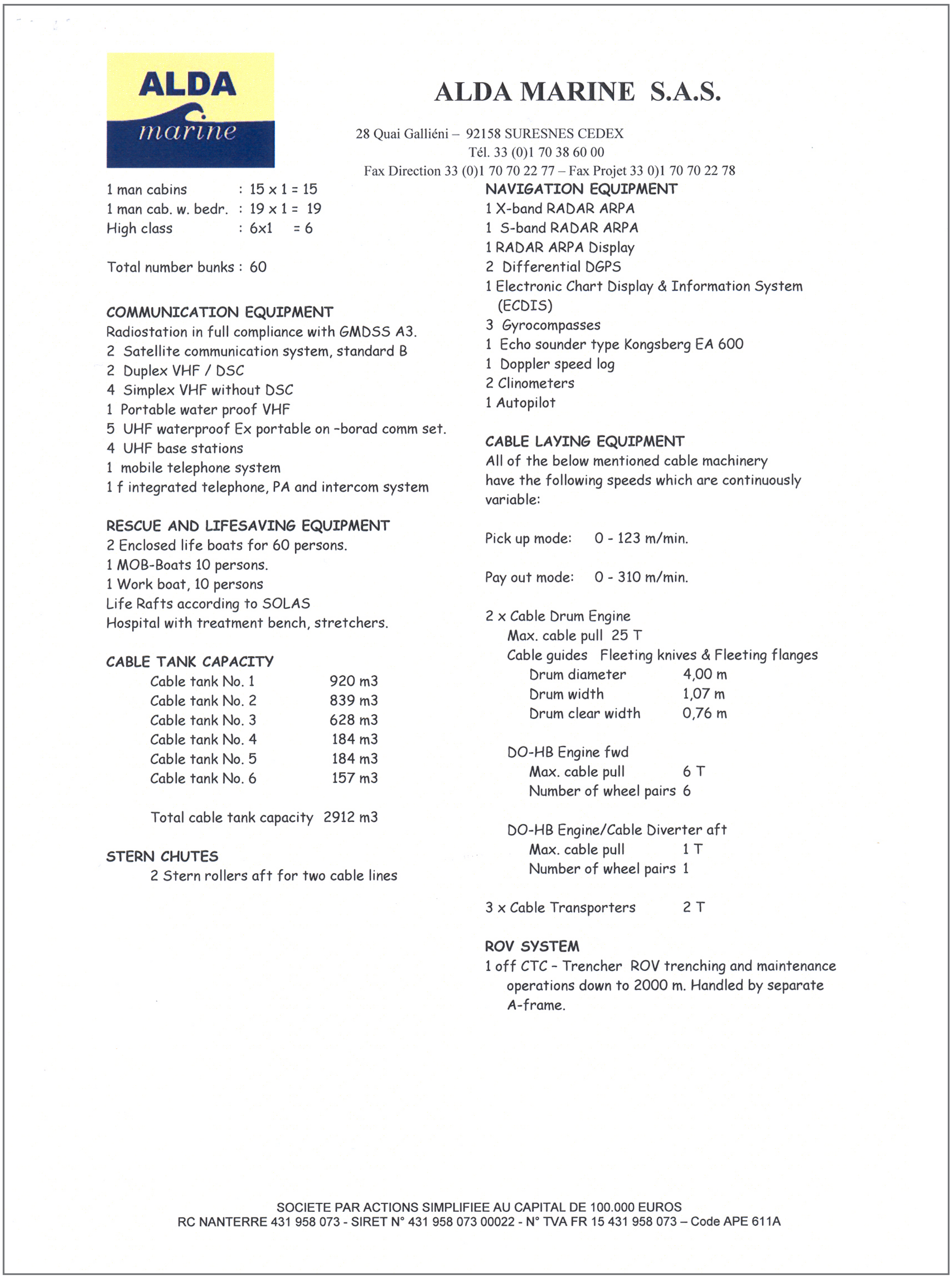
ENGINE AND PROPULSION
Main engines : 2x VEB, type 12VDS48/42 AL, 2 x 5295 kW – 500 rpm
Propellers : 2 x Controllable pitch propeller 3400 mm diameter, 221 rpm
Bow thrusters : 2 x Lips, 1500 kW
Aft thrusters : 2 x Lips, 1500 kW
Speed : Max 16 kts
Service 15 kts

MANOEUVRING
Dynamic Positioning : Alstom
Reference systems:
DGPS
HPR

DECK EQUIPMENT
Capstans : 2 x 10 t forebody
Cranes : 1 x 10 tons – 25 m
2 x 2 tons – 10 m
1 x 5 ton gantry
1 x 14.5 tons – 12.5 m (stern)

Winches : 2 x 8 tons forebody
2 x 8 tons aft body
Tugger winches : 2 x 10 t on aft deck
Windlass : 2 x AV Sp IX/ 62.

SOCIETE PAR ACTIONS SIMPLIFIEE AU CAPITAL DE 100.000 EUROS
RC NANTERRE 431 958 073 - SIRET N° 431 958 073 00022 - N° TVA FR 15 431 958 073 – Code APE 611A



ALDA MARINE S.A.S.

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Tél. 33 (0)1 70 38 60 00
Fax Direction 33 (0)1 70 70 22 77 – Fax Projet 33 0)1 70 70 22 78

1 man cabins	: 15 x 1 = 15
1 man cab. w. bedr.	: 19 x 1 = 19
High class	: 6x1 = 6

Total number bunks : 60

COMMUNICATION EQUIPMENT

Radiostation in full compliance with GMDSS A3.
2 Satellite communication system, standard B
2 Duplex VHF / DSC
4 Simplex VHF without DSC
1 Portable water proof VHF
5 UHF waterproof Ex portable on –borad comm set.
4 UHF base stations
1 mobile telephone system
1 f integrated telephone, PA and intercom system

RESCUE AND LIFESAVING EQUIPMENT

2 Enclosed life boats for 60 persons.
1 MOB-Boats 10 persons.
1 Work boat, 10 persons
Life Rafts according to SOLAS
Hospital with treatment bench, stretchers.

CABLE TANK CAPACITY

Cable tank No. 1	920 m3
Cable tank No. 2	839 m3
Cable tank No. 3	628 m3
Cable tank No. 4	184 m3
Cable tank No. 5	184 m3
Cable tank No. 6	157 m3
Total cable tank capacity	2912 m3

STERN CHUTES

2 Stern rollers aft for two cable lines

NAVIGATION EQUIPMENT

1 X-band RADAR ARPA
1 S-band RADAR ARPA
1 RADAR ARPA Display
2 Differential DGPS
1 Electronic Chart Display & Information System (ECDIS)
3 Gyrocompasses
1 Echo sounder type Kongsberg EA 600
1 Doppler speed log
2 Clinometers
1 Autopilot

CABLE LAYING EQUIPMENT

All of the below mentioned cable machinery have the following speeds which are continuously variable:

Pick up mode: 0 - 123 m/min.

Pay out mode: 0 - 310 m/min.

2 x Cable Drum Engine
Max. cable pull 25 T
Cable guides Fleeting knives & Fleeting flanges

Drum diameter	4,00 m
Drum width	1,07 m
Drum clear width	0,76 m

DO-HB Engine fwd

Max. cable pull	6 T
Number of wheel pairs	6

DO-HB Engine/Cable Diverter aft

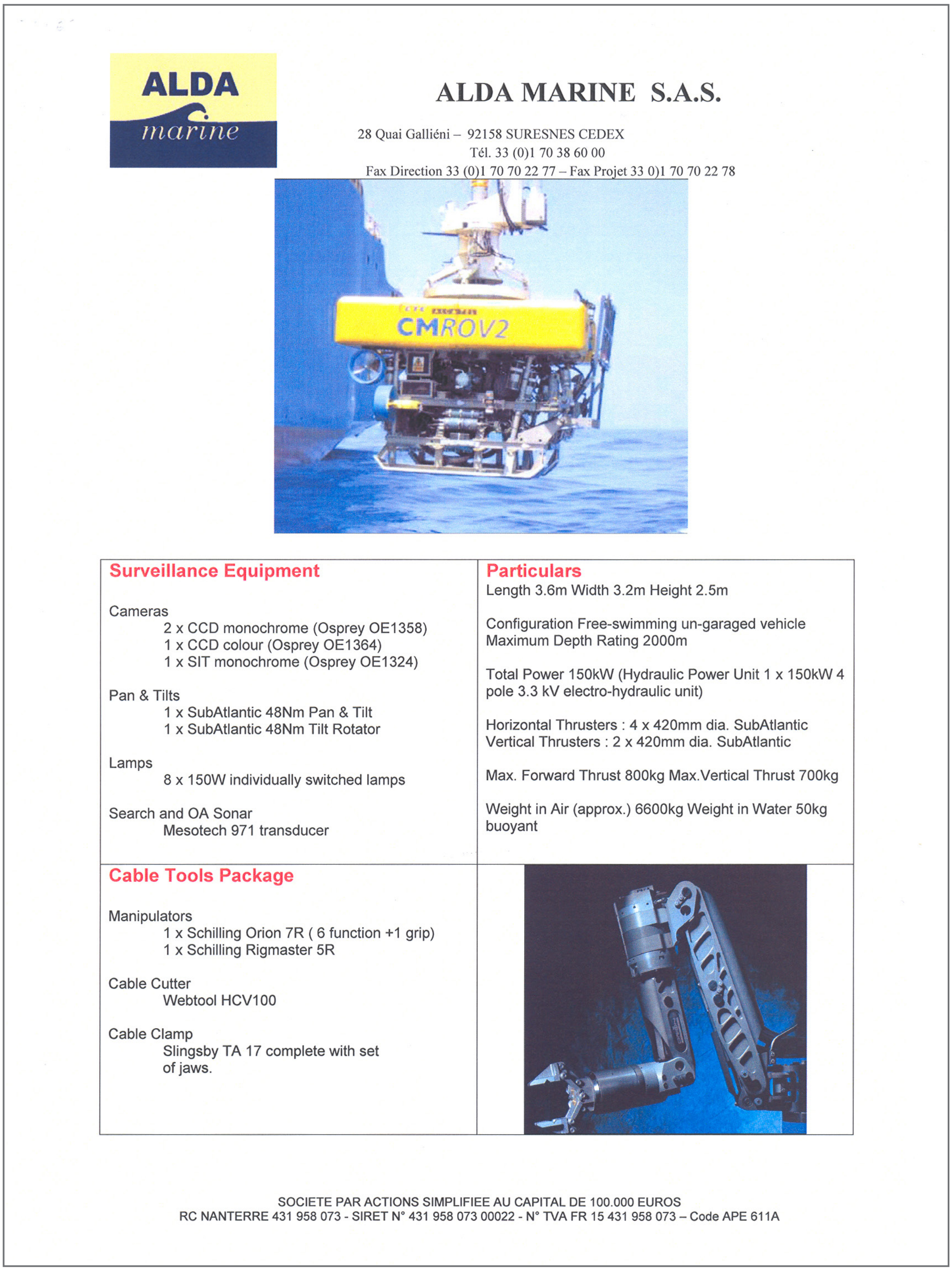
Max. cable pull	1 T
Number of wheel pairs	1

3 x Cable Transporters 2 T

ROV SYSTEM

1 off CTC – Trencher ROV trenching and maintenance operations down to 2000 m. Handled by separate A-frame.

SOCIETE PAR ACTIONS SIMPLIFIEE AU CAPITAL DE 100.000 EUROS
RC NANTERRE 431 958 073 - SIRET N° 431 958 073 00022 - N° TVA FR 15 431 958 073 – Code APE 611A



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Fax Direction 33 (0)1 70 70 22 77 – Fax Projet 33 0)1 70 70 22 78

Surveillance Equipment

Cameras
- 2 x CCD monochrome (Osprey OE1358)
- 1 x CCD colour (Osprey OE1364)
- 1 x SIT monochrome (Osprey OE1324)

Pan & Tilts
- 1 x SubAtlantic 48Nm Pan & Tilt
- 1 x SubAtlantic 48Nm Tilt Rotator

Lamps
- 8 x 150W individually switched lamps

Search and OA Sonar
- Mesotech 971 transducer

Particulars

Length 3.6m Width 3.2m Height 2.5m

Configuration Free-swimming un-garaged vehicle
Maximum Depth Rating 2000m

Total Power 150kW (Hydraulic Power Unit 1 x 150kW 4 pole 3.3 kV electro-hydraulic unit)

Horizontal Thrusters : 4 x 420mm dia. SubAtlantic
Vertical Thrusters : 2 x 420mm dia. SubAtlantic

Max. Forward Thrust 800kg Max.Vertical Thrust 700kg

Weight in Air (approx.) 6600kg Weight in Water 50kg buoyant

Cable Tools Package

Manipulators
- 1 x Schilling Orion 7R (6 function +1 grip)
- 1 x Schilling Rigmaster 5R

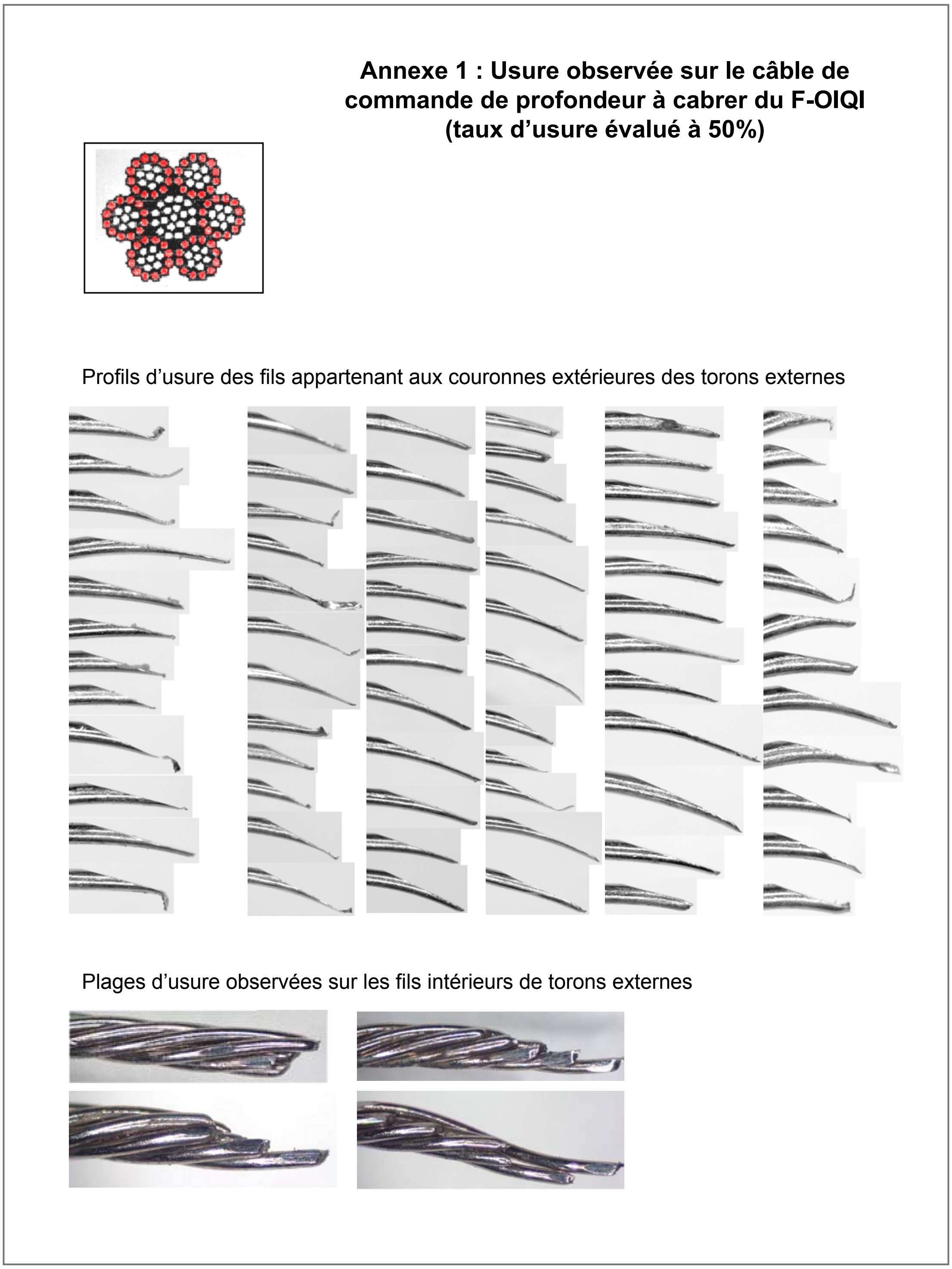
Cable Cutter
- Webtool HCV100

Cable Clamp
- Slingsby TA 17 complete with set of jaws.

SOCIETE PAR ACTIONS SIMPLIFIEE AU CAPITAL DE 100.000 EUROS
RC NANTERRE 431 958 073 - SIRET N° 431 958 073 00022 - N° TVA FR 15 431 958 073 – Code APE 611A

Appendix 5

Wear observed on the cables

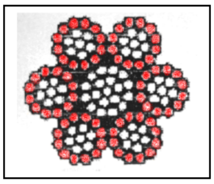


Annexe 1 : Usure observée sur le câble de commande de profondeur à cabrer du F-OIQI (taux d'usure évalué à 50%)

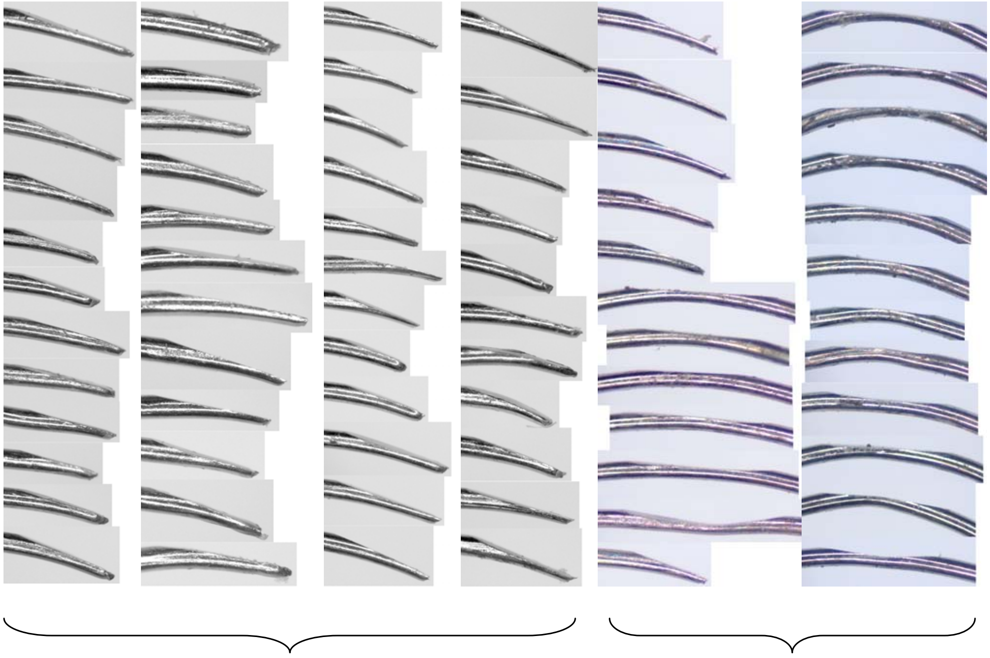
Profils d'usure des fils appartenant aux couronnes extérieures des torons externes

Plages d'usure observées sur les fils intérieurs de torons externes

Annexe 2 : Usure observée sur le câble de commande de profondeur à piquer du F-OIQI
(taux d’usure évalué à 35%)

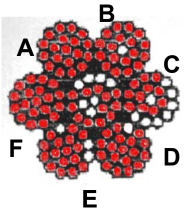


Profils d’usure des fils appartenant aux couronnes extérieures des torons externes



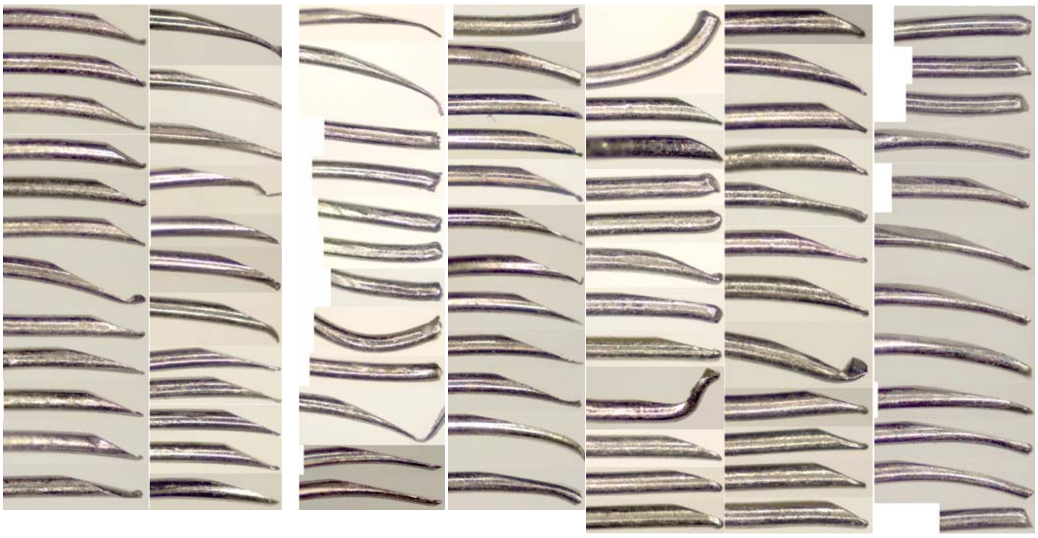
Torons rompus au cours de l’essai

Torons non rompus après essais : Les fils rompus l’ont été au cours des manipulations post essai.

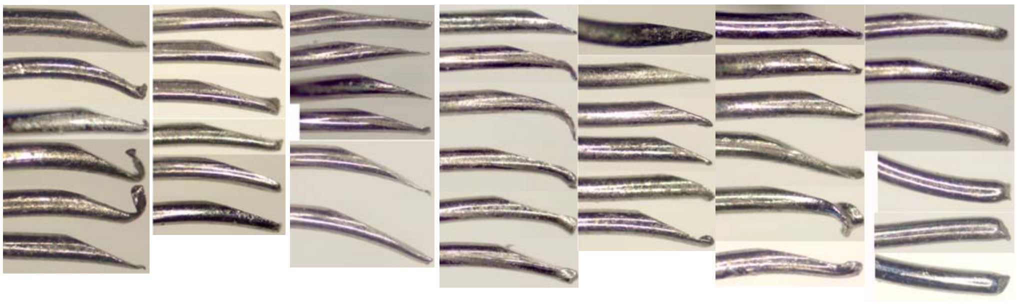


Annexe 3 : Usure observée sur le câble de commande de roulis du F-OIJL (Taux d'usure évalué à 80%)

Profils d'usure des fils appartenant aux couronnes extérieures



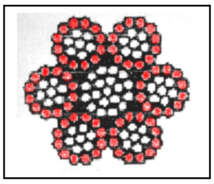
Profils d'usure des fils appartenant aux couronnes intérieures



Profils d'usure des fils d'âme

Toron A | **Toron B** | **Toron C** | **Toron D** | **Toron E** | **Toron F** | **Toron central**

Annexe 4 : Usure observée sur le câble d'essai de traction N°5 (taux d'usure évalué à 50%)

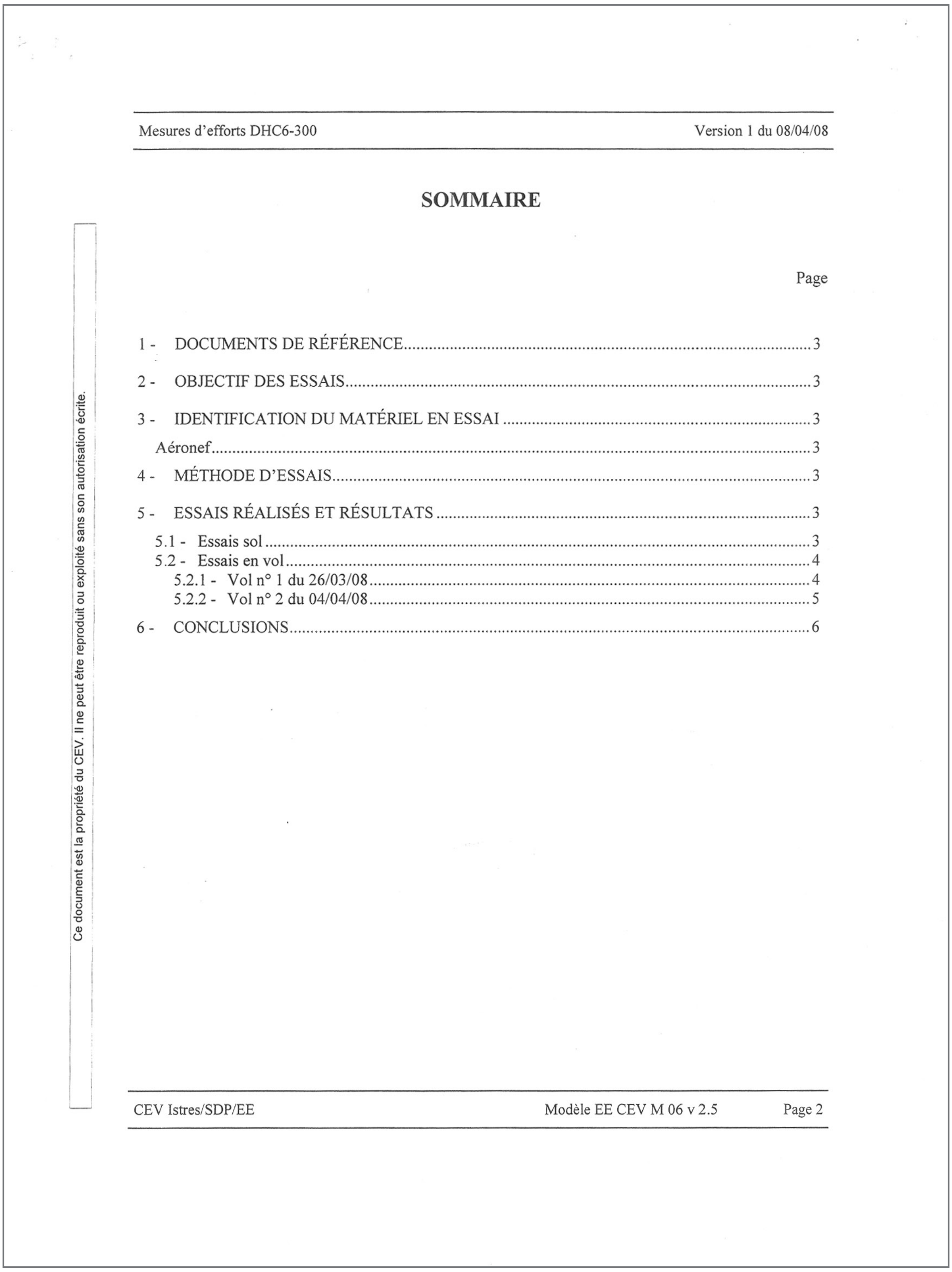


Profils d'usure des fils appartenant aux couronnes extérieures des torons externes

Plages d'usure observées sur les fils intérieurs de torons externes

Appendix 6

Report on tests



SOMMAIRE

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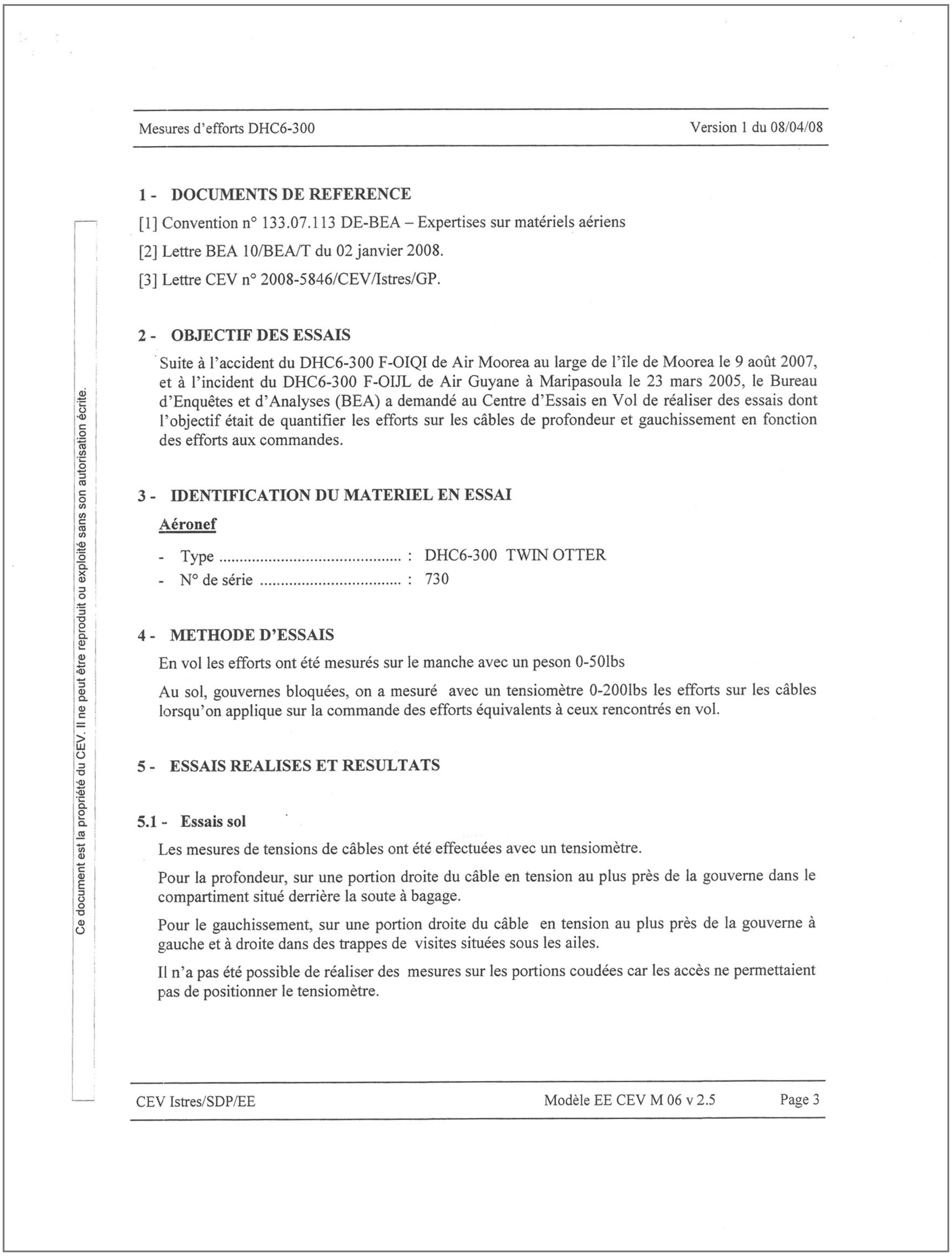

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1 - DOCUMENTS DE REFERENCE

[1] Convention n° 133.07.113 DE-BEA – Expertises sur matériels aériens

[2] Lettre BEA 10/BEA/T du 02 janvier 2008.

[3] Lettre CEV n° 2008-5846/CEV/Istres/GP.

2 - OBJECTIF DES ESSAIS

Suite à l'accident du DHC6-300 F-OIQI de Air Moorea au large de l'île de Moorea le 9 août 2007, et à l'incident du DHC6-300 F-OIJL de Air Guyane à Maripasoula le 23 mars 2005, le Bureau d'Enquêtes et d'Analyses (BEA) a demandé au Centre d'Essais en Vol de réaliser des essais dont l'objectif était de quantifier les efforts sur les câbles de profondeur et gauchissement en fonction des efforts aux commandes.

3 - IDENTIFICATION DU MATERIEL EN ESSAI

Aéronef

- Type .... : DHC6-300 TWIN OTTER
- N° de série .... : 730

4 - METHODE D'ESSAIS

En vol les efforts ont été mesurés sur le manche avec un peson 0-50lbs

Au sol, gouvernes bloquées, on a mesuré avec un tensiomètre 0-200lbs les efforts sur les câbles lorsqu'on applique sur la commande des efforts équivalents à ceux rencontrés en vol.

5 - ESSAIS REALISES ET RESULTATS

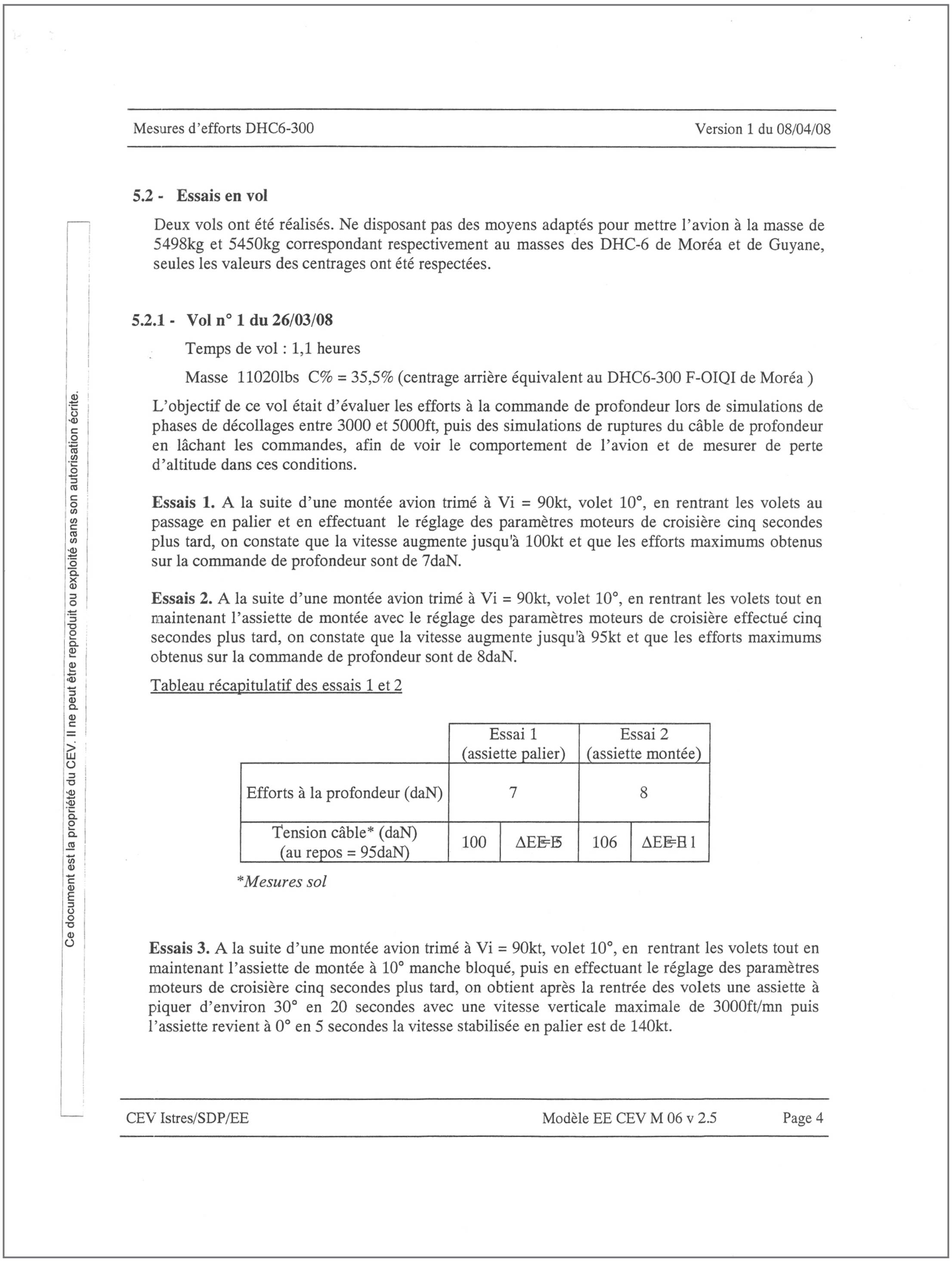
5.1 - Essais sol

Les mesures de tensions de câbles ont été effectuées avec un tensiomètre.

Pour la profondeur, sur une portion droite du câble en tension au plus près de la gouverne dans le compartiment situé derrière la soute à bagage.

Pour le gauchissement, sur une portion droite du câble en tension au plus près de la gouverne à gauche et à droite dans des trappes de visites situées sous les ailes.

Il n'a pas été possible de réaliser des mesures sur les portions coudées car les accès ne permettaient pas de positionner le tensiomètre.



5.2 - Essais en vol

Deux vols ont été réalisés. Ne disposant pas des moyens adaptés pour mettre l'avion à la masse de 5498kg et 5450kg correspondant respectivement au masses des DHC-6 de Moréa et de Guyane, seules les valeurs des centrages ont été respectées.

5.2.1 - Vol n° 1 du 26/03/08

Temps de vol : 1,1 heures

Masse 11020lbs C% = 35,5% (centrage arrière équivalent au DHC6-300 F-OIQI de Moréa)

L'objectif de ce vol était d'évaluer les efforts à la commande de profondeur lors de simulations de phases de décollages entre 3000 et 5000ft, puis des simulations de ruptures du câble de profondeur en lâchant les commandes, afin de voir le comportement de l'avion et de mesurer de perte d'altitude dans ces conditions.

Essais 1. A la suite d'une montée avion trimé à Vi = 90kt, volet 10°, en rentrant les volets au passage en palier et en effectuant le réglage des paramètres moteurs de croisière cinq secondes plus tard, on constate que la vitesse augmente jusqu'à 100kt et que les efforts maximums obtenus sur la commande de profondeur sont de 7daN.

Essais 2. A la suite d'une montée avion trimé à Vi = 90kt, volet 10°, en rentrant les volets tout en maintenant l'assiette de montée avec le réglage des paramètres moteurs de croisière effectué cinq secondes plus tard, on constate que la vitesse augmente jusqu'à 95kt et que les efforts maximums obtenus sur la commande de profondeur sont de 8daN.

<u>Tableau récapitulatif des essais 1 et 2</u>

	Essai 1 (assiette palier)		Essai 2 (assiette montée)	
Efforts à la profondeur (daN)	7		8	
Tension câble* (daN) (au repos = 95daN)	100	ΔE=5	106	ΔE=11

**Mesures sol*

Essais 3. A la suite d'une montée avion trimé à Vi = 90kt, volet 10°, en rentrant les volets tout en maintenant l'assiette de montée à 10° manche bloqué, puis en effectuant le réglage des paramètres moteurs de croisière cinq secondes plus tard, on obtient après la rentrée des volets une assiette à piquer d'environ 30° en 20 secondes avec une vitesse verticale maximale de 3000ft/mn puis l'assiette revient à 0° en 5 secondes la vitesse stabilisée en palier est de 140kt.

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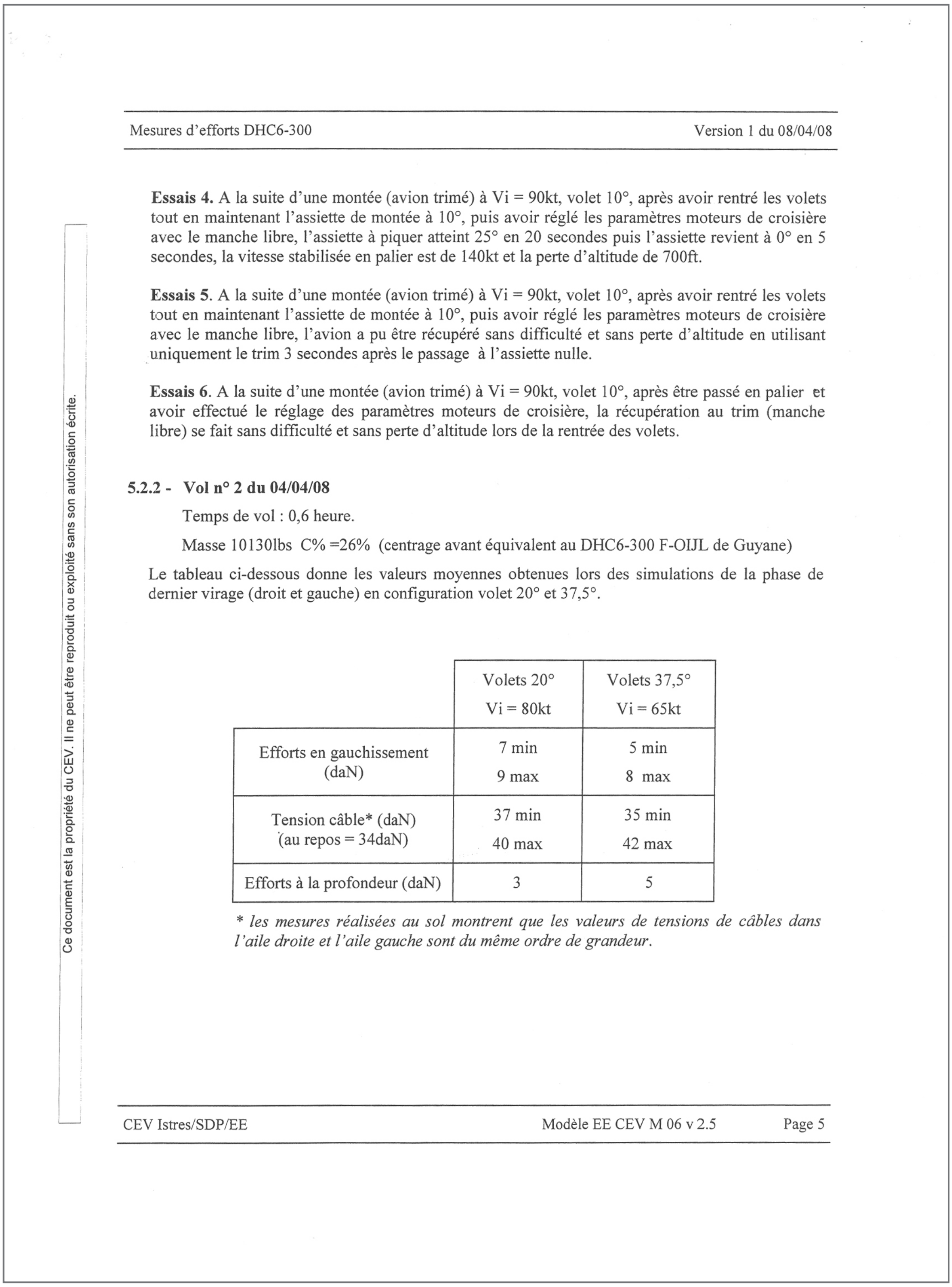

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Essais 4. A la suite d'une montée (avion trimé) à Vi = 90kt, volet 10°, après avoir rentré les volets tout en maintenant l'assiette de montée à 10°, puis avoir réglé les paramètres moteurs de croisière avec le manche libre, l'assiette à piquer atteint 25° en 20 secondes puis l'assiette revient à 0° en 5 secondes, la vitesse stabilisée en palier est de 140kt et la perte d'altitude de 700ft.

Essais 5. A la suite d'une montée (avion trimé) à Vi = 90kt, volet 10°, après avoir rentré les volets tout en maintenant l'assiette de montée à 10°, puis avoir réglé les paramètres moteurs de croisière avec le manche libre, l'avion a pu être récupéré sans difficulté et sans perte d'altitude en utilisant uniquement le trim 3 secondes après le passage à l'assiette nulle.

Essais 6. A la suite d'une montée (avion trimé) à Vi = 90kt, volet 10°, après être passé en palier et avoir effectué le réglage des paramètres moteurs de croisière, la récupération au trim (manche libre) se fait sans difficulté et sans perte d'altitude lors de la rentrée des volets.

5.2.2 - Vol n° 2 du 04/04/08

Temps de vol : 0,6 heure.

Masse 10130lbs C% =26% (centrage avant équivalent au DHC6-300 F-OIJL de Guyane)

Le tableau ci-dessous donne les valeurs moyennes obtenues lors des simulations de la phase de dernier virage (droit et gauche) en configuration volet 20° et 37,5°.

	Volets 20° Vi = 80kt	Volets 37,5° Vi = 65kt
Efforts en gauchissement (daN)	7 min 9 max	5 min 8 max
Tension câble* (daN) (au repos = 34daN)	37 min 40 max	35 min 42 max
Efforts à la profondeur (daN)	3	5

** les mesures réalisées au sol montrent que les valeurs de tensions de câbles dans l'aile droite et l'aile gauche sont du même ordre de grandeur.*

6 - CONCLUSIONS

A la demande du Bureau d'Enquête et d'Analyse (BEA), le Centre d'Essais en Vol (CEV) a réalisé, suite aux accidents des DHC6-300 de Moréa et de Guyane, des essais dont l'objectif était d'évaluer les efforts aux commandes de profondeur et gauchissement et sur les câbles des commandes respectifs, ainsi que les conséquences d'une rupture du câble de la profondeur et de la capacité de pilotage au trim de profondeur dans ces conditions.

Lors les différents essais réalisés, les efforts maximaux atteints ont été de 8daN à la commande profondeur entraînant une augmentation de la tension de câble de la commande de profondeur de 11daN lors des essais en vol rectiligne et de 8daN à la commande de gauchissement entraînant une augmentation de la tension de câble de la commande de gauchissement de 8daN au cours des essais de simulation de dernier virage en configuration volets 37.5° .

Les simulations de la rupture du câble de profondeur en phase de montée après décollage ont permis de montrer que la perte d'altitude avant que l'avion ne se remette de lui-même en palier est de 700ft, la vitesse indiquée atteinte est alors de 140kt.

Dans les mêmes conditions, si l'avion est contré au trim, la perte d'altitude est quasiment nulle. Dans les conditions de l'essai, cette manœuvre ne pose pas de difficulté particulière.

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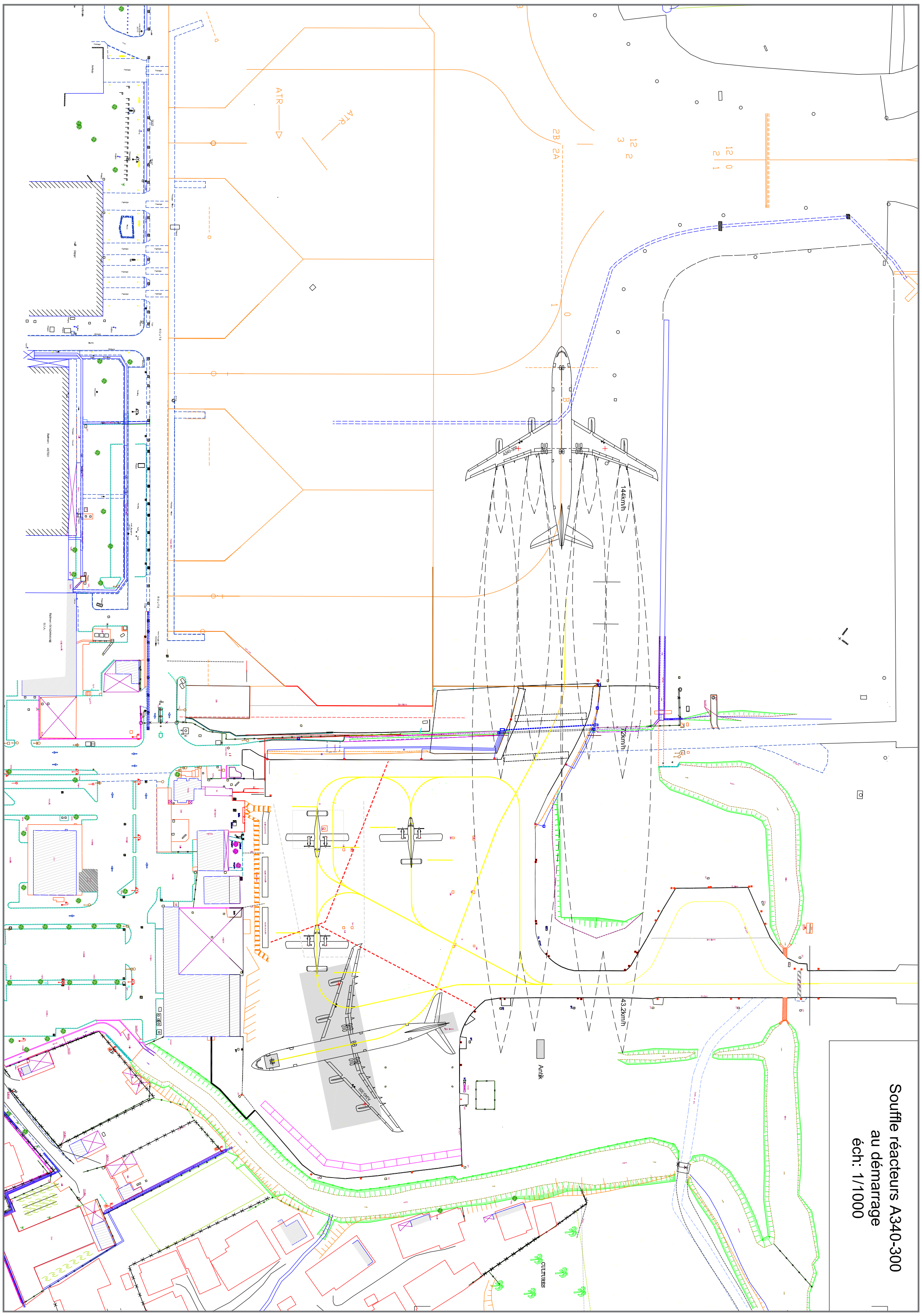
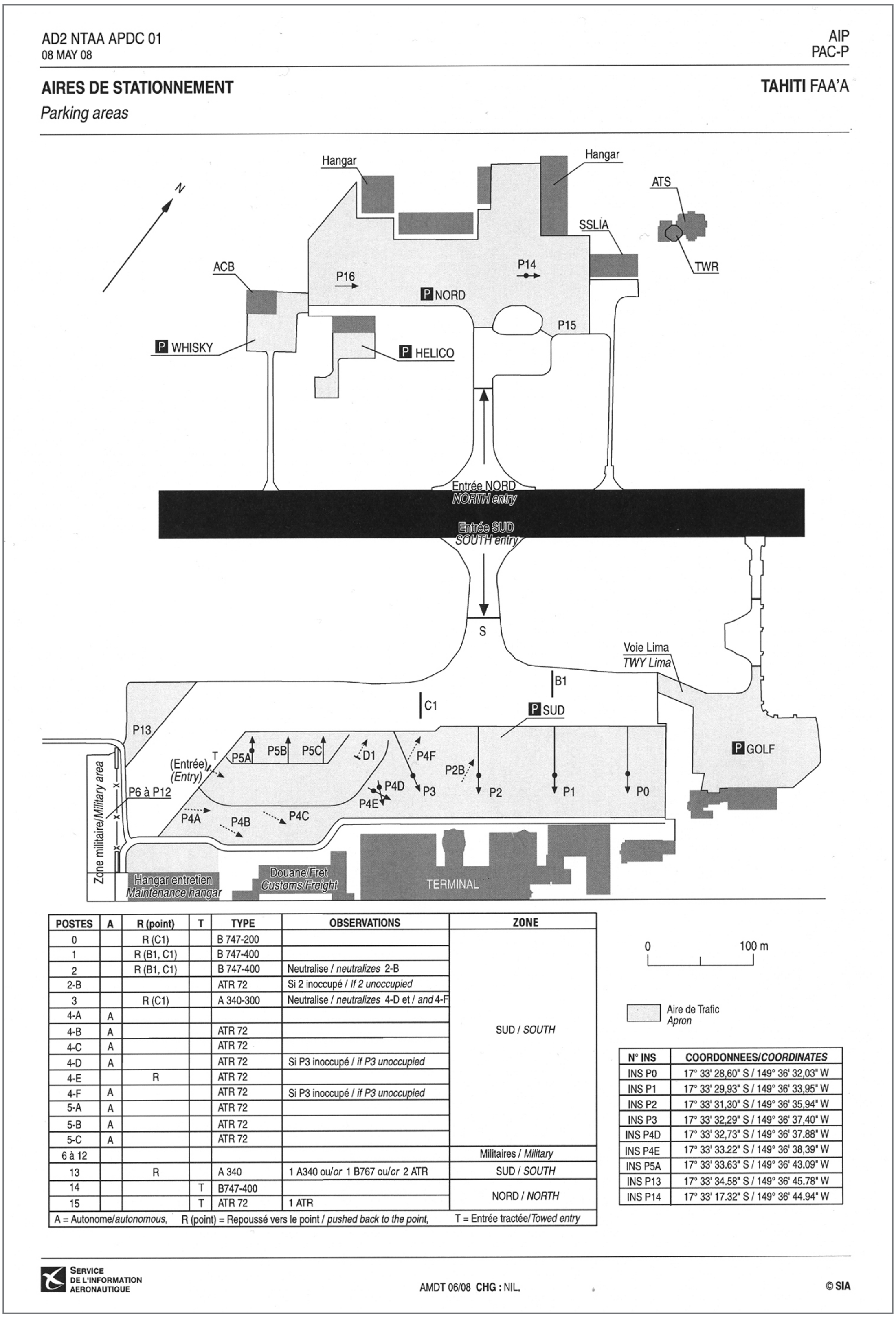
Appendix 7

DHC6 parking areas





AD2 NTAA APDC 01
08 MAY 08

AIP
PAC-P

AIRES DE STATIONNEMENT
Parking areas

TAHITI FAA'A

POSTES	A	R (point)	T	TYPE	OBSERVATIONS	ZONE
0		R (C1)		B 747-200		SUD / *SOUTH*
1		R (B1, C1)		B 747-400		
2		R (B1, C1)		B 747-400	Neutralise / *neutralizes* 2-B	
2-B				ATR 72	Si 2 inoccupé / *If 2 unoccupied*	
3		R (C1)		A 340-300	Neutralise / *neutralizes* 4-D et / *and* 4-F	
4-A	A					
4-B	A			ATR 72		
4-C	A			ATR 72		
4-D	A			ATR 72	Si P3 inoccupé / *if P3 unoccupied*	
4-E		R		ATR 72		
4-F	A			ATR 72	Si P3 inoccupé / *if P3 unoccupied*	
5-A	A			ATR 72		
5-B	A			ATR 72		
5-C	A			ATR 72		
6 à 12						Militaires / *Military*
13		R		A 340	1 A340 ou/*or* 1 B767 ou/*or* 2 ATR	SUD / *SOUTH*
14			T	B747-400		NORD / *NORTH*
15			T	ATR 72	1 ATR	

A = Autonome/*autonomous*, R (point) = Repoussé vers le point / *pushed back to the point*, T = Entrée tractée/*Towed entry*

▨ Aire de Trafic
Apron

N° INS	COORDONNEES/*COORDINATES*
INS P0	17° 33' 28,60" S / 149° 36' 32,03" W
INS P1	17° 33' 29,93" S / 149° 36' 33,95" W
INS P2	17° 33' 31,30" S / 149° 36' 35,94" W
INS P3	17° 33' 32,29" S / 149° 36' 37,40" W
INS P4D	17° 33' 32,73" S / 149° 36' 37.88" W
INS P4E	17° 33' 33.22" S / 149° 36' 38,39" W
INS P5A	17° 33' 33.63" S / 149° 36' 43.09" W
INS P13	17° 33' 34.58" S / 149° 36' 45.78" W
INS P14	17° 33' 17.32" S / 149° 36' 44.94" W

SERVICE
DE L'INFORMATION
AERONAUTIQUE

AMDT 06/08 **CHG :** NIL.

© SIA

Appendix 8

Incident on 17 August 2005

to the SAAB 2000 registered F-GMVD,
operated by Régional,
at Marseille Airport

1. History of Flight

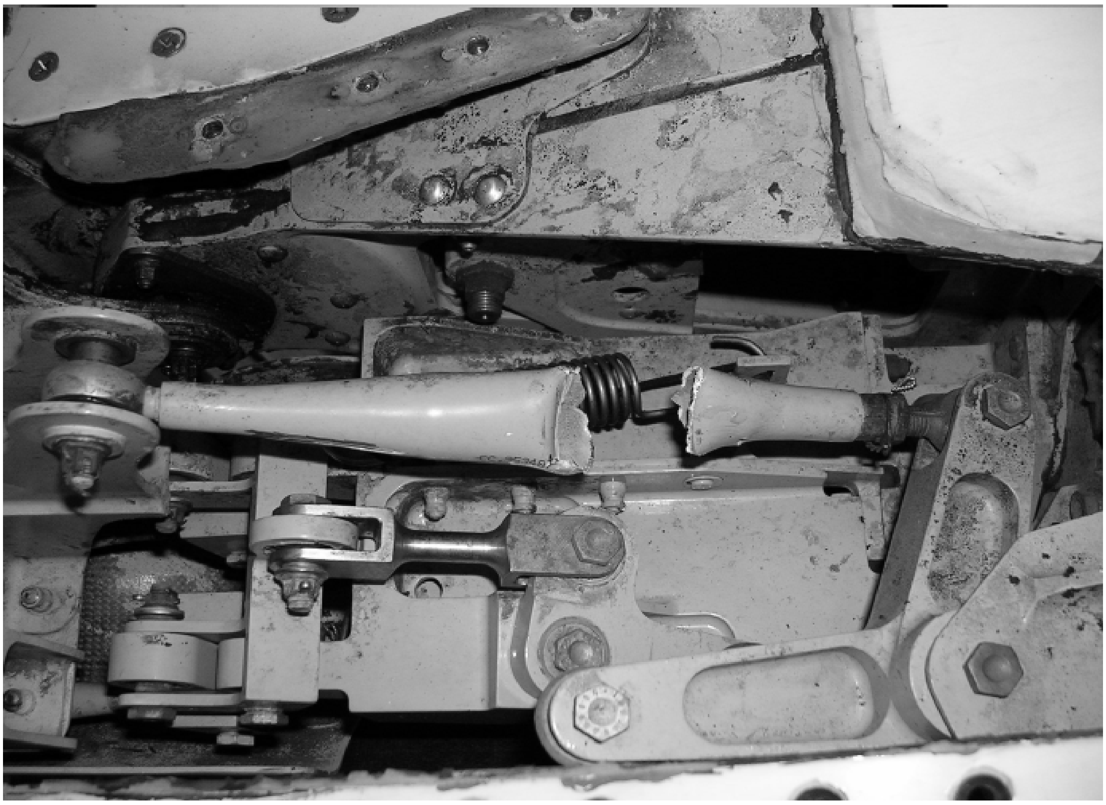
The crew left the aeroplane at around 19 h 45 at parking stand 25B after having locked the controls. The following day at around 12 h 00, they took it over again at the same stand. Nothing particular was noticed during the pre-flight check.

During takeoff from runway 14G with the co-pilot at the controls (PF), the latter noticed that he was unable to hold the plane in roll. The control column was at the right stop to try to maintain the wings level.

An EMERGENCY return was requested. The landing took place at high speed (170kt) as the crew could not keep the wings level at a lower speed. The impact was violent. The crew managed to control and stop the aeroplane on the runway.

2. Damage to the Aircraft

The right wing aileron pushrod was found broken as a result of bending.



3. Examinations of the Aileron Pushrod

No marks that could indicate an external mechanical load (impact) on the control surface was found.

The only existing mark was on the lower surface of the control surface. It was caused by the rear edge of the underside of the wing and showed the control surface reached a violent stop.

The conclusion of the examinations carried out at the aeroplane manufacturer was as follows:

“The ultimate compression load for this rod is 15.870 N which should correspond to airspeed of at least 65.1 m/s (126.5 kt) from the aft direction of the aircraft/aileron. A preliminary analysis of the failed rod has been performed indicating that the push rod has been subjected to high momentary loads with subsequent instant failure. This is based on comparison with earlier pushrods having failed during extreme winds/jet blasts from behind.”

The flight controls lock (gust-lock), that is required in the post-landing check-list, was in place. JAR25.679 states that the gust-lock must sustain 65 kt. The level of the load having been assessed at 126.5 kt, it can be considered that the flight controls were subject to a load that was four times the specified limit.

4. Research on Parameters

Régional performed an analysis of the recorded parameters on the whole of its fleet of Saab 2000. The research was oriented on the possible appearance of a value of aileron trim due to an abnormal position of the left aileron following bending of the pushrod.

This research did not reveal anything exceptional in relation to F-GMVD. The aileron trim curves for F-GMVD did not bring to light a new average trim value for the period from 8 May to 17 August 2005. In addition, the flight crew did not observe anything particular in relation to the aeroplane's flying performance during the flights on 16 August.

This all confirms that the bending of the pushrod occurred during the time the aeroplane was parked at Marseille-Provence before the flight of 17 August.

5. Meteorological Information

The general situation indicated an average wind of five knots between 17 h 50 on 16 August and 14 h 52 on 17 August and nothing exceeding twenty knots during the time of the stopover of F-GMVD. There were no storm conditions.

6. Research on Possible Jet Blast

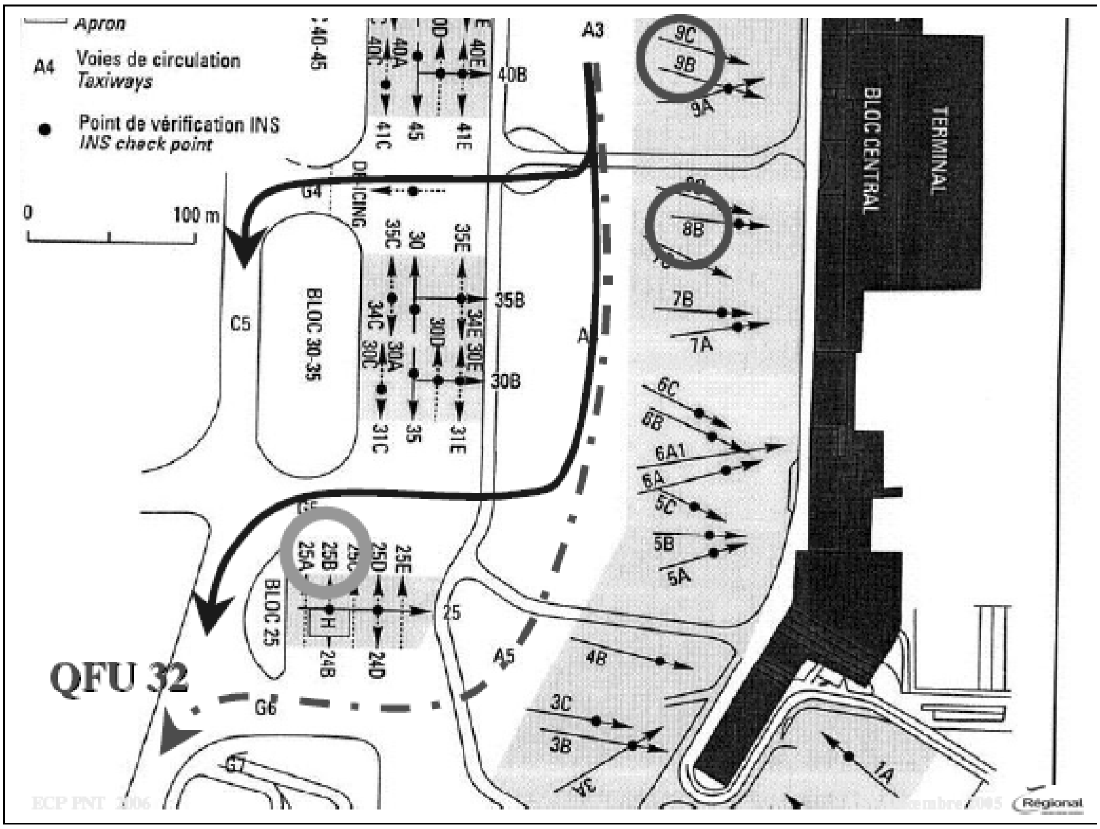
A mechanical impact or wind having been excluded, the only remaining possibility was that of jet blast.

In order to be able to establish a relation between the speed of a blast determined by the manufacturer and the reality of jet blast, an evaluation was made with the aid of technical documentation technique obtained from various operators.

The research was thus oriented on the possibility of jet blast reaching a value close to 126 kt near to F-GMVD.

This value cannot normally occur during taxiing of an aeroplane, so it was necessary to suppose that some engine thrust had occurred beyond the normal position of the thrust levers during the taxiing phase.

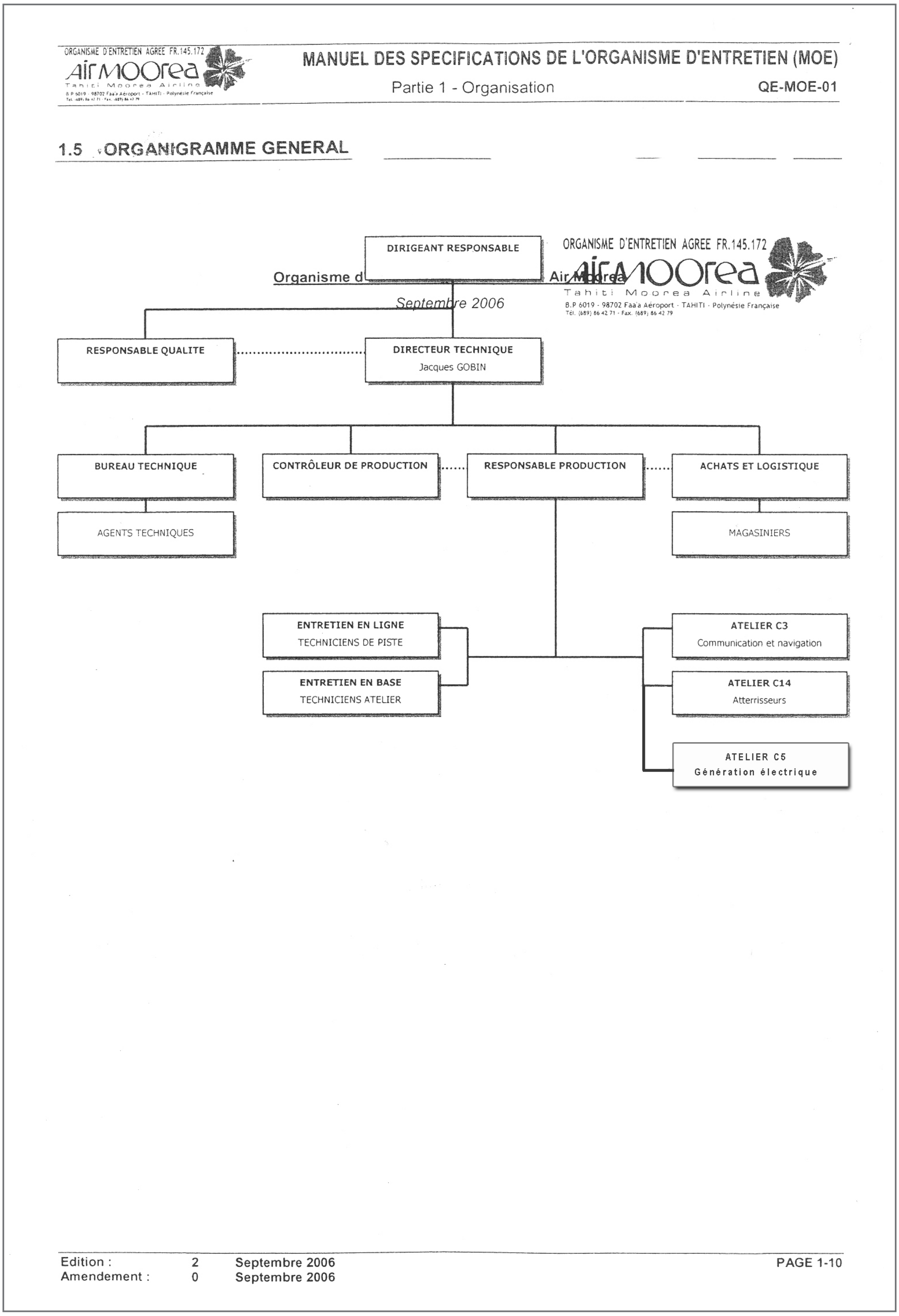
The ground movements of the aeroplanes were not recorded. Taxiways G4 and G5 are usually used to access taxiway C (Appendix 3). It cannot, however, be excluded that taxiway G6 was used by choice or by mistake. In that case, the turn from G6 to C6 might require increased thrust.



For information, a similar case of the failure of an aileron control was recorded in 1998 on a Saab 2000 belonging to Crossair at Marseille. It was identified thanks to the testimony of Régional station maintenance technician. He had been asked by technicians from Crossair to work on one of their Saab 2000's that had been subjected to jet blast from a B737. The jet blast having been noticed, the flight was cancelled.

The probable cause of the incident was jet blast from a B777 taxiing while F-GMVD was parked.

Organisation chart and personnel of maintenance organisation



ORGANISME D'ENTRETIEN AGREE FR.145.172
AirMoorea
Tahiti Moorea Airline
B.P 6019 · 98702 Faa'a Aéroport · TAHITI · Polynésie Française
Tél. (689) 86 42 71 · Fax. (689) 86 42 79

MANUEL DES SPECIFICATIONS DE L'ORGANISME D'ENTRETIEN (MOE)

Partie 1 - Organisation

QE-MOE-01

1.5 ORGANIGRAMME GENERAL

Organisme d Air Moorea
Septembre 2006

ORGANISME D'ENTRETIEN AGREE FR.145.172
AirMoorea
Tahiti Moorea Airline
B.P 6019 · 98702 Faa'a Aéroport · TAHITI · Polynésie Française
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DIRIGEANT RESPONSABLE

RESPONSABLE QUALITE

DIRECTEUR TECHNIQUE
Jacques GOBIN

BUREAU TECHNIQUE
AGENTS TECHNIQUES

CONTRÔLEUR DE PRODUCTION

RESPONSABLE PRODUCTION

ACHATS ET LOGISTIQUE
MAGASINIERS

ENTRETIEN EN LIGNE
TECHNICIENS DE PISTE

ENTRETIEN EN BASE
TECHNICIENS ATELIER

ATELIER C3
Communication et navigation

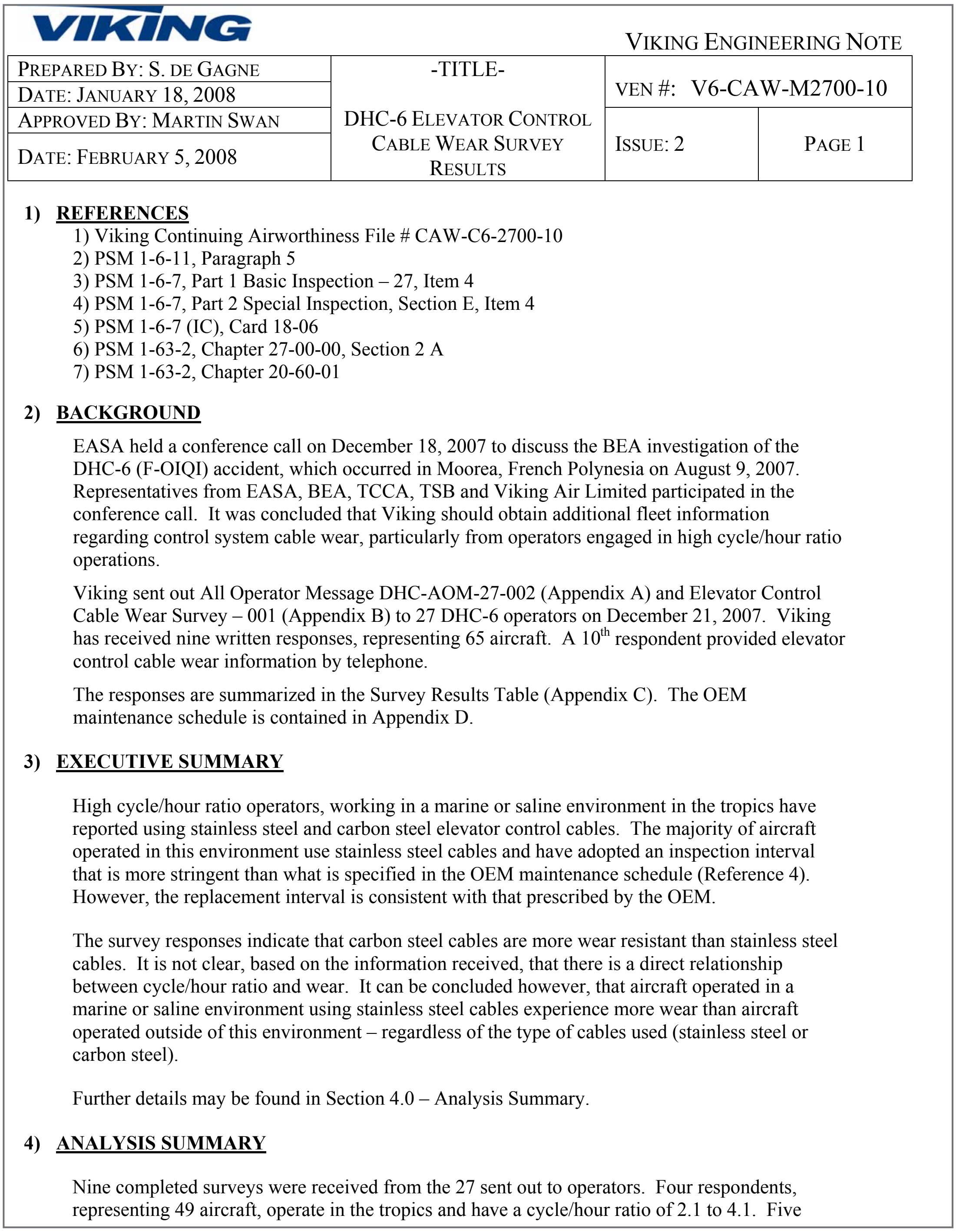
ATELIER C14
Atterrisseurs

ATELIER C5
Génération électrique

Edition :	2	Septembre 2006	PAGE 1-10
Amendement :	0	Septembre 2006	

Appendix 10

Procedure for inspecting cables



Viking Engineering Note

Prepared By: S. de Gagne	-TITLE-	VEN #: V6-CAW-M2700-10	
Date: January 18, 2008			
Approved By: Martin Swan	DHC-6 Elevator Control Cable Wear Survey Results	Issue: 2	Page 1
Date: February 5, 2008			

1) REFERENCES

1) Viking Continuing Airworthiness File # CAW-C6-2700-10
2) PSM 1-6-11, Paragraph 5
3) PSM 1-6-7, Part 1 Basic Inspection – 27, Item 4
4) PSM 1-6-7, Part 2 Special Inspection, Section E, Item 4
5) PSM 1-6-7 (IC), Card 18-06
6) PSM 1-63-2, Chapter 27-00-00, Section 2 A
7) PSM 1-63-2, Chapter 20-60-01

2) BACKGROUND

EASA held a conference call on December 18, 2007 to discuss the BEA investigation of the DHC-6 (F-OIQI) accident, which occurred in Moorea, French Polynesia on August 9, 2007. Representatives from EASA, BEA, TCCA, TSB and Viking Air Limited participated in the conference call. It was concluded that Viking should obtain additional fleet information regarding control system cable wear, particularly from operators engaged in high cycle/hour ratio operations.

Viking sent out All Operator Message DHC-AOM-27-002 (Appendix A) and Elevator Control Cable Wear Survey – 001 (Appendix B) to 27 DHC-6 operators on December 21, 2007. Viking has received nine written responses, representing 65 aircraft. A 10th respondent provided elevator control cable wear information by telephone.

The responses are summarized in the Survey Results Table (Appendix C). The OEM maintenance schedule is contained in Appendix D.

3) EXECUTIVE SUMMARY

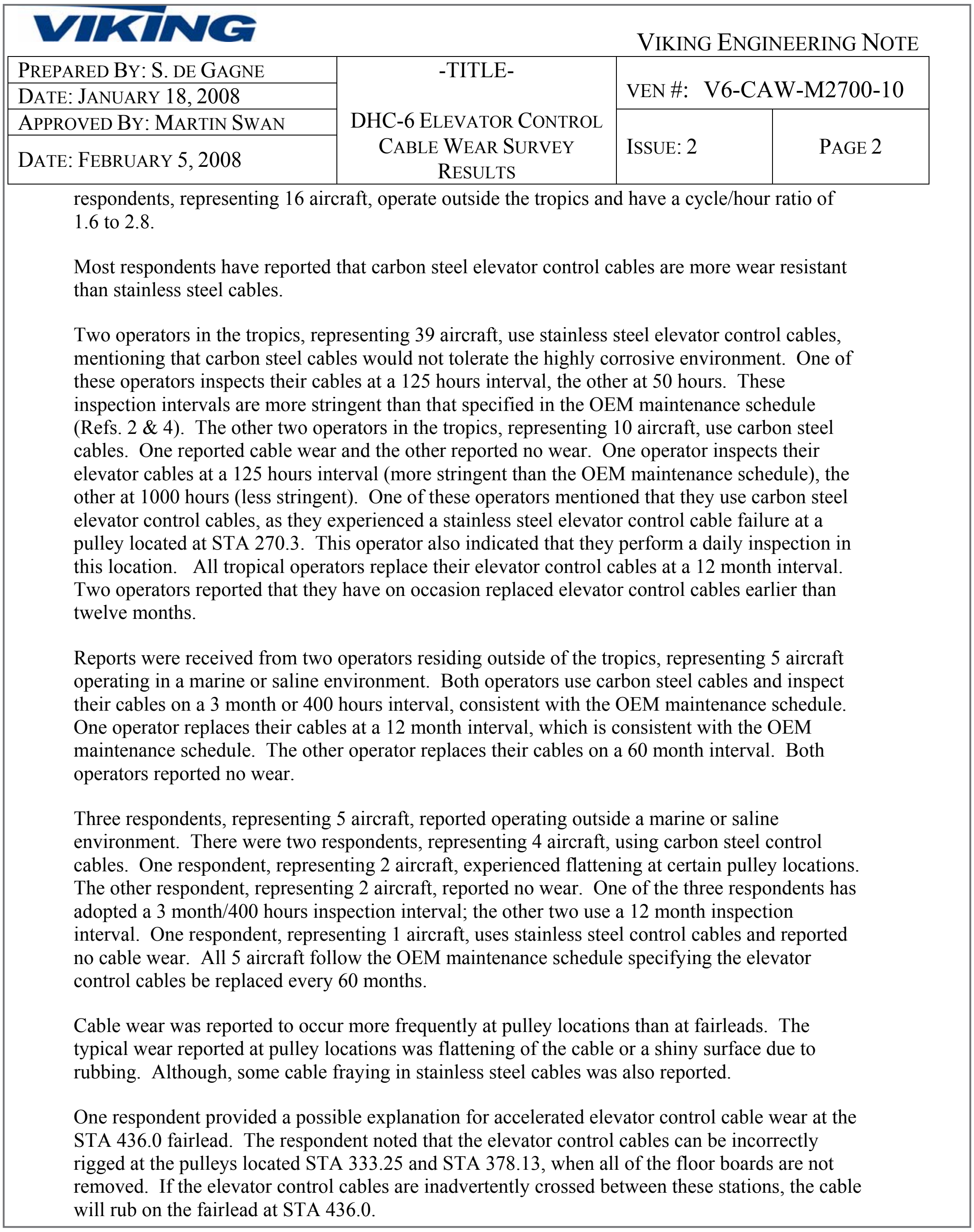
High cycle/hour ratio operators, working in a marine or saline environment in the tropics have reported using stainless steel and carbon steel elevator control cables. The majority of aircraft operated in this environment use stainless steel cables and have adopted an inspection interval that is more stringent than what is specified in the OEM maintenance schedule (Reference 4). However, the replacement interval is consistent with that prescribed by the OEM.

The survey responses indicate that carbon steel cables are more wear resistant than stainless steel cables. It is not clear, based on the information received, that there is a direct relationship between cycle/hour ratio and wear. It can be concluded however, that aircraft operated in a marine or saline environment using stainless steel cables experience more wear than aircraft operated outside of this environment – regardless of the type of cables used (stainless steel or carbon steel).

Further details may be found in Section 4.0 – Analysis Summary.

4) ANALYSIS SUMMARY

Nine completed surveys were received from the 27 sent out to operators. Four respondents, representing 49 aircraft, operate in the tropics and have a cycle/hour ratio of 2.1 to 4.1. Five



VIKING ENGINEERING NOTE

PREPARED BY: S. DE GAGNE	-TITLE- DHC-6 ELEVATOR CONTROL CABLE WEAR SURVEY RESULTS	VEN #: V6-CAW-M2700-10	
DATE: JANUARY 18, 2008			
APPROVED BY: MARTIN SWAN		ISSUE: 2	PAGE 2
DATE: FEBRUARY 5, 2008			

respondents, representing 16 aircraft, operate outside the tropics and have a cycle/hour ratio of 1.6 to 2.8.

Most respondents have reported that carbon steel elevator control cables are more wear resistant than stainless steel cables.

Two operators in the tropics, representing 39 aircraft, use stainless steel elevator control cables, mentioning that carbon steel cables would not tolerate the highly corrosive environment. One of these operators inspects their cables at a 125 hours interval, the other at 50 hours. These inspection intervals are more stringent than that specified in the OEM maintenance schedule (Refs. 2 & 4). The other two operators in the tropics, representing 10 aircraft, use carbon steel cables. One reported cable wear and the other reported no wear. One operator inspects their elevator cables at a 125 hours interval (more stringent than the OEM maintenance schedule), the other at 1000 hours (less stringent). One of these operators mentioned that they use carbon steel elevator control cables, as they experienced a stainless steel elevator control cable failure at a pulley located at STA 270.3. This operator also indicated that they perform a daily inspection in this location. All tropical operators replace their elevator control cables at a 12 month interval. Two operators reported that they have on occasion replaced elevator control cables earlier than twelve months.

Reports were received from two operators residing outside of the tropics, representing 5 aircraft operating in a marine or saline environment. Both operators use carbon steel cables and inspect their cables on a 3 month or 400 hours interval, consistent with the OEM maintenance schedule. One operator replaces their cables at a 12 month interval, which is consistent with the OEM maintenance schedule. The other operator replaces their cables on a 60 month interval. Both operators reported no wear.

Three respondents, representing 5 aircraft, reported operating outside a marine or saline environment. There were two respondents, representing 4 aircraft, using carbon steel control cables. One respondent, representing 2 aircraft, experienced flattening at certain pulley locations. The other respondent, representing 2 aircraft, reported no wear. One of the three respondents has adopted a 3 month/400 hours inspection interval; the other two use a 12 month inspection interval. One respondent, representing 1 aircraft, uses stainless steel control cables and reported no cable wear. All 5 aircraft follow the OEM maintenance schedule specifying the elevator control cables be replaced every 60 months.

Cable wear was reported to occur more frequently at pulley locations than at fairleads. The typical wear reported at pulley locations was flattening of the cable or a shiny surface due to rubbing. Although, some cable fraying in stainless steel cables was also reported.

One respondent provided a possible explanation for accelerated elevator control cable wear at the STA 436.0 fairlead. The respondent noted that the elevator control cables can be incorrectly rigged at the pulleys located STA 333.25 and STA 378.13, when all of the floor boards are not removed. If the elevator control cables are inadvertently crossed between these stations, the cable will rub on the fairlead at STA 436.0.

5) SURVEY RESULTS - DISCUSSION

This Section presents the information reported by operators. For reference purposes, an elevator control system schematic is included at the end of this Section.

Viking Air Limited received survey results from nine operators, representing 65 aircraft. Out of this group, 60 aircraft are operating in a marine or saline environment. 48 aircraft operate strictly on floats, nine aircraft operate solely on wheels, and 3 aircraft operate on either wheels or floats.

OPERATIONS IN A MARINE OR SALINE ENVIRONMENT

Out of 60 aircraft operating in a marine or saline environment, 46 aircraft use stainless steel elevator control cables and 14 use carbon steel.

1. The users of stainless steel cables have the following comments:
   i. Carbon steel cables appear to be more wear resistant than stainless steel, but require more attention to corrosion proofing.
   ii. For aircraft operated in the tropics, some stainless steel elevator control cables required changing earlier than the 12 month interval specified in the operator’s maintenance program, due to wear such as fraying and flattening.
   iii. Other operators reported no instances of wear requiring early replacement elevator control cables.
   iv. Two operators reported that fairleads have been replaced due to wear.
   v. No operators reported changing cables due to corrosion.
2. The users of carbon steel cables have the following comments:
   i. No problems between inspections, cables are like new when replaced after 5 years.
   ii. We lost an aircraft that was equipped with stainless steel cables; we now use only carbon steel cables. Despite the marine environment, carbon steel cables last longer. Inspections at STA 267.0 are done daily.
   iii. Stainless steel cables are not as wear resistant as carbon steel cables; although wear is not a factor due to 12 month replacement time.
   iv. Some fairlead changes have been reported. One respondent reported fairleads being bent inadvertently by maintenance personnel.
   v. No cables have been changed due to corrosion.
   Note: One operator reported replacing cables at 8 months due to wear. Another respondent suggests that oxidation prevalent in a humid environment accelerates wear in the control cables at the pulleys located at STA 378.13.
   vi. Carbon steel cables are preferred by some operators for economic reasons; even in a saline environment. Stainless steel cables are more expensive (20% in some cases).

OPERATIONS OUTSIDE A MARINE OR SALINE ENVIRONMENT

Three respondents, representing 5 aircraft, were received involving aircraft being operated outside a marine or saline environment. Out of the 5 aircraft, 1 uses stainless steel elevator control cables and 4 use carbon steel cables.

1. The user of stainless steel elevator control cables reported the following:
    i. We change our cables every 60 months and inspect them every year. We have not experienced any pre-mature wear before replacement time.
    ii. No cables changed due to corrosion.
2. The users of carbon steel cables have the following comments:
    i. Cables are like new when replaced every 5 years.
    ii. Two respondents reported that fairleads are replaced as required.
    iii. No cables changed due to corrosion.

TYPE, LOCATION, AND POSSIBLE CAUSES FOR ELEVATOR CONTROL CABLE WEAR.

Elevator control cable wear has been reported at STA 270.3, STA 333.25, STA 378.13 and STA 436.0.

The reports indicate that the wear occurs most often at the pulleys located at STA 333.25 and STA 378.13. One operator indicated that they are replacing carbon steel cables every 8 months on average due to wear and broken strands only in the forward segment of the cables. This is consistent with the OEM maintenance schedule (1000 hour replacement interval), as the operator achieves 1500 hours per year (approx. 1000 hrs in 8 months).

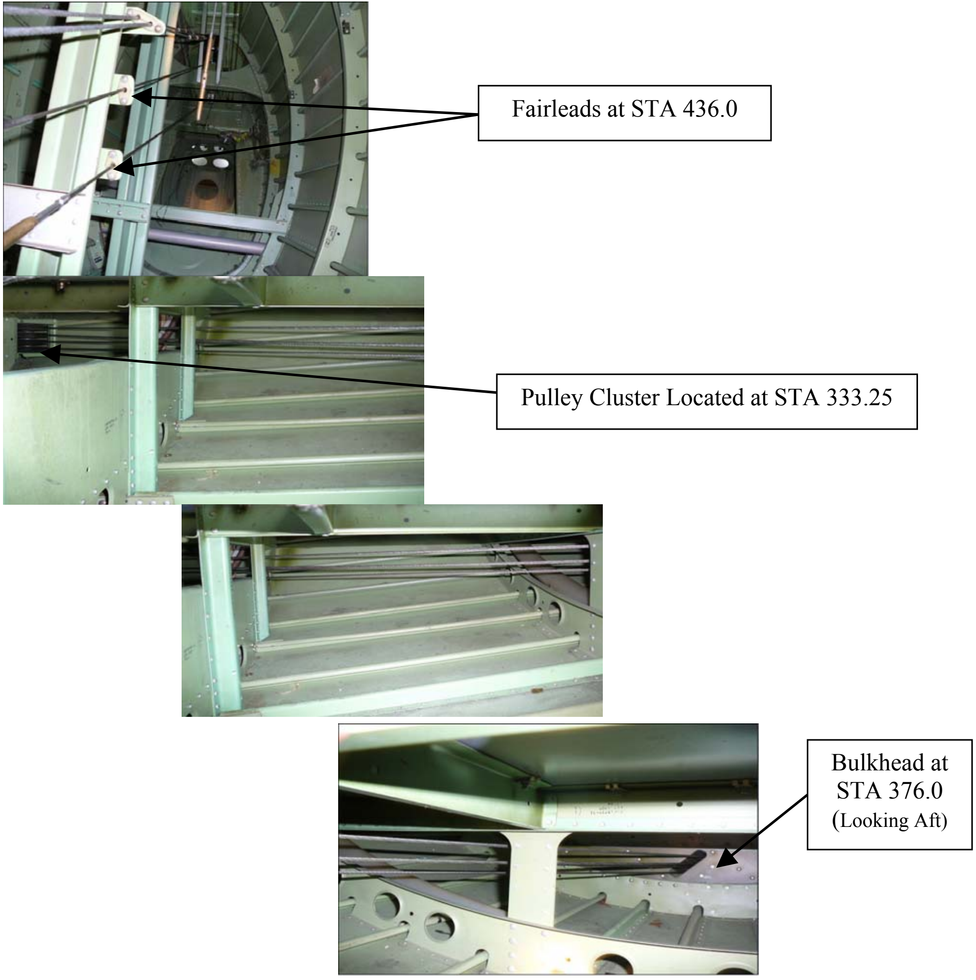
Other comments received are as follows:

1. Cause of cable wear (stainless steel) is mainly confined to routing at pulley locations only. Type of wear include: shiny (which is monitored within limits), fraying: (which constitute an immediate replacement – usually caught at 1-3 wires in one strand), flattening (which is cause for replacement – hardly ever detected).
2. The most likely explanation for excessive wear (stainless steel) at STA 436.0 fairlead is incorrect rigging; one needs to be careful that the cables coming off the pulleys at STA 333.25 line up with the pulleys at STA 378.13 – the floor boards need to be lifted up to ensure each cable is placed on the correct pulley. If the elevator control cables at STA 378.13 are installed on the wrong pulley, the cable will chafe on the fairlead at STA 436.0.

VIKING

VIKING ENGINEERING NOTE

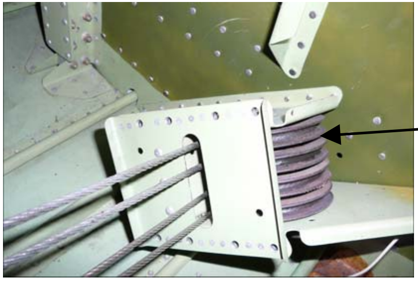
PREPARED BY: S. DE GAGNE DATE: JANUARY 18, 2008	-TITLE- DHC-6 ELEVATOR CONTROL CABLE WEAR SURVEY RESULTS	VEN #: V6-CAW-M2700-10	
APPROVED BY: MARTIN SWAN DATE: FEBRUARY 5, 2008		ISSUE: 2	PAGE 5



Fairleads at STA 436.0

Pulley Cluster Located at STA 333.25

Bulkhead at STA 376.0 (Looking Aft)



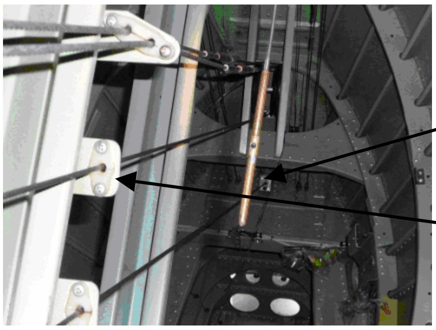
Pulley cluster located at STA 378.13

3. Any aircraft that is operated in a hot humid climate has accelerated wear (carbon steel) at the pulley at STA 378.13. This is due to condensation running down the cables and then collecting at the pulleys. The condensation causes oxidation on the control cables. The control cables transit back and forth through the pulleys during normal flight operations. The pulleys wear off the oxide, leaving a bare surface. This allows another layer of oxide to form, creating a cycle that accelerates cable wear.

4. Experience has indicated that it is beneficial to tension cables to the low end of the range in the rigging specifications (less wear).

5. Replacement interval on cables is sufficiently short to detect cable damage before failure.

6. The fairlead at STA 486.34 if not relocated as per TAB 646/9 has been found to show signs of wear or found worn out and the elevator cable rubbing on P/N C6FS1714-3 (MOD 6/1458).



Fairlead at STA 486.34

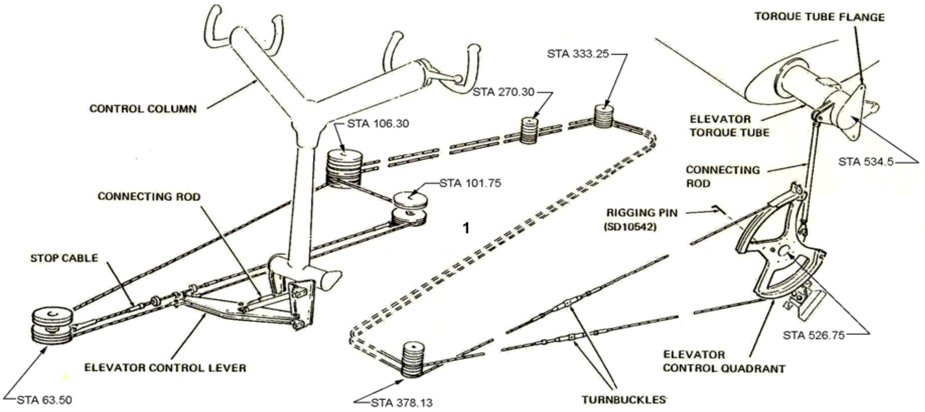
Fairlead at STA 436.0

7. It was noted during a CPCP program inspection that in the aft empennage area there was some minor wear on some ribs and at feed through holes. This may be cause by a low tension on the elevator cables.

8. We have removed cables (carbon steel) that have discoloring and loss of flexibility from fuselages received from other areas of the world. We are unsure as to the source of the cable

or what factors may have led to this condition. These aircraft were removed from service long before being shipped for repair.

DHC-6 ELEVATOR CONTROL SYSTEM - SCHEMATIC

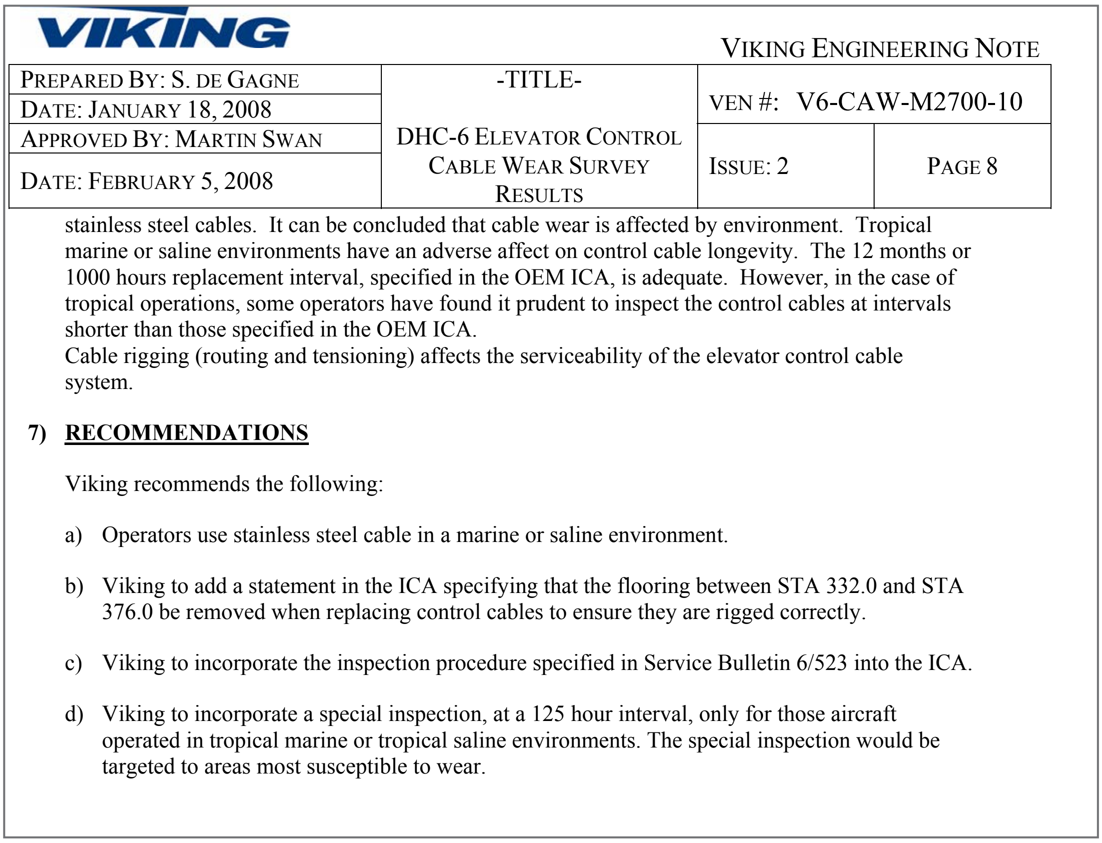


ELEVATOR CONTROL SYSTEM - PART NUMBERS

LOCATION	CARBON STEEL	STAINLESS STEEL
Elevator lever stop cable	C6CF1100-11	E.O. 69053-5
Front of elevator lever to station 426.75	C6CF1146-1	E.O. 69053-1
Rear of elevator lever to station 426.75	C6CF1147-1	E.O. 69053-2
Upper cable, station 426.75 to elevator quadrant	C6CF1150-1	E.O. 69053-3
Lower cable, station 426.75 to elevator quadrant	C6CF1151-1	E.O. 69053-4

6) CONCLUSION

Viking has concluded that an unsafe condition does not exist in the DHC-6 elevator cable controls. Some respondents indicated that carbon steel elevator control cables are more wear resistant than



stainless steel cables. It can be concluded that cable wear is affected by environment. Tropical marine or saline environments have an adverse affect on control cable longevity. The 12 months or 1000 hours replacement interval, specified in the OEM ICA, is adequate. However, in the case of tropical operations, some operators have found it prudent to inspect the control cables at intervals shorter than those specified in the OEM ICA.
Cable rigging (routing and tensioning) affects the serviceability of the elevator control cable system.

7) RECOMMENDATIONS

Viking recommends the following:

a) Operators use stainless steel cable in a marine or saline environment.

b) Viking to add a statement in the ICA specifying that the flooring between STA 332.0 and STA 376.0 be removed when replacing control cables to ensure they are rigged correctly.

c) Viking to incorporate the inspection procedure specified in Service Bulletin 6/523 into the ICA.

d) Viking to incorporate a special inspection, at a 125 hour interval, only for those aircraft operated in tropical marine or tropical saline environments. The special inspection would be targeted to areas most susceptible to wear.

VIKING ENGINEERING NOTE

PREPARED BY: S. DE GAGNE DATE: JANUARY 18, 2008 APPROVED BY: MARTIN SWAN DATE: FEBRUARY 5, 2008	-TITLE- DHC-6 ELEVATOR CONTROL CABLE WEAR SURVEY RESULTS	VEN #: V6-CAW-M2700-10 ISSUE: 2	PAGE 9

APPENDIX A
ALL OPERATOR MESSAGE DHC-AOM-27-002

ALL OPERATORS MESSAGE DHC-6-AOM-XX-XXX

TO: ALL HIGH CYCLE OPERATORS OF DHC-6 AIRCRAFT

ATTN: DIRECTOR/MANAGER OF:
PURCHASING
MAINTENANCE
ENGINEERING
QUALITY CONTROL
FLIGHT OPERATIONS

FROM: VIKING AIR LIMITED

DATE: 2/5/2008

SUBJECT: SURVEY TO GATHER INFORMATION REGARDING ELEVATOR CONTROL CABLE WEAR IN HIGH CYCLE OPERATIONS

BACKGROUND:

Viking Air Limited has been providing technical data to the Transport Safety Board, Transport Canada, EASA, and the French BEA pertaining to a DHC-6 Accident that occurred on August 9, 2007 in French Polynesia. As a result of the investigation, the French BEA has requested further information pertaining to aircraft service history; specifically elevator control cable wear information for cycle/hour ratio operations of 3:1 and higher.

PURPOSE:

The issuance of this AOM is to request service data from operators of aircraft with a cycle/hour ratio of 3:1 or greater via completion of the **Elevator Control Cable Wear survey - 001**.

REASON:

Collecting this data is critical to the ongoing investigation of the August 9th accident and in determining if further action or modification to the existing OEM maintenance schedule is warranted.

OPERATOR ACTION:

Please complete the attached Survey and return it to the contact provided on the following page. Any additional comments and feedback you may have should be included on a separate sheet attached to the survey. All responses will be held in confidence.

VIKING ENGINEERING NOTE

PREPARED BY: S. DE GAGNE	-TITLE- DHC-6 ELEVATOR CONTROL CABLE WEAR SURVEY RESULTS	VEN #: V6-CAW-M2700-10	
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APPROVED BY: MARTIN SWAN		ISSUE: 2	PAGE 10
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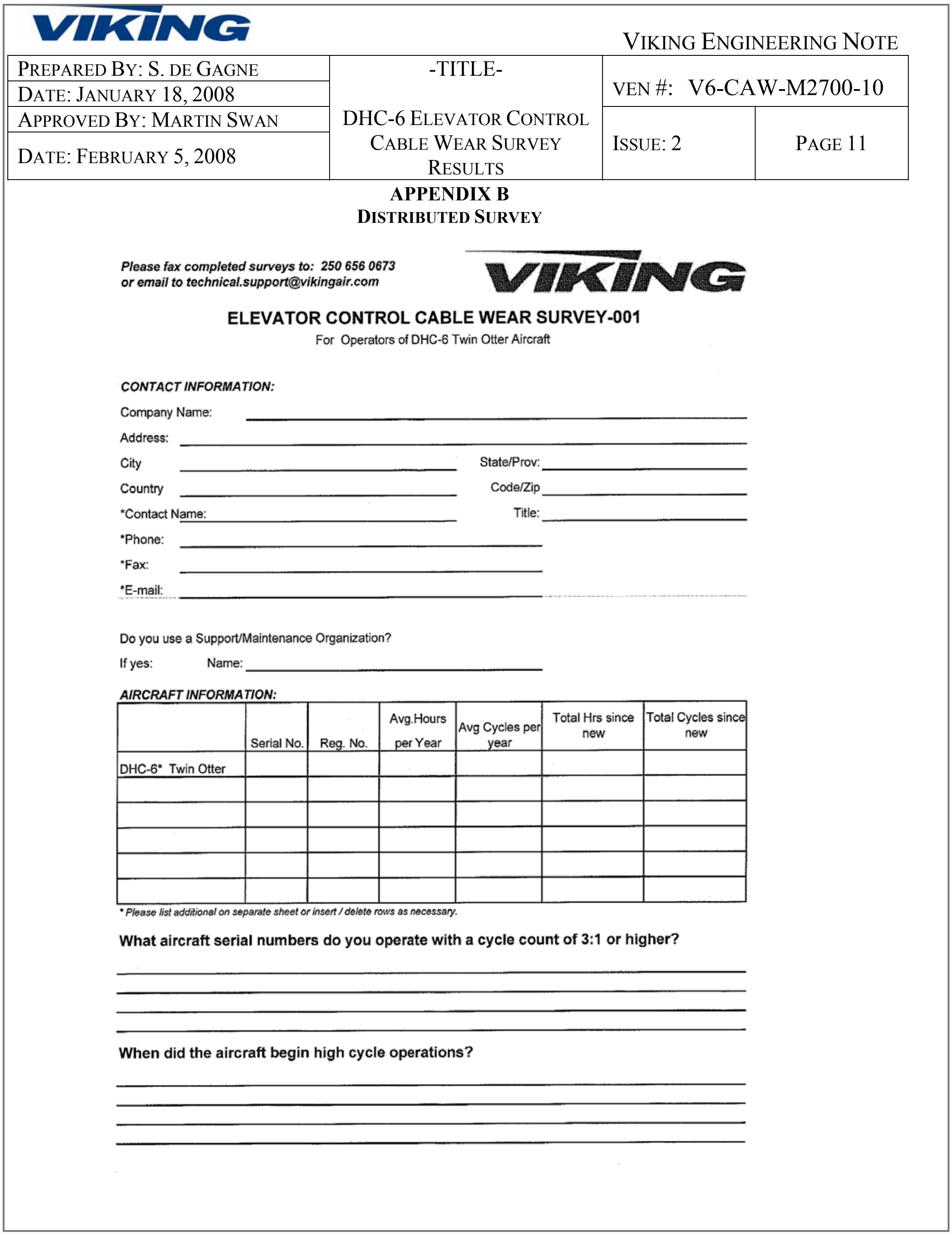
Please contact our Technical Support desk at:

Email: technical.support@vikingair.com
Fax: (250)-656-0673
Phone: (250)-656-7227
Toll Free: 1-800-663-8444

Your cooperation in this matter is greatly appreciated.

Yours truly,

George Gee
Product Support Manager



VIKING ENGINEERING NOTE

PREPARED BY: S. DE GAGNE	-TITLE- DHC-6 ELEVATOR CONTROL CABLE WEAR SURVEY RESULTS	VEN #: V6-CAW-M2700-10	
DATE: JANUARY 18, 2008			
APPROVED BY: MARTIN SWAN		ISSUE: 2	PAGE 11
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APPENDIX B
DISTRIBUTED SURVEY

Please fax completed surveys to: 250 656 0673
or email to technical.support@vikingair.com

ELEVATOR CONTROL CABLE WEAR SURVEY-001

For Operators of DHC-6 Twin Otter Aircraft

CONTACT INFORMATION:

Company Name:

Address:

City

State/Prov:

Country

Code/Zip

*Contact Name:

Title:

*Phone:

*Fax:

*E-mail:

Do you use a Support/Maintenance Organization?

If yes: Name:

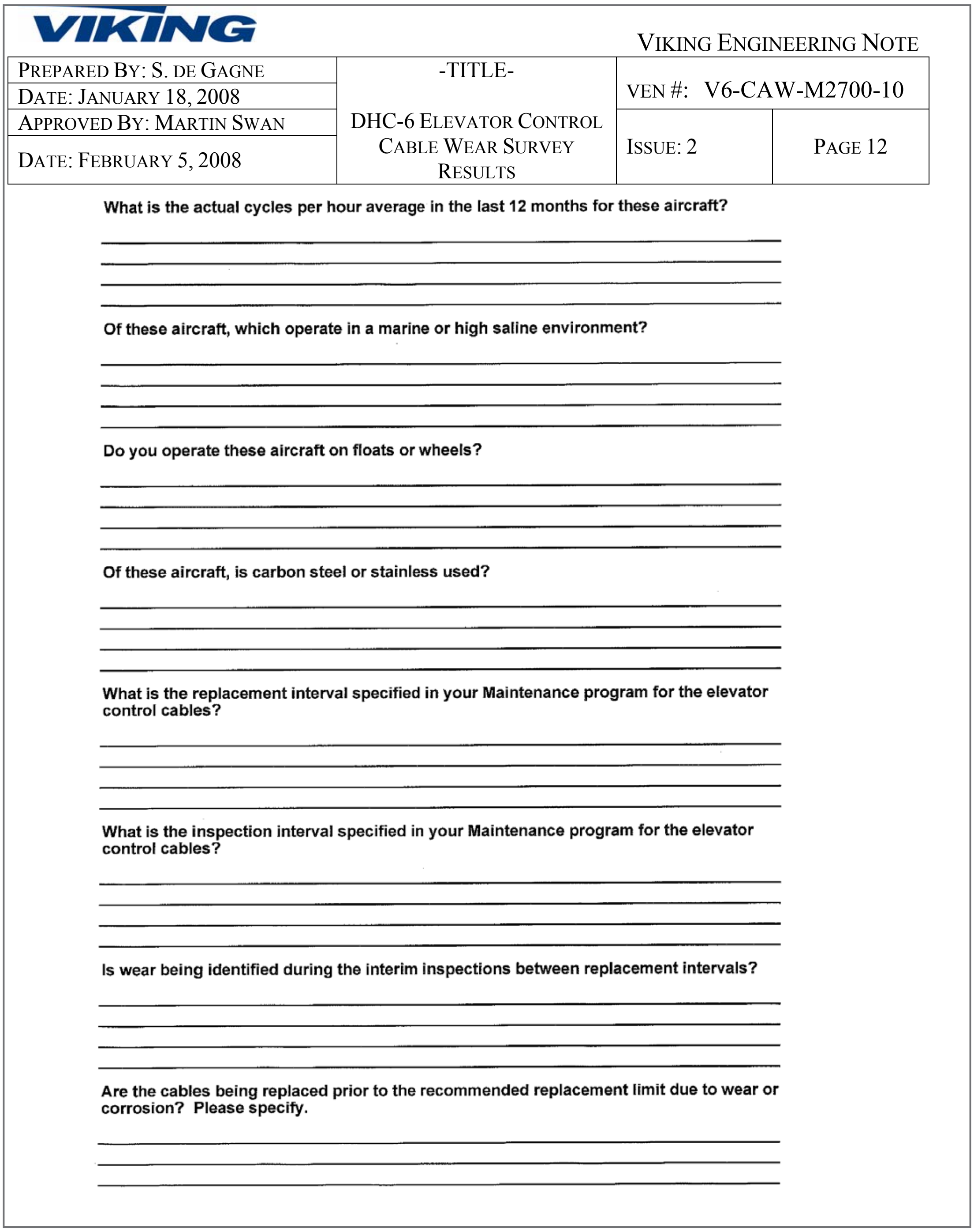
AIRCRAFT INFORMATION:

	Serial No.	Reg. No.	Avg.Hours per Year	Avg Cycles per year	Total Hrs since new	Total Cycles since new
DHC-6* Twin Otter						

** Please list additional on separate sheet or insert / delete rows as necessary.*

What aircraft serial numbers do you operate with a cycle count of 3:1 or higher?

When did the aircraft begin high cycle operations?



VIKING ENGINEERING NOTE

PREPARED BY: S. DE GAGNE DATE: JANUARY 18, 2008 APPROVED BY: MARTIN SWAN DATE: FEBRUARY 5, 2008	-TITLE- DHC-6 ELEVATOR CONTROL CABLE WEAR SURVEY RESULTS	VEN #: V6-CAW-M2700-10	
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What is the actual cycles per hour average in the last 12 months for these aircraft?

Of these aircraft, which operate in a marine or high saline environment?

Do you operate these aircraft on floats or wheels?

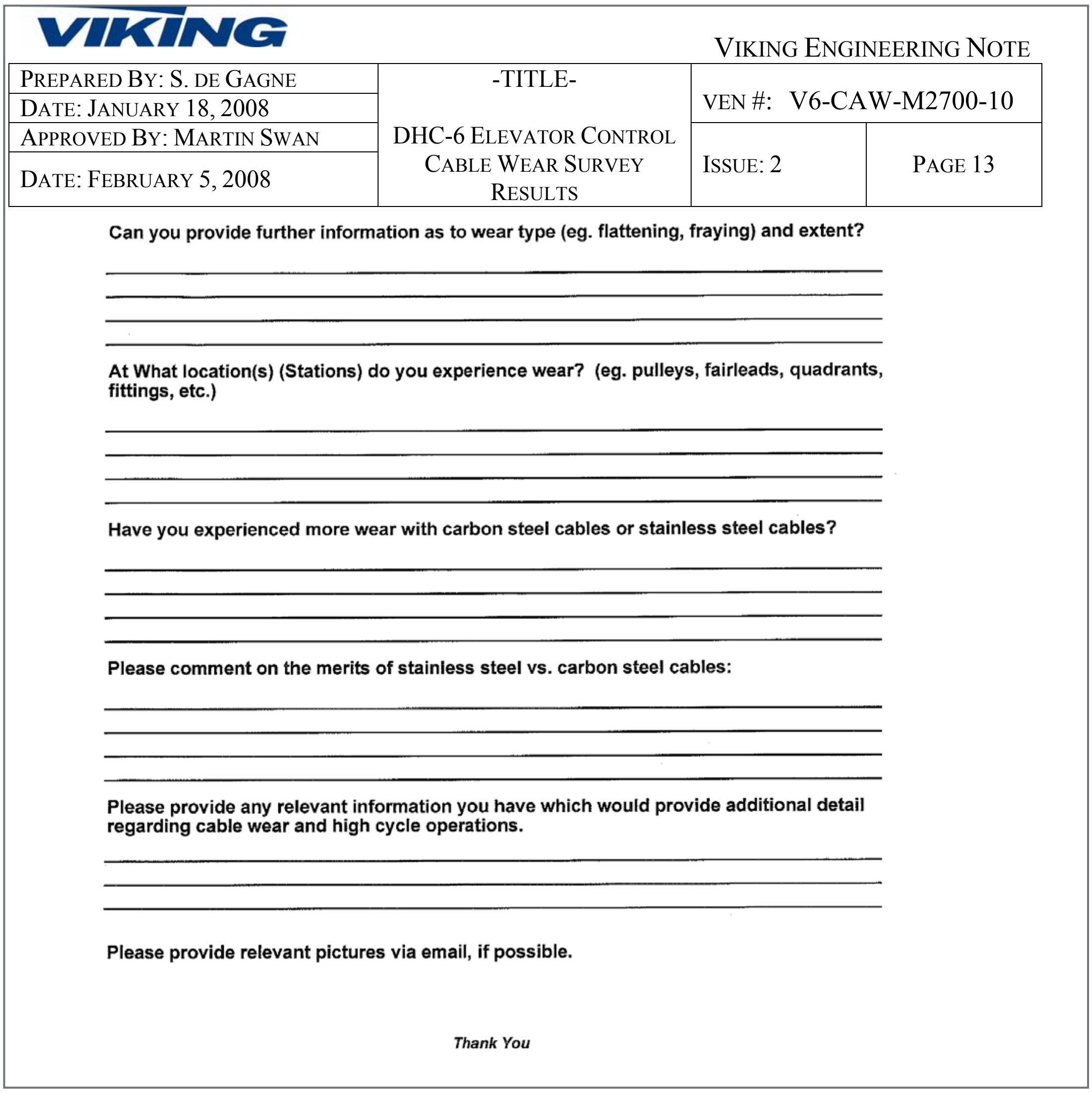
Of these aircraft, is carbon steel or stainless used?

What is the replacement interval specified in your Maintenance program for the elevator control cables?

What is the inspection interval specified in your Maintenance program for the elevator control cables?

Is wear being identified during the interim inspections between replacement intervals?

Are the cables being replaced prior to the recommended replacement limit due to wear or corrosion? Please specify.



VIKING

VIKING ENGINEERING NOTE

PREPARED BY: S. DE GAGNE	-TITLE- DHC-6 ELEVATOR CONTROL CABLE WEAR SURVEY RESULTS	VEN #: V6-CAW-M2700-10	
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Can you provide further information as to wear type (eg. flattening, fraying) and extent?

At What location(s) (Stations) do you experience wear? (eg. pulleys, fairleads, quadrants, fittings, etc.)

Have you experienced more wear with carbon steel cables or stainless steel cables?

Please comment on the merits of stainless steel vs. carbon steel cables:

Please provide any relevant information you have which would provide additional detail regarding cable wear and high cycle operations.

Please provide relevant pictures via email, if possible.

Thank You

VIKING

VIKING ENGINEERING NOTE

PREPARED BY: S. DE GAGNE	-TITLE-	VEN #: V6-CAW-M2700-10	
DATE: JANUARY 18, 2008	DHC-6 ELEVATOR CONTROL CABLE WEAR SURVEY RESULTS		
APPROVED BY: MARTIN SWAN		ISSUE: 2	PAGE 14
DATE: FEBRUARY 5, 2008			

APPENDIX C –
ELEVATOR CONTROL CABLE SURVEY RESULTS

																Mte Program Inspection Interval			General Comments on Cable wear						
	Tropics	Avg. Hours per Year	Avg. Cycles per Year	Total Hours (since new)	Total Cycles (since new)	Cycle/Hour ratio ≥ 3:1	# months operated in high Cycle/Hour ratio	Avg. Cycle/Hour in last 12 months	Operated in Marine or High Saline	Operated on Floats Only	Operated on Wheels Only	Both Floats & Wheels	Uses Carbon Steel Cables	Uses Stainless Steel Cables	Mte Program Replacement Interval (mths)	(mths)	(hrs)	Early Cable Replac. for wear / corros.	Wear found in interim inspect. between replac. intervals?	Type of wear (flattening, fraying)	Wear Locations STA.? (pulleys, quadrants, fittings)	Cable Wear at Fairlead or Fairlead Replacement	More Wear on SST or Carbon Steel Cables	Merits of SST over Carbon Steel Cables	Comments on other Factors affecting Cable Wear
1	0	860.0	1541	29754.9	45512	0	0	1.8	1	0	0	1	1	0	60	3	400	0	0	No Wear	N/A	1	No SST used	No SST used	Cables are like new when replaced every 5 yrs
2	0	1060.0	1781	32520.3	15468	0	0	1.7	1	0	0	1	1	0	60	3	400	0	0	No Wear	N/A	1	No SST used	No SST used	
3	0	667.7	1055	32451.3	11408	0	0	1.6	1	0	0	1	1	0	60	3	400	0	0	No Wear	N/A	1	No SST used	No SST used	
4	0	714.0	1064	23808	27204	0	0	1.5	0	0	1	0	1	0	60	3	400	0	0	No Wear	N/A	1	No SST used	No SST used	
5	0	70.4	133	19033.5	25198	0	0	1.9	0	0	1	0	1	0	60	3	400	0	0	No Wear	N/A	1	No SST used	No SST used	
6	0	755.0	1220	42661.26	86919	0	0	1.6	1	0	1	0	1	0	12	3	400	0	0	No Wear	N/A	0	No SST used	No SST used	No Further comments
7	0	710.0	1150	32039.4	67776	0	0	1.6	1	0	1	0	1	0	12	3	400	0	0	No Wear	N/A	0	No SST used	No SST used	
8	0	1000.0	2000	29511.6	47202	0	0	2.0	1	1	0	0	0	1	12	3	400	2	2	Flattening of outer Strands	STA 436.0	1	Carbon steel cables appear to be more wear resistant than stainless steel.	Carbon steel cables appear to be more wear resistant than stainless steel, but requires more attention to corrosion proofing. We replaced a complete set of carbon steel engine cables because we neglected to re apply corrosion proofing at the wing root pulleys after inspection.	The wearability of SST cables is in question. Faireads appear to suffer less from wear. Carbon steel cables appear to be more wear resistant than stainless steel. However, as the cables that we found worn were stainless, and all we use in that area is stainless, I cannot comment on whether the carbon steel would be better in that area.
9	0	1000.0	2000	29480.5	33213	0	0	2.0	1	1	0	0	0	1	12	3	400								
10	0	1000.0	2000	34824	56713	0	0	2.0	1	1	0	0	0	1	12	3	400								
11	0	1000.0	2000	26492.3	34861	0	0	2.0	1	1	0	0	0	1	12	3	400								
12	0	1000.0	2000	32586.8	56798	0	0	2.0	1	1	0	0	0	1	12	3	400								
13	0	1000.0	2000	40295.7	66547	0	0	2.0	1	1	0	0	0	1	12	3	400								
14	1	1500.0	3450	37417.8	45223	0	0	2.3	1	0	1	0	1	0	12	1	125	0	0	No Wear	N/A	0	No SST used	No SST used	Lost an A/C due to SST cable. Despite the marine environment, Carbon Steel Cables last longer. Inspection at sta. 267 are done daily. Replacing cables every 8 months on average due to wear and broken strands, but only in the forward segments.
15	1	1500.0	3450	38273.2	62602	0	0	2.3	1	0	1	0	1	0	12	1	125	0	0	No Wear	N/A	0	No SST used	No SST used	
16	1	1500.0	3450	28740.4	43910	0	0	2.3	1	0	1	0	1	0	12	1	125	0	0	No Wear	N/A	0	No SST used	No SST used	
17	1	1500.0	3450	25274.8	42415	0	0	2.3	1	0	1	0	1	0	12	1	125	0	0	No Wear	N/A	0	No SST used	No SST used	
18	1	1500.0	3450	45541.9	49684	0	0	2.3	1	0	1	0	1	0	12	1	125	0	0	No Wear	N/A	0	No SST used	No SST used	
19	1	1500.0	3450	31943	37661	0	0	2.3	1	0	1	0	1	0	12	1	125	0	0	No Wear	N/A	0	No SST used	No SST used	
20	1	1500.0	3450	19343.9	33068	0	0	2.3	1	0	1	0	1	0	12	1	125	0	0	No Wear	N/A	0	No SST used	No SST used	
21	1								1	0	1	0	0	1				1			STA 267	0	SST has so much easier wear than Carbon STL	SST great for extreme corrosion environment, but wear much faster	Stainless Steel Cable broke and A/C was a total lost
22	0	1100	3450	19912.4	62276	2.8	0	3.1	0	0	1	0	0	1	60	12		0	0	No Wear	N/A	0	Can't comment. We always use SST	Can't comment. We always use SST	We have not experienced any pre-mature wear before replacement

	Tropics	Avg. Hours per Year	Avg. Cycles per Year	Total Hours (since new)	Total Cycles (since new)	Cycle/Hour ratio ≥ 3:1	# months operated in high Cycle/Hour ratio	Avg. Cycle/Hour in last 12 months	Operated in Marine or High Saline	Operated on Floats Only	Operated on Wheels Only	Both Floats & Wheels	Uses Carbon Steel Cables	Uses Stainless Steel Cables	Mte Program Replacement Interval (mths)	Mte Program Inspection Interval		Early Cable Replac. for wear / corros.	General Comments on Cable wear						
																(mths)	(hrs)		Wear found in interim inspect. between replac. intervals?	Type of wear (flattening, fraying)	Wear Locations STA.? (pulleys, quadrants, fittings)	Cable Wear at Fairlead or Fairlead Replacement	More Wear on SST or Carbon Steel Cables	Merits of SST over Carbon Steel Cables	Comments on other Factors affecting Cable Wear
23	0		1200						0	0	1	0	1	0	60	12		0	0		STA 332, 376 at the pulleys	1	No experience with SST	From Operator Feeback; SST wear very quickly	We find flat spotting over the pulleys at STA 332 and 376. We find minor flat spotting of carbon cables but usually major wear of fairleads.
24	0		1000						0	0	1	0	1	0	60	12		0	0		STA 332, 376 at the pulleys	1	No experience with SST	From Operator Feeback; SST wear very quickly	
25	1	500	1500	16973.9	27243			3.0	1	1	0	0	0	1	12		125	1	1	Sometime. Shiny, Flattening and broken strands	STA 271.9, 332.00, 376.00 at the pulleys	0	No Carbon Steel used	No Carbon Steel used	Cable Wear is mainly confined to Routing at Pulley locations only. Type of wear include: Shiny:monitored within limits, Fraying:immediate replacement (usual cought at 1-3 wires in one strand), Flattening:cause for replacement (hardly ever detected).
26	1	1100	3000	29503.5	50955			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
27	1	1100	3000	31260.9	53384			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
28	1	1100	3000	23525.9	38878			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
29	1	1100	3000	26410.7	48798			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
30	1	1100	3000	21501.9	44360			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
31	1	1100	3000	31258.3	52231			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
32	1	1100	3000	28401.1	48741			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
33	1	1100	3000	27928.1	42185			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
34	1	1100	3000	32078.9	73441			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
35	1	1100	3000	31724.2	71844			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
36	1	1100	3000	40304	84419			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
37	1	1100	3000	35926	65134			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
38	1	1100	3000	30753.8	58282			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
39	1	1100	3000	29362.8	60689			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
40	1	1100	3000	30527	58023			2.7	1	1	0	0	0	1	12		125	1	1			0	No Carbon Steel used	No Carbon Steel used	
41	1	760	2258	21266.8	41087	1		3.0	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
42	1	819.7	2347	26249.8	54431	1		2.9	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
43	1	1065.8	2748.3	36572.9	72618	1		2.6	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
44	1	908.4	2117.6	43403.3	90698	1		2.3	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
45	1	683.8	1987.3	32456.8	55784	1		2.9	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
46	1	1121	2740	34329.5	69423	1		2.4	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
47	1	953	2397.3	49518.4	102478	1		2.5	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	

VIKING ENGINEERING NOTE

PREPARED BY: S. DE GAGNE
DATE: JANUARY 18, 2008
APPROVED BY: MARTIN SWAN
DATE: FEBRUARY 5, 2008

-TITLE-

DHC-6 ELEVATOR CONTROL CABLE WEAR SURVEY RESULTS

VEN #: V6-CAW-M2700-10
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																Mte Program Inspection Interval			General Comments on Cable wear						
	Tropics	Avg. Hours per Year	Avg. Cycles per Year	Total Hours (since new)	Total Cycles (since new)	Cycle/Hour ratio ≥ 3:1	# months operated in high Cycle/Hour ratio	Avg. Cycle/Hour in last 12 months	Operated in Marine or High Saline	Operated on Floats Only	Operated on Wheels Only	Both Floats & Wheels	Uses Carbon Steel Cables	Uses Stainless Steel Cables	Mte Program Replacement Interval (mths)	(mths)	(hrs)	Early Cable Replac. for wear / corros.	Wear found in interim inspect. between replac. intervals?	Type of wear (flattening, fraying)	Wear Locations STA.? (pulleys, quadrants, fittings)	Cable Wear at Fairlead or Fairlead Replacement	More Wear on SST or Carbon Steel Cables	Merits of SST over Carbon Steel Cables	Comments on other Factors affecting Cable Wear
48	1	1063.3	2748	40827.2	41223	1		2.6	1	1	0	0	0	1	12		50	0	1	We find blending wear and broken wires in the forward elevator cable. at the following stations: Fairleads at hydraulic bay area, at tail section near cargo compartment, 7B station, forward cable.	Cable wear is found at the following stations: Fairleads at hydraulic bay area, at tail section near cargo compartment, 7B station, forward cable.	1	More Wear on SST Cables	More Corrosion Resistant	It would be better for stainless steel cables to reduce rubbing on fairleads if we provide more or enough clearance in the area.
49	1	977.1	2486.6	38087.7	56609	1		2.5	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
50	1	1116	2741	41861.5	85740	1		2.5	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
51	1	978.1	2356	35339.9	56719	1		2.4	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
52	1	1000	2359	30208.9	58695	1		2.4	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
53	1	872.8	2140.3	35687.9	46386	1		2.5	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
54	1	972.6	2806.6	28611.4	36111	1		2.9	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
55	1	414	961.3	31525.2	39802	1		2.3	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
56	1	695.5	2037.6	26956.4	55736	1		2.9	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
57	1	544.2	1567	30242.5	51356	1		2.9	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
58	1	385.2	812.6	33704.6	50144	1		2.1	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
59	1	726.1	2037.6	30204.3	52103	1		2.8	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
60	1	756.1	2203.3	28559.9	46873	1		2.9	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
61	1	917.2	2245.3	41688.1	83925	1		2.4	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
62	1	1062	2649	48571	107841	1		2.5	1	1	0	0	0	1	12		50	0	1			1	More Wear on SST Cables	More Corrosion Resistant	
63	1	848.6	3440.25	26346.76	81692	1		4.1	1	0	1	0	1	0	12	12	1000	0	0	No Wear	N/A	0	No SST used	No SST used	
64	1	974.7	3907.75	33,758.64	105353	1		4.0	1	0	1	0	1	0	12	12	1000	0	0	No Wear	N/A	0	No SST used	No SST used	
65	1	995.9	3823.75	33,314.83	101628	1		3.8	1	0	1	0	1	0	12	12	1000	0	0	No Wear	N/A	0	No SST used	No SST used	
		61048.2	153962.5	1978642.2	3474720.0	27.8	0	2.5	60	44	18	3	19	46	N/A	N/A	N/A	19	40	N/A	N/A	24			

APPENDIX D
DHC-6 ELEVATOR CONTROL CABLE INSPECTION SCHEDULE

The table (below) shows the OEM inspection requirements in flight hours and calendar time where applicable.

ELEVATOR CONTROL CABLE MAINTENANCE SCHEDULE

	OUTSIDE A MARINE OR HIGH SALINE ENVIRONMENT	HIGH SALT CONTENT OR MARINE ENVIRONMENT (FLOAT/LANDPLANE)
ELEVATOR CONTROL CABLE INSPECTION	EVERY 1000 HRS OR 12 MONTHS PSM 1-6-7 SECTION 27-4 EVERY 1000 HRS OR 12 MONTHS PSM 1-6-7(IC) CARDS 15-15, 18-06, 19-01, 20-11, 21-10, CAL 18-6	EVERY 400 HOURS OR 3 MONTHS PSM 1-6-7 SECTION 27-4 EVERY 400 HOURS OR 3 MONTHS PSM 1-6-7(IC) CARD SP1-E4
ELEVATOR CONTROL CABLE REPLACEMENT	EVERY 60 MONTHS PSM 1-6-7 SECTION 27-4 EVERY 5 YEARS PSM 1-6-7(IC) CARD SP2-C8	EVERY 12 MONTHS PSM 1-6-7 SECTION 27-4 EVERY 12 MONTHS PSM 1-6-7(IC) CARD SP1-E5

ELEVATOR CONTROL CABLE INSPECTION

Cables are to be inspected In accordance with Aircraft Maintenance Manual Section 20-60-01. Carbon steel elevator control cables are to be lubricated in accordance with that same section.

Inspection requirements are in accordance with Manuals PSM 1-6-7 and 1-6-7(IC) which specifies:

> Elevator control cables be inspected from flight compartment to empennage for fraying, corrosion, flattening, proper attachment and security, pulleys for condition and freedom of movement, pulley brackets and guide for condition and security, turnbuckles for security.
>
> Instruction NOTES include:
>
> NOTE 1: Inspect cables for fraying, corrosion, flattening, security and deterioration of protective coatings. Special attention on either side of pulley clusters at STAs 267.0, 332.0 and 376.0 for corrosion and fraying. Apply external lubricant to carbon steel non-jacketed cables in accordance with Maintenance Manual. Do not lubricate stainless steel or jacketed cables.
>
> NOTE 2: It is important to operate controls through full range during inspection so that cables move away from pulleys and all portions of cables are exposed for inspection.
>
> NOTE 3: Remove all access panels that are required to get free and clear view of area being inspected. Install all access panels.
>
> NOTE 4: Stainless steel control cables are available in lieu of carbon steel cables when operating on floats or in a marine or saline environment.

Appendix 11
Incident on 22 March 2005
to the DHC6 registered F-OIJL,
operated by Air Guyane,
at Maripasoula aerodrome (French Guyana)

1 - History of Flight

The DHC6 registered F-OIJL was undertaking a cargo flight between Cayenne and Maripasoula aerodromes.

On arrival, the pilot made a runway circuit to land on QFU 07. During the last turn, at a height of around our hundred feet, he noticed that the roll control was ineffective and performed a go around. During this sequence, the left wing struck the top of a tree, damaging the leading edge and the wig tip.

As the speed increased, the pilot was able to regain some effective roll. He made a runway circuit, lined up for final approach to QFU 25 with a speed of 100 kt and landed the aeroplane on the laterite shoulder of the runway. The aeroplane ran for approximately four hundred metres before coming to a stop.

Examination of the aileron controls brought to light a failure in the right aileron lower control cable at the level of the passage into the right wing root of a cable guide fitted with a polyamide ring. The cable was very worn in the failure area; the same applied to the upper control cable on the same aileron.

2 - The Cables

The cables on this aeroplane were made of stainless steel. They were all 7 x 19 configuration with a diameter of 1/8 inch for those controlling pitch and roll. The two left wing aileron control cables as well as those of elevator control also had wear marks, though less noticeable than those of the right aileron cables.

The cables had been installed new between February and May 2003 before the aeroplane arrived at Air Guyane. The aeroplane then had a total of 25,493.6 flying hours and 48,639 cycles.

On the date of the incident, the aeroplane totalled 27 574 flying hours and 51 457 cycles of which 2,080.4 flying hours and 2,818 cycles since its arrival at Air Guyane.

The last inspections had been performed:

- ❒ for the elevator cables, in February 2005, 166 hours and 211 cycles before the accident. The mechanic had not recorded any observations;
- ❒ for the right aileron cables, in November 2004, 656 hours and 890 cycles before the accident. No observations had been recorded;
- ❒ for the left wing aileron cables, in December 2004, 526 hours and 710 cycles before the accident. No observations had been recorded.

These cables are replaced every five years.

Note: The manufacturer considers that the aeroplane was operating in a marine environment, and stated that the elevator control cables should have been changed after twelve months of operation. The opinion of the operator was different since, not having any maritime over-flights, it applied the regulations that imposed a change every five years, without any special inspections.

Air Guyane also possessed two DHC6 equipped with carbon steel cables. The inspections carried out following the accident showed that they were all in good condition.

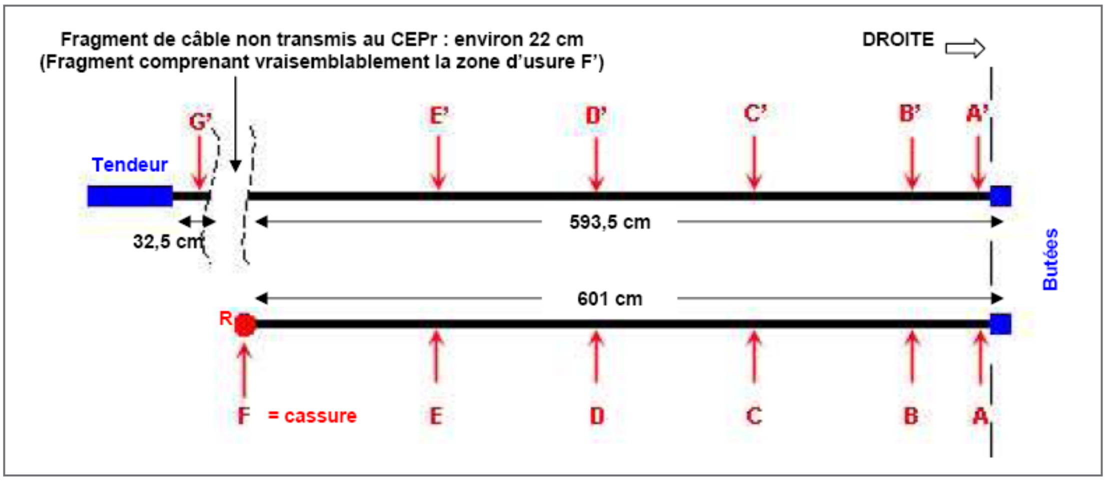
3 - Examination of the Right Aileron Control Cables

The work performed showed that the cables had been affected by a more or less pronounced wear phenomenon. As this phenomenon evolved over time, the resistant section of the wires diminished and led to the failure of the right aileron control cable.

The two right aileron control cables were examined in the lab. They were made of type 18.08 stainless steel whose chemical composition corresponded to the variety described in the MIL-W683420 standard.

3.1 Location of the worn area

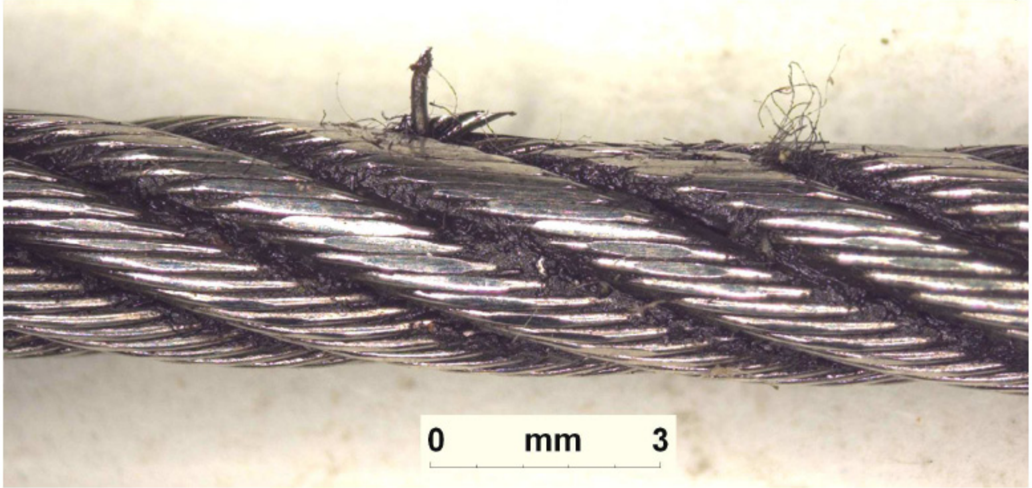
The following identifies the wear observed on the cables:



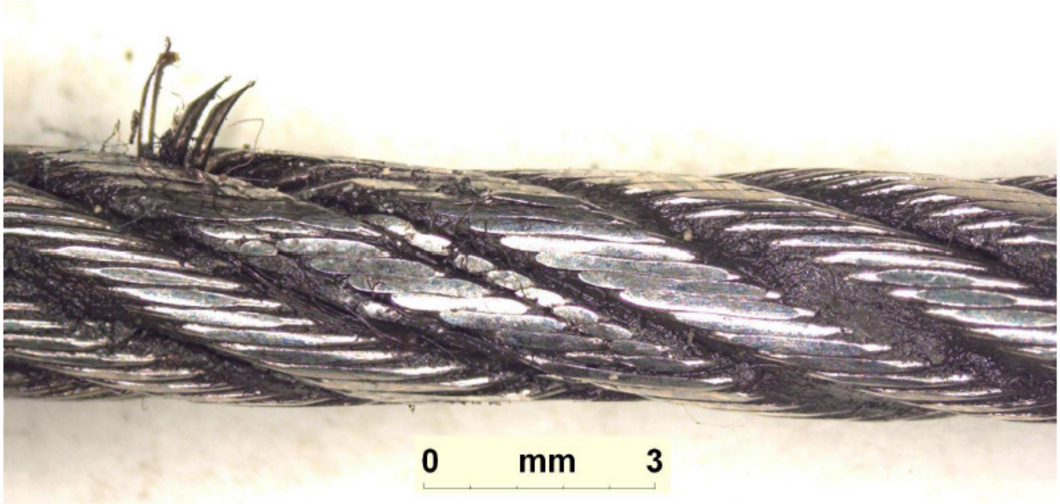
The wear noted on the lower and upper cables was located exactly the same distance from the stops and had the same appearance.

- The wear zones A and A′ extended about 3 to 4 cm and on a lower sector at 180°. They were characterised by the formation of flat spots on the outer wires.
- The wear zones B and B′ extended about 3 to 10 cm and on a lower sector at 90°. They were not characterised by flat spots but rather by small tears on the outer wires.
- The wear zones C, C′, D, D′, E and E′ had the same appearance. They extended between 3 and 6 cm and were identified on the whole outside of the cable. This wear was very significant and was characterised by the formation of flat spots on the outer wires.

- Wear zone F was located to the right of the break in the cable. The type of wear was identical to that at C, D and E.

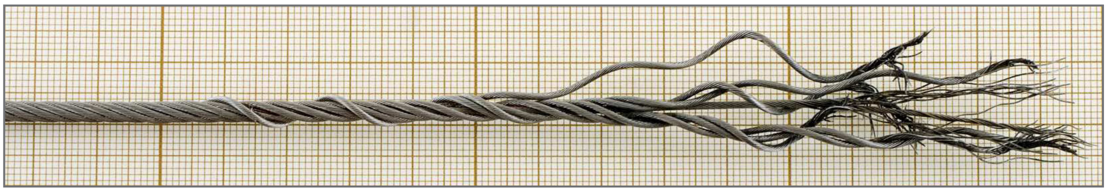


Cliché 5 : Zone d'usure E' sur le câble supérieur



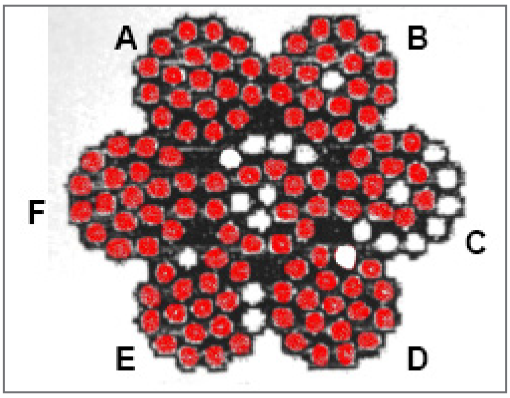
Cliché 6 : Zone d'usure E sur le câble inférieur

3.2 Examination of the Break in the Lower Cable



On the cross-section below (strands identified arbitrarily from A to F), the broken wires in line with wear are identified in red, that is to say 113 wires from a total of 133. This wear was characterised by the formation of flat spots, with traces of chafing parallel to the cable axis.

The twenty other wires failed under twisting traction with a striction of the wires in line with the failure surface. Several of them, part of strand C, showed wear behind their wear. This wear was of the same type as those noted in line with the breaks.



4 - Tests

Tests were carried out to measure the loads on the control column to control roll. The values that were noted varied from seven to nine daN, according to the configuration of the flaps (approach or landing).

The initial tension of the aileron control cables for Guyana was 95 lbs (42.2 daN).

The failure of the twenty wires thus occurred under a load of around 50 daN.

5 - Replacement of Roll Control Cables

During the aeroplane's overhaul, carbon steel cables were installed.

The installation instructions supplied by the manufacturer required that adequate centring of the cables be performed and that their freedom of movement be checked all along their path (cable guide, pulleys), in order to avoid hard contacts that could cause sustained chafing. The manufacturer's documentation completed the installation instructions with details on the adjustments as well as on the tensile characteristics.

It was noted, during their installation, that the two new right aileron control cables touched the upper part of the cable guide in a significant manner. It was also confirmed that no procedure existed to maintain correct centring and free movement of the cables. Increased surveillance of the cables was decided on. On 5 December 2005, an inspection did not reveal any deterioration of these cables.

6. Analysis and Conclusion

Without being able to confirm this, incorrect installation could explain the unusual wear of the two right aileron control cables since this wear was noticed only during this check. The traces of wear on the other cables, the left aileron and elevator, though abnormal, were in fact notable less pronounced. However, in comparison with the two other aeroplanes in the fleet, this confirmed a tendency to increased wear on the stainless steel cables.

This incident also revealed that:

- ❐ visual inspection of the cables was not sufficient to guarantee the detection of traces of any wear. In fact, the elevator control cable that was found worn had been checked 166 hours previously;
- ❐ the pilot's inputs on the roll control, of around 50 daN, were sufficient in themselves to break the twenty remaining cable wires.

COMMENTS BY CANADA

Transport Canada's Representations to the Bureau d'Enquêtes et d'Analyses (BEA) regarding the 2nd Draft Investigation Report 978-2-11-098029-8 (TSB # A07F0125)
Air Moorea, de Havilland DHC-6-300, Registration F-OIQI
Moorea, French Polynesia – 9 August 2007

The BEA via the Transportation Safety Board of Canada (TSB) provided Transport Canada (TC) a copy of a second draft investigation report regarding this accident. This report was provided in the French language. The appropriate officials, fluent in both the French and English languages reviewed the draft report however they experienced difficulty fully understanding the report as presented. Transport Canada was provided with an English translation of the Analysis, Conclusions and Recommendations. Attached is a copy of the translated document (Appendix A) and forms the basis for the following representations. Representations only reference the translated document and not the 2nd Draft Report written in the French language.

Transport Canada suggests that the BEA may wish to edit the Draft Report for clarity and ease of comprehension.

Representation 1
2.2 Pitch-up Control Cable Failure Scenario
The 2nd paragraph states in part, *"The wear on the cable where it failed was due to its chafing on the polyamide bush located in the cable guide."*

This area was subject to the dismissed inspection criteria noted within the report. In particular the area was due for inspection every three months or 400 hours flight time. The report fails to clearly state what inspections were carried out with regard to the inspection of the subject cables.

Representation 2
2.2 Pitch-up Control Cable Failure Scenario
The 2nd paragraph states in part, *"The wear on the cable where it failed was due to its chafing on the polyamide bush located in the cable guide."*

Polyamide has been widely used as anti-friction material. It is unclear how the bush will cause chafing and wear failure of the cable. It is suggested that the report explains how this occurred.

Representation 3
2.2 Pitch-up Control Cable Failure Scenario
The 7th paragraph states in part, *"...initial failure of several strands, including the central strand, under the effect of the external phenomenon..."*

The failure of very few of the strands in the vicinity of the reported failure point should provide unmistakable cockpit indication of a problem. This would be evident as frayed cable strands moved through the fairlead. Any frayed cables should have been detected during inspection.

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Representation 4
2.3.2 Maintenance of F-OIQI
The 1st paragraph states in part, *"No doubt can be cast on the quality of these checks, the maintenance organization having been subject to an oversight inspection in March 2007 that had not led to any significant comments."*
Transport Canada believes that this statement is contrary to the evidence shown in the report where as the organization:

- Did not maintain adequate maintenance records;
- Altered the Original Equipment Manufacturer (OEM) program without regulatory approval;
- Arbitrarily dismissed the special inspections; and,
- Permitted the aircraft to fly with time expired components.

Representation 5
2.3.2 Maintenance of F-OIQI
The 2nd paragraph states in part, *"As to the special cable inspections linked to use in saline conditions, they do not appear to have been deliberately ignored but rather fallen into disuse on the Air Moorea fleet well before the arrival of F-OIQI"*

This paragraph is not understood either in the original document or the translated document. It is of benefit to the reviewer that the maintenance carried out on the accident aircraft is clearly stated as to both completion and documentation. Transport Canada requested this information earlier in the investigation but has not received a response. Clear evidence (documentation, interview, or other means) that indicates this area was inspected must be available. The identification of the last time an inspection of the cables was carried out as required by Instructions for Continued Airworthiness (ICA) would add value to the report.

The report should indicate whether the operator's inspection program as incorporated more stringent or less stringent than what is recommended by the aircraft OEM. The report states the special cable inspections had fallen into "disuse" but does not suggest they were ignored.

An operator who arbitrarily or otherwise decides not to follow OEM recommendations runs a very high risk of operating an aircraft that has deteriorated to below a safe level of conformance with its type design.

The fact that the operator elected to not comply with these inspection requirements is beyond the expected control of the OEM. Such matters are of the purview of the governing airworthiness authority. Without clear evidence this aircraft was properly maintained, it is difficult to ignore the possibility that the failed cable had never been subjected to the required inspection criteria.

Transport Canada suggests exact clarification is needed in what the inspection schedule the operator was following. This information will assist in determining the adequacy of the present ICA.

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Representation 6

2.3.2 Maintenance of F-OIQI

The report states, *"Before any other considerations, three factors may explain this evolution: these special checks did not coincide with the scheduled checks (400 hours is not a multiple of 125 hours); the structure of the Maintenance Manual does not facilitate these checks; finally, the maintenance organisation was used to carbon steel cables on which no deterioration had ever been noticed during their replacement."*

The report goes on to states, *"When F-OIQI arrived, Air Moorea, which was not made aware of the specific characteristics of the stainless steel cable, or even informed of these specific characteristics, had not been informed of the installation of stainless steel cables, the only mention in the dossier being a different reference. In addition, even this was not done in such a way as to draw particular attention to it, carbon steel and stainless steel cables being interchangeable, so that the maintenance of F-OIQI was thus undertaken in the same way as that of the rest of the fleet."*

In the inspection of aircraft, many tasks are not in synchronization with « scheduled » inspections. In this case, one viable option would be to incorporate the 400 hr requirement at 375hrs. In any case, an operator's maintenance schedule must account for such items. For your information, in Canada, aircraft that are being transferred between maintenance programs are done so pursuant to Canadian Aviation Regulation CAR 605.87, specifically Standard 625 Appendix F.

CAR 605.87, Appendix F states as follows:

"(8) Airworthiness Limitations

The prorating procedures described in section (4) above do not apply to items designated in the type approval document as "airworthiness limitations", or "life limits". This will not normally be a problem, since such limitations apply equally to all operators. Certain life-limited items, however, can have different limits depending on the installation or the aircraft role. Because of the critical nature of parts subject to life limits or other airworthiness limitations, when transferring ***identical life-limited products between programs to which different limits apply, the lower limit shall be observed, irrespective of whether that limit forms part of the old or the new program****, unless written approval for some other procedure is obtained from the Director, Airworthiness Branch.*

For example, an aircraft operated under CAR 605.87, would require new cables installed upon commencing operation in a saline environment unless the installed cables were less than a year old. For the opposite scenario (aircraft relocated to a non saline environment) the cables would still be subject to a one-year life (or less depending on installation date), thereafter subject to the non-saline life of five years.

For your information, you may refer to the following internet addresses.
http://www.tc.gc.ca/CivilAviation/Regserv/Affairs/cars/Part6/Standards/625.htm#625_87
http://www.tc.gc.ca/CivilAviation/Regserv/Affairs/cars/Part6/Standards/a625f.htm

.../4

Representation 7
2.3.2 Maintenance of F-OIQI
The last paragraph states, *"It is difficult to say whether the mandatory checks would have made it possible to detect the wear on the cable. In fact, this wear is very difficult to detect on an installed cable, especially if one has not previously been confronted with this phenomenon."*

The existing ICA recommends the removal of the cable to facilitate adequate inspection. Transport Canada believes that the particular area in question is readily accessible for inspection of the control cable.

Based on worldwide fleet reporting, facts show just the opposite of this statement. Transport Canada believes that the existing ICA/mandatory checks as recommended by the OEM are sufficient to preclude the operation of an aircraft with control cables in an unsafe condition.

Representation 8
2.3.3 Continuing airworthiness of the cables
The second paragraph states in part, *"It is therefore questionable why the mandatory inspections and the recommended methods are the same, since the two types of cable, of different materials, are not affected by the same phenomena."*

While the characteristics of Stainless steel vs. Carbon steel cables are different, the inspection techniques are identical. In both cases cables are inspected for corrosion, flattening, fraying and tension as well as correct installation, binding and freedom of movement. This is not peculiar to the DHC-6 but rather generic in the industry. Please refer to FAA Advisory Circular AC43.13-1B, 7-149.

Representation 9
2.3.3 Continuing airworthiness of the cables
The third paragraph states in part, *"The investigation showed that, according to the type of cable chosen, the maintenance programmes cannot be identical."*

While the characteristics of Stainless steel vs. Carbon steel cables are different, the inspection techniques are identical. In both cases, cables are inspected for corrosion, flattening, fraying and tension as well as correct installation, binding and freedom of movement. This is not peculiar to the DHC-6 but rather generic in the industry. Please refer to FAA Advisory Circular AC43.13-1B, 7-149.

Representation 10
2.3.3 Continuing Airworthiness of the cables
The fourth paragraph states in part, *"On the basis of their own experience, some operators had reduced the interval for special inspections down to fifty hours on stainless steel cables. This is indicative of the speed at which wear can appear and propagate."*

These operators whom had revised inspection and replacement criteria did so after several years of operating large fleets of aircraft in saline environment. It is not uncommon for any aircraft operator to revise a maintenance schedule based on environmental or operating experience.

.../5

It is important to note that none of these operators determined to extend inspection and replacement criteria, as did Air Moorea as suggested within the report.

Representation 11
2.3.3 Continuing airworthiness of the cables
The last sentence of this section states, *"It is also surprising that these disparities in maintenance had not alerted the manufacturer and the authorities."*

The abnormalities noted were uncovered as a result of the published inspection criteria. It is not expected that inspection results are relayed to the manufacturer or the authorities where the approved inspection requirements or other corrective actions is in place to ensure mitigation of said abnormalities.

In Canada, pursuant to CAR 591 abnormalities outside of this criteria are to be reported to Transport Canada.

Present in-service history and a fleet campaign of several DHC-6 operators worldwide have not indicated a systemic problem related to flight control cables.

Representation 12
2.4 The Phenomenon of Jet Blast
The report does not provide information, such as witness accounts and duration of exposure etc., of evidence that the Air Moorea fleet or F-OIQO was actually exposed to jet blast.

If the aircraft was witnessed to be exposed to jet blast, then special inspection PSM 1-6-7 page 33 "Ground Gust Condition Inspection" item 5 on page 34 was due. If the Air Moorea fleet was routinely exposed then the operation must be examined. Transport Canada suggests that detailed information and further analysis is required for this issue.

3 - CONCLUSIONS

Representation 13
3.1 Findings
The 3rd through 6th sentences state, *"The propeller on the right engine should have been removed in March 2007.*
The airplane had been subjected to strong turbulence in July 2007. No work file was found. Only the reinstallation of cabin equipment was mentioned in the equipment list.
The operator had requested a modification of the Maintenance Manual relating to the special inspections of cables, though no trace of any such inspections could be found for F-OIQI.
The limited-life parts file for F-OIQI contained errors on installation and replacement dates."
and, the 30th sentence states, *"The last oversight operation carried out on 6 March 2007 did not bring to light any dysfunction in the maintenance organisation that could endanger the safety of flights."*

These conclusions presented in the 3rd to 6th sentences are in conflict with the conclusion statement on the 30th sentence whereas no problems with maintenance were apparent. Please also refer to Representation 4.

…/6

Representation 14
3.1 Findings
The 13th sentence in this section states, *"They* (the cables) *had been removed, checked and reinstalled in October 2006..."*

The report does not mention where this maintenance action was undertaken, nor are there references to any supporting documentation. Addition of this information may improve understanding of the maintenance history

Representation 15
3.1 Findings
The 15th sentence of this section states, *"F-OIQI was the only airplane in the Air Moorea fleet equipped with stainless steel cables. The operator was not aware of this characteristic, which was only apparent through a reference."*

Air Moorea upon entering F-OIQI into service would have been required to review the inspection program for this particular aircraft. This is not peculiar to the DHC-6, but to any new aircraft an operator adds to their fleet. During this review the installation of Stainless Steel cables would have been noted when applying the required inspection criteria of PSM 1-6-7 Part 2, SP1. This information needs to be added to the report.

Representation 16
3.1 Findings
The 19th sentence of this section states, *"Other worn areas were found on the elevator control cables."*

It is not surprising that areas of discrepancy are noted if the recommended inspection program was not being followed.

4 - RECOMMENDATIONS

Representation 17
4.1 Initial Recommendations
The last sentence of this section states, *"At the time of publication of this report, no information on the inspections that may have been performed, nor on any possible wear detected, has been supplied to the BEA"*

Transport Canada was provided with the results of the fleet survey conducted by Viking. These results were shared with the BEA through the Transportation Safety Board of Canada. The report contains several references to the information provided.

Transport Canada insists that this paragraph be removed as it is misleading and indicates a failure to cooperate with the investigation.

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Representation 18
4.1 Recommendations on the Cables
Recommendation 4.2.1 states, *"That stainless steel control surface cables be forbidden on the DHC6, at least until improved knowledge on their behaviour makes it possible to determine new regulatory requirements and to establish appropriate maintenance procedures"*

Transport Canada is confident the existing Instructions for Continued Airworthiness checks as recommended by the OEM are sufficient to preclude the operation of an aircraft with control cables in an unsafe condition. The OEM has revised the maintenance requirements for those aircraft operating in tropical environment to a 125-hour interval.

Transport Canada does not believe present in-service history or any evidence presently in this investigation supports this recommendation.

Representation 19
Recommendation 4.2.2 states, *"That a review be undertaken, in the light of the lessons learned in this investigation, of the design and in-service experience of other aircraft on which stainless steel cables are used for the primary controls so as to determine the measures that may prove useful to safety."*

Transport Canada does not believe present in-service history or any evidence presently in this investigation supports this recommendation.

Representation 20
Recommendation 4.2.3 states, *"The authorities encourage operators to transmit to manufacturers all information on technical anomalies detected that are not included in the maintenance documentation."*

Transport Canada believes the abnormalities noted in this report were uncovered as a result of the published inspection criteria. It is not expected that inspection results are relayed to the manufacturer or the authorities where the approved inspection requirements or other corrective actions is in place to insure mitigation of said abnormalities. In Canada, pursuant to Canadian Aviation Regulation CAR 591 abnormalities outside of this criteria are to be reported to Transport Canada via the Service Difficulty Report program.

Summary
In the case of this accident, Transport Canada, National Aircraft Certification have expended much energy in a comprehensive review of the accident details as provided, service history with regard to stainless steel cables, and Instructions for Continued Airworthiness. National Aircraft Certification remains confident when the DHC-6 aircraft is operated in compliance with the existing Instructions for Continued Airworthiness as recommended by the OEM, no unsafe condition exists.

Viking Air Limited Comments1) – Report 071008 (English Translation)

	BEA Report 071008 Reference			
Item	**Section**	**Paragraph**	**Content**	**Viking Comments**
1	2.2	2	The wear on the cable where it failed was due to its chafing on the polyamide bush located in the cable guide. This wear was significant: due to the structure of the cable it had affected all of the strands except the central strand, and had led to the failure or the almost total reduction in cross-section of 72 wires out of the 132 that made up the cable.	The location of the cable wear has been reported to occur at the fairlead located at STA 436. This location is readily accessible and easy to inspect. Had the OEM schedule been followed, the following maintenance actions would have occurred: 1) New cables installed per PSM 1-6-7, Special Inspection SP1 (E-4a) prior to the aircraft being operated in a high salt content or marine environment; 2) PSM 1-6-7, Special Inspection SP1 (E-4), for condition, corrosion and fraying, applicable to aircraft operated in a high salt content or marine environment (3 months or every 400 hours; whichever occurs first) should have been carried out twice, as the aircraft was operated by Air Moorea 841 hours prior to the accident. Notes: 1) The second inspection would have taken place approximately 41 hours before the accident, in a readily accessible location. 2) These replacement and inspection requirements have been in place since 1995.

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1) The comments are being provided by Viking on a confidential and without prejudice basis and is being furnished solely for the benefit of the BEA for its Report and may not be reproduced or provided to any other person for any other purpose without the prior written consent of Viking. The fact that Viking does not comment on a particular section of the draft Report does not mean that it agrees with the content of that section but rather since Viking was not involved in the investigation, it is not in a position to comment on or provide any opinion or judgement. These comments have been provided on the basis of an incomplete English translation of the draft Report provided to Viking. Viking is not in a position to verify the accuracy of the translation and its comments are subject to such translation being accurate and complete.
Nothing herein shall be interpreted as Viking agreeing with the recommendations or conclusions of the Report.

	BEA Report 071008 Reference			
Item	**Section**	**Paragraph**	**Content**	**Viking Comments**
2	**2.2**	**6**	To arrive at the failure in the case of F-OIQI, it was thus necessary for some additional phenomenon to occur that aggravated the cable's weakness. The cable was in compliance with the specifications and, apart from the wear, no damage previous to the accident had been observed. The effect of fatigue could also be eliminated, since none of the wires on the broken cable showed any signs of fatigue. However, if the fatigue test performed on a worn cable clearly showed that it could fail with the application of cyclic loads, of the kind that can be encountered in service, after a relatively low number of cycles, it also confirmed the appearance in such a case of signs of fatigue. The additional phenomenon could thus only be external to the airplane.	The statement, *"no damage previous to the accident had been observed"* is relevant only if Air Moorea was in compliance with the following OEM Special Inspections specified in PSM 1-6-7: 1) SP1(E-4) for aircraft operating in a high salt content or marine environment; 2) Basic Inspection, Chapter 27, Item 11a) elevator quadrant inspection for aircraft exposed to windy conditions while parked; 3) SP3 (G) Severe Turbulence or Buffeting Inspection; and, 4) SP3 (H) Ground Gust Condition Inspection. To our knowledge, there is no evidence that Air Moorea was in compliance with these OEM Special Inspections.
3	**2.2**	**7**	The failure of the worn cable thus necessarily occurred on two occasions, with the initial failure of several strands, including the central strand, under the effect of the external phenomenon, then the failure of the last strands under the effect of the in-service load. The nature of the tests and the elements available made it impossible to go any further with this description, even though, during the tests, the failure stress on the worn last strand was of the order of the load exerted on the cable to counter the pitch moment on flap retraction. The absence of any indications of fatigue on the fracture surfaces of the wires, despite strong turbulence encountered about a month before the accident, shows that the successive episodes in the failure of the cable occurred over a relatively short period.	PSM 1-6-7 specifies special inspections applicable to aircraft exposed to external phenomenon such as high saline environments, ground gusts or severe turbulence. These are as follows: 1) High Salt Content or Marine Environment, SP1 (E-4); 2) Ground Gusts, Basic Inspection, Chapter 27, Item 11a elevator quadrant inspection when an aircraft is subjected to ground winds; 3) Ground Gust Condition Inspection, SP3 (H); and, 4) Severe Turbulence of Buffeting Inspection SP3 (G). There appears to be no record of this necessary inspection being performed by Air Moorea.
4	**2.2**	**12**	Since, in addition, a single exposure is	Assuming cable failure as a result of wear

	BEA Report 071008 Reference			
Item	**Section**	**Paragraph**	**Content**	**Viking Comments**
			enough to start the process of cable destruction, this cause appears, by a process of elimination, to be the explanation for the event.	was the cause of the accident, this could have been prevented if the following OEM maintenance actions, specified in PSM 1-6-7 had been accomplished: 1. The elevator control cables replaced in accordance with Special Inspection SP1 (E-4a) prior to the aircraft starting operation in a high salt content or marine environment; 2. Special Inspection SP1 (E-4) for aircraft operated in a high salt content or marine environment; 3. Special Inspection SP3 (G) for aircraft exposed to severe turbulence or buffeting; 4. Special Inspection SP3 (H) for aircraft exposed to ground gusts; and 5. Elevator quadrant inspection , Basic Inspection, Chapter 27, Item 11 a).
5	**2.3.2**	**1**	The standard checks on the airplane had been performed in accordance with the registered and approved programme. No doubt can be cast on the quality of these checks, the maintenance organisation having been subject to an oversight inspection in March 2007 that had not led to any significant comments. It should of course be noted, as the DGAC did during the inspection in September 2007, that follow-up on the documentation was not carried out as strictly as could be expected. This does not, however, imply that the maintenance operations themselves were not carried out seriously and competently.	To our knowledge, there is no evidence that F-OIQI was maintained in accordance with the OEM maintenance schedule (PSM 1-6-7). In fact, our understanding is as follows: 1. The aircraft did not have new cables installed prior to being operated in a high salt content or marine environment, per SP1 (E-4a); 2. The aircraft was not being maintained to the OEM maintenance schedule applicable to aircraft operated in high salt content or marine environment, per SP1 (E-4); 3. The OEM special elevator quadrant inspection applicable to aircraft parked in windy conditions was not carried out, per Basic Inspection, Chapter 11a;

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				4. The aircraft was not being maintained to the OEM maintenance schedule applicable to aircraft subjected to severe turbulence or buffeting, per SP3 (G); 5. The aircraft was not being maintained to the OEM maintenance schedule applicable to aircraft subjected to ground gust conditions; 6. One propeller was overdue for overhaul; and, There are no maintenance records indicating that the inspections were carried out by appropriately qualified maintenance personnel, and therefore it cannot be assumed that the inspections were indeed carried out.
6	**2.3.2**	**2**	As to the special cable inspections linked to use in saline conditions, they do not appear to have been deliberately ignored but rather fallen into disuse on the Air Moorea fleet well before the arrival of F-OIQI.	It is important that DHC-6 operators maintain their aircraft in accordance with the Inspection Requirements Manual PSM 1-6-7 or alternate programs authorized by their local regulatory authority. The statement, "they do not appear to have been deliberately ignored but rather fallen into disuse" suggests that Air Moorea was not following the OEM maintenance schedule for saline conditions and that the DGAC did not formally authorize a deviation. There is no reason provided why the special cable inspections for saline conditions had fallen into disuse by Air Moorea.
7	**2.3.2**	**3**	Before any other considerations, three factors may explain this evolution: these special checks did not coincide with the scheduled checks (400 hours is not a multiple of 125 hours);	The OEM Inspection Requirements Manual (PSM 1-6-7) takes many factors into consideration when determining

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			the structure of the Maintenance Manual does not facilitate these checks; finally, the maintenance organisation was used to carbon steel cables on which no deterioration had ever been noticed during their replacement.	control cable replacement intervals, type of inspection and frequency of inspection. It is common to impose special inspections, not aligned to the basic maintenance schedule, to account for environmental and operational factors. A deviation to the OEM maintenance schedule requires the involvement of the operator's regulatory authority. The Structural Components Service Life Limits Manual (PSM 1-6-11) and Inspection Requirements Manual (PSM 1-6-7) requires that the elevator control cable be replaced every year, for aircraft operated in high salt content or marine environment.
8	2.3.2	4	When F-OIQI arrived, Air Moorea, which was not made aware of the specific characteristics of the stainless steel cable, or even informed of these specific characteristics, had not been informed of the installation of stainless steel cables, the only mention in the dossier being a different reference. In addition, even this was not done in such a way as to draw particular attention to it, carbon steel and stainless steel cables being interchangeable, so that the maintenance of F-OIQI was thus undertaken in the same way as that of the rest of the fleet.	The OEM maintenance schedule does not differentiate between carbon steel and stainless steel cables. This is due to the implementation, in 1995, of a stringent control cable inspection and replacement interval, that was applicable to both stainless steel and carbon steel cables. Once this was implemented, the number of Service Difficulty Reports (SDRs) received by Transport Canada dropped dramatically (35 SDRs relating to elevator cables prior to August 1995; 1 SDR subsequent to this). The fact that one SDR (wear found on carbon steel cable) has been reported in 13 years is indicative of the effective and conservative maintenance schedule implemented in 1995. Although not an SDR, Viking is

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				aware of one stainless steel elevator cable that failed at a pulley located at STA 270.3. Had Air Moorea replaced the cables prior to operating the aircraft in a high salt content or marine environment, as specified in PSM 1-6-7, Special Inspection SP1 (E-4a), almost certainly, carbon steel cables would have been installed; as is customary at Air Moorea. Assuming no replacement, if Air Moorea had adhered to PSM 1-6-7, Special Inspection SP1 (E-4) for aircraft operated in high salt content or marine environment, at least two inspections of the elevator control cables would have occurred and any worn out cable detected. Further, given that additional special inspections were required, in response to operational conditions (ground gusts and severe turbulence), the control system should have been inspected more often than what was done by Air Moorea.
9	**2.3.2**	**5**	It is difficult to say whether the mandatory checks would have made it possible to detect the wear on the cable. In fact, this wear is very difficult to detect on an installed cable, especially if one has not previously been confronted with this phenomenon.	We are of the view that any damage to the control cable would have been detected in the second special inspection, as it was due 41 hours before the accident. It is not difficult to detect cable wear at the fairlead located at STA 236. It is readily accessible and had the inspection been performed by qualified personnel, any wear in the cable would have been obvious.
10	**2.3.3**	**1**	The installation of stainless steel cables had been decided on to counter corrosion problems detected on carbon steel cables, in addition to measures for annual replacement	The one year replacement interval and special inspection (every 3 months or 400 hours, whichever occurs first) is applicable to both stainless steel and carbon steel

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			and inspection that had been put in place. No measures specific to stainless steel cables had been planned.	cables. After this maintenance schedule was implemented in 1995, there was only one SDR relating to elevator control cables reported to Transport Canada. Therefore, no additional specific measures for stainless steel cables are required. Further, a note was added to PSM 1-6-7, Special Inspection SP1 (E-4) stating: If required, inspection interval may be reduced due to environmental conditions.
11	**2.3.3**	**2**	Thus, a certain amount of ambiguity persists even today as both cable types are considered interchangeable and can be installed according to the operator's choice, the replacement and inspection intervals being exactly the same. However, the sensitivity of each type is different: carbon steel is more sensitive to corrosion but more resistant to wear while stainless steel has the opposite characteristics. It is therefore questionable why the mandatory inspections and the recommended methods are the same, since the two types of cable, of different materials, are not affected by the same phenomena.	In Viking's view, no ambiguity exists between stainless steel cables and carbon steel cables in regards to safety. The special inspection for high salt content or marine environments, with the additional note indicating the inspection interval may be further reduced is appropriate for both stainless steel and carbon steel cables. The stringent one year replacement interval and 3 month/400 hour inspection interval ensures from a safety perspective that wear associated with stainless steel cables plus wear and corrosion on carbon steel cables is appropriately addressed. It is further assumed that the control cables are properly rigged (installed on the proper pulley and tensioned per OEM specifications). If not properly rigged, carbon steel and stainless steel cables are both much more susceptible to wear.
12	**2.3.3**	**3**	The investigation showed that, according to the type of cable chosen, the maintenance programmes cannot be identical. If the inspection periods following intervals based on a length of use, expressed in hours, or on the calendar, is appropriate for problems of corrosion, it is inappropriate for wear phenomena, where the number of cycles is	The stringent one year replacement interval and 3 month/400 hour inspection interval ensures that wear associated with stainless steel cables plus wear and corrosion on carbon steel cables is appropriately addressed from a safety perspective.

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			primordial. It also seems astonishing that, for land operations, a replacement was scheduled only every five years, with only one inspection scheduled every thousand hours.	
13	**2.3.3**	**4**	No awareness campaign for operators was carried out on the risks of wear. On the basis of their own experience, some operators had reduced the interval for special inspections down to fifty hours on stainless steel cables. This is indicative of the speed at which wear can appear and propagate. We note today that this phenomenon had been known for a long time but that apparently no studies had ever been carried out to understand the process (appearance, speed, evolution of resistance) and to determine what the consequences of this could be.	This practice is contained in the note accompanying PSM 1-6-7, Special Inspection SP1 (E-4). It is not uncommon for operators to establish maintenance programs that deviate from OEM requirements, but these changes must be authorized by their regulatory authority. Operators do not have the authority to alter their maintenance programs independently. One operator elected to modify their maintenance program to reduce the inspection interval to 50 hours. This operator adhered to the note included in PSM 1-6-7, Special Inspection SP1 (E-4), reducing the inspection interval after considering their environmental conditions and presumably received the necessary authorization from its regulatory authority.
14	**2.4**	**1**	The investigation once again emphasized the importance of the phenomenon of jet blast for safety. Other events with less dramatic consequences have already been analysed and have shown the perverse effects of jet blast on flight controls, even with only a single exposure to it. In fact, if an individual aware of the phenomenon does not witness it, the damage caused by jet blast on an airplane is for the most part undetectable during the pre-flight inspection.	It is our view that jet blast does not adversely affect the elevator up cable when the pitch lock is installed. If a jet blast was to force the elevator down, this would be reacted primarily by the control stop; not the up elevator cable. The up elevator control cable would experience a low tensile load. This low tensile load would not cause wires to fail due to jet blast.
15	**3.1**	**4**	The airplane had been subjected to strong turbulence in July 2007. No work file was found. Only the reinstallation of cabin	It is not clear to Viking if the turbulence in July 2007 occurred in the air or on the ground (e.g. jet blast). Viking understands

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			equipment was mentioned in the equipment list.	that there is no record of an inspection to either PSM 1-6-7, Basic Inspection, Chapter 27, Item 11a (quadrant - ground winds) and SP3 H (ground gust – including jet blast) or SP3 G (severe turbulence or buffeting) or any other inspection of the control system after the strong turbulence incident occurring in July 2007.
16	**3.1**	**5**	The operator had requested a modification of the Maintenance Manual relating to the special inspections of cables, though no trace of any such inspections could be found for F-OIQI.	Viking understands this to mean that Air Moorea applied to the DGAC for an alleviation to the OEM maintenance schedule special inspection (PSM 1-6-7, Special Inspection SP1 (E-4)). If so, Viking has no knowledge whether the DGAC authorized this change to Air Moorea's DHC-6 maintenance program.
17	**3.1**	**6**	The limited-life parts file for F-OIQI contained errors on installation and replacement dates.	In Viking's view, this may have contributed to any control cables not being replaced prior to the aircraft being operated in a high salt content or marine environment, as required under the OEM maintenance schedule.
18	**3.1**	**10**	The elevator control cables were made of stainless steel and had been installed new on 11 March 2005. They had been removed, checked and re-installed in October 2006, before delivery of the airplane to Air Moorea.	In Viking's view, the control cables should have been replaced prior to the aircraft starting operation in a high salt content or marine environment per PSM 1-6-7, Special Inspection SP1 (E-4a). The requirement to replace the control cables should have been identified during the maintenance program bridging exercise, which is the responsibility of the operator. When an aircraft is inducted into an operator's fleet, the operator is required to carefully review when life limited items need to be replaced, and determine what maintenance tasks are due or will be due taking into account the new environment

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				the aircraft will be operated in.
19	**3.1**	**11**	The airplane had flown 6,260 cycles (for 1,100 flying hours) since the installation of the new cables, of which 5,150 cycles for Air Moorea (for 841 flying hours) since its entry into service at Air Moorea.	As indicated, the existing cables should have been replaced prior to its entry into service with Air Moorea. In any event, the cables should have been inspected a minimum of 2 times in accordance with PSM 1-6-7, Special Inspection SP1 (E-4). This means the second inspection would have taken place approximately 41 hours prior to the accident.
20	**3.1**	**12**	F-OIQI was the only airplane in the Air Moorea fleet equipped with stainless steel cables. The operator was not aware of this characteristic, which was only apparent through a reference.	The control cables should have been replaced prior to the aircraft starting operation in a high salt content or marine environment per PSM 1-6-7, Special Inspection SP1 (E-4a). Air Moorea would have removed the stainless steel cables and almost certainly have installed carbon steel cables, consistent with the rest of their fleet. However, properly inspected cables, whether stainless steel or carbon steel, would have revealed damage if any existed.
21	**3.1**	**16**	Other worn areas were found on the elevator control cables.	In our view, worn cables would have been detected if inspected and rigged (routing and/or tension) in accordance with OEM maintenance schedule and specifications.
22	**3.1**	**17**	The failure of an elevator control cable leads to the loss of pitch control of the airplane.	It should be noted that it is possible to control the aircraft with elevator trim, when the primary pitch control (elevator) is not functioning.
23	**3.1**	**21**	Twin Otter cables can be made of carbon steel or stainless steel. These two types of cables are interchangeable on the airplane. Their inspection and replacement programmes are the same although their behaviour is different: carbon steel cables are more sensitive to corrosion, stainless steel to wear.	The inspection schedule is conservative and is applicable to both stainless steel and carbon steel cables. Operators may increase the inspection frequency due to their environmental conditions, as specified in the note contained in PSM 1-6-7, Special Inspection SP1 (E-4).

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24	3.1	22	The inspections required by the manufacturer are based on the number of flying hours performed or on the calendar and not on a number of cycles. This inspection rhythm is well adapted for the phenomenon of corrosion but not for that of wear.	The maintenance schedule (PSM 1-6-7) is designed to address both wear and corrosion. In addition, the stringent replacement interval and short inspection frequency associated with special inspections covers the cycle aspect.
25	3.1	23	No special inspection or reduction in potential service life for stainless steel cables was recommended for operations outside of maritime areas.	Viking has not received Service Difficulty Reports (SDRs) regarding stainless steel control cables in aircraft not operated in high salt content or marine environments. That is the reason for the special maintenance and replacement instructions for high salt content or marine environment PSM 1-6-7, Special Inspection SP1 (E-4 and (E-4a).
26	3.1	24	Several operators had adopted special inspection intervals closer together than those recommended by the manufacturer.	This is consistent with the note included in PSM 1-6-7, Special Inspection SP1 (E-4). Typically, operators obtain authorization from their local regulatory authority before making changes to their maintenance program.
27	3.1	27	After the accident, an inspection led by the DGAC did not reveal any irregularities with any link to the accident.	Viking understands that it was reported that Air Moorea was not adhering to the OEM schedule, nor was this authorized by the DGAC. It was also noted that the life limited parts files for F-OIQI contained errors. In addition, we understand there was a lack of maintenance records with regard to control cable inspections. Had PSM 1-6-7, Special Inspection SP1 (E-4), second inspection required at 800 hours been carried out by appropriately qualified personnel, the accident may have been avoided, assuming cause was worn cables. In addition, the special inspections applicable to aircraft exposed to specific operational conditions (SP3)

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				would have required the elevator control system to be inspected more frequently than what was done by Air Moorea.
28	**3.1**	**28**	The failure of the pitch-up cable in the area with 50% wear cannot be explained only by the loads on the elevator control during operations.	Viking notes that it is possible the failure in the cable at STA 236 occurred on impact with the water, and if so the actual cause of the accident may be unrelated to a cable tensile failure.
29	**3.1**	**30**	An external phenomenon, most likely jet blast, caused the failure of several strands in the worn area. The final strands failed as a result of the in-flight loads on the elevator control.	It should be noted that the tensile load carried by the elevator up cable is very low when the pitch lock is installed. The reason for this is when the elevator is subjected to a tail wind, with the pitch lock installed, the down elevator travel is restrained by the elevator stop. It is not possible for a properly rigged elevator control system to incur large tensile loads in the up elevator cable with the pitch lock installed; the elevator stop carries nearly all the load. Therefore, Viking is doubtful that the jet blast event(s) caused tensile failure in the up elevator control cable. It is possible that the elevator control system was incorrectly rigged and improperly maintained. This would cause the pilot to lose control of the aircraft in pitch due to an up elevator cable tensile failure or the control system to jam and the remaining cable strands to fail in tension upon impact with the water.
30	**3.1**	**31**	The process of cable failure occurred over a short period of time. No signs of fatigue appear on the failed wires.	An inspection was due no later than 41 hours prior to the accident. Any wear would have been detected had the cable been properly inspected.
31	**3.2**	**1**	The accident was caused by the loss of airplane pitch control following the failure, at a low height, of the elevator pitch-up control	Assuming the cause of the accident is that the pilot lost control of the airplane in pitch, at the time the flaps were retracted,

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			cable at the time the flaps were retracted.	it is still uncertain what caused the elevator control system to fail.
32	**3.2**	**3**	The following factors may have contributed to the accident: The absence of information and training for pilots on the loss of pitch control. The operator's omission of special inspections. The failure by the manufacturer and the aviation authorities to fully take into account the wear phenomenon. The failure by the airworthiness authorities, airport authorities and operators to fully take into account the risks associated with jet blast. The rules for replacement of stainless steel cables on a calendar basis, without	The second special inspection (Ref. PSM 1-6-7, Special Inspection SP1 (E-4)) would have been done no later than 41 hours before the time of the accident. Any significant cable wear at STA 436 would have been detected. Had the operator conducted the inspections per PSM 1-6-7, Special Inspections SP1 (E-4) and the SP3 (G) & (H), any cable wear would have been detected at an early stage. The replacement, inspection and maintenance requirements take into account and address the wear phenomenon whether the cables are stainless steel or carbon steel.

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			taking into account the activity of the airplane in relation to its type of operation.	The cables should have been replaced prior to the aircraft being operated in a high salt content or marine environment. It appears that the OEM inspections per PSM 1-6-7, Special Inspections SP1 (E-4), SP3 (G and H) may not have been conducted on F-OIQI.
33	**4.1**	**2**	The BEA also asked that any cables found to be worn should be sent to it in the context of this investigation. Transport Canada and EASA issued the BEA's recommendation, Transport Canada specifying erroneously that there had been no failure in the worn area. Following this recommendation, Transport Canada subsequently issued a service alert bulletin for those operating and maintaining Twin Otters. This bulletin reminded them of the necessity of being informed of and applying the instructions relating to inspection and replacement of cables and also specified that any other defects or any other events of this type should be notified to it in the context of the service report programme.	As of October, 2008, the OEM is aware of one SDR resulting from the Service Alert Bulletin, issued by Transport Canada. The SDR involved wear in a carbon steel cable. Although not an SDR, Viking is aware of one stainless steel elevator cable that failed at a pulley located at STA 270.3.
34	**4.2**	**1**	Stainless steel cables' sensitivity to wear has been established, even though cables of this type are installed on the primary controls of many airplanes. Further, the investigation showed both that the characteristics of the cable in relation to tensile failure were greatly modified by wear and that the process of wear itself, in particular its speed of propagation, was little known (thus, several operators of DHC6's significantly reduced the cable inspection intervals recommended by the manufacturer). As a result, given the current state of knowledge, no wear on a control surface cable can be accepted	The wear limits specified in PSM 1-63-2 Chapter 20-60-01 requires cables to be replaced if flattening, wear or any broken strands are detected. Some operators have implemented more frequent inspections due to their specific environmental conditions. This is specified in PSM 1-6-7, Special Inspection SP1 (E-4). Additional special inspections, taking into account operational conditions (SP3), are also required.

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			without risking safety.	
35	**4.2.1**		That stainless steel control surface cables be forbidden on the DHC6, at least until improved knowledge on their behaviour makes it possible to determine new regulatory requirements and to establish appropriate maintenance procedures.	The current cable replacement interval and in our view the inspection frequency are adequate for maintaining both stainless steel and carbon steel cables. Some operators have implemented more frequent inspections than what is currently specified by the OEM, which is normal practice when specific environmental conditions warrant a maintenance program change. Viking has recently issued PSM 1-6-7 Temporary Revision TR-100 specifying that operators in the tropics inspect elevator and rudder primary control cables every 125 hours or 3 months, whichever occurs first. In any event, the previous inspection schedule, if followed, would have detected any worn or damaged cables whether stainless steel or carbon steel.
36	**4.2**	**2**	The installation of stainless steel cables has been authorised since 1985. Even though it was rapidly noted that these cables were subject to wear, it was left to the initiative of the operators to adopt, alone, the preventive measures to check this phenomenon and no risk evaluation was performed. The cables correspond to a technical standard but, once installed on an airplane, only the operator can describe their condition and the manufacturer ensure any follow-up. It has been noted in the course of this investigation that anomalies had been discovered on several occasions, but that the operators had been satisfied to change the cables without informing the manufacturer about it. Since there is no process for following up events	Stricter maintenance actions were implemented in 1995 to address concerns about control cables. The implementation of the one year replacement interval, applicable to aircraft operated in high salt content or marine environment, significantly reduced the number of Service Difficulty Reports to one in a 13 year period. This initiative was undertaken by the OEM in collaboration with Transport Canada. The single SDR, involving wear found on a carbon steel cable, indicates that these stringent measures are effective for both stainless steel cables and carbon steel cables.

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			during operations for this equipment, there is no established procedure to systematically search for the causes of any failures and determine the corrective measures. This phenomenon is certainly not restricted to cables alone.	
37	**4.2.3**		The authorities encourage operators to transmit to manufacturers all information on technical anomalies detected that are not included in the maintenance documentation.	Service Difficulty Reporting is mandatory in Canada. This would include reporting the detection of premature wear in control cables, which has not been a concern since the introduction of the stricter maintenance requirements in 1995, as indicated above.

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