F O R E W O R D

This report presents the technical conclusions reached by the Accident Investigation Office (Bureau Enquêtes-Accidents) on the circumstances and causes of this accident.

In accordance with Annex 13 to the Convention on International Civil Aviation, the analysis of the accident and the conclusions and safety recommendations contained in this report are intended neither to apportion blame, nor to assess individual or collective liability. The sole objective is to draw lessons from this occurrence which may help to prevent future accidents.

With this in mind, and to ensure that enhanced safety may be the beneficiary of any areas of doubt, some of the recommendations proposed may concern points whose validity has not so far been irrefutably demonstrated, or which may even have no direct relation to the causes of the accident.

In addition, this report has been written following exhaustive investigation, and is therefore based on experience and knowledge which may differ substantially from that which prevailed at the time of the accident.

Finally, although the people and organizations consulted were invited to present their observations at the appropriate moment, the investigation was not conducted in an adversarial manner.

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 report has been translated and published by the Bureau Enquêtes-Accidents to make its reading easier for English speaking people. As accurate as the translation may be, please refer to the original text in French.

S Y N O P S I S

Date and time
Friday 20 January 1995
at 16.32 UTC[1]

Site of accident
Le Bourget Airport

Type of flight
Public transport (passengers)
(non-scheduled)

Aircraft
Falcon 20E
E Series Falcon Fan Jet
Registration F-GHLN

Owner
Société Lyonnaise de Crédit Bail
(SLIBAIL)

Operator
LEADAIR UNIJET

Persons on board
7 Passengers
2 Flight crew
1 Cabin crew

Summary

Immediately after takeoff from runway 25, damage occurred to the left engine. The control tower advised the flight crew that they could land as they wished and alerted the Rescue and Fire Fighting Service. The aircraft turned to the left in order to land on runway 25. Throughout the circuit, numerous witnesses saw that the rear part of the aircraft was on fire. The aircraft crashed level with the threshold of runway 21, slid for approximately 400 meters and burned. Some dead birds were found on the runway.

Consequences

	Fatal Injuries	Equipment	Cargo
CREW	3	Destroyed	Destroyed
PASSENGERS	7		

[1] All times in this report are UTC, except where otherwise specified. One hour should be added to express French time on the day of the accident.

1- FACTUAL INFORMATION

1.1 History of the Flight

On 20 January 1995, the Falcon 20E registered F-GHLN, operated by LEADAIR UNIJET was to undertake an IFR flight from Le Bourget to Sibiu (Romania) under the designation LEA 001N.

The flight crew consisted of two pilots, the cabin crew of one stewardess. There were seven passengers who were to take part in a hunt, whose baggage included, in particular, guns and munitions. As a result of the limited size of the baggage hold, one of the cabin seats was used to stow a part of the baggage.

The aircraft took off from runway 25 at 16.30 after having waited for the end of the storm which had swept across the airfield from 16.00 to 16.25. The runway lights were illuminated.

The controller, who was in radio contact with the aircraft, noticed a flash near the left engine immediately after the aircraft had executed the rotation, then, a few seconds later, a much larger flame. The crash alarm was activated. The controller informed the flightcrew that the Rescue and Fire Fighting Service had been alerted and that they could land as they wished. The flightcrew announced that they would land back on runway 25. The controller saw the aircraft pass over the threshold of runway 07 (see Appendix 1) and turn left to go downwind.
Throughout the flight, numerous witnesses saw the rear of the plane on fire.

At approximately 16.32, the aircraft struck the ground at the junction of the two runways across the threshold of runway 21 and slid for more than 400 meters (see Appendix 1). The cockpit and cabin were engulfed by flames. The airport Rescue and Fire Fighting Service (RFFS)arrived at the scene at 16.33 and began to tackle the blaze. The firemen established that there were no survivors.

Engine debris was strewn around the vicinity of runway 07/25. Various debris from the aircraft was recovered from under its flight path.

Around fifteen dead lapwings were discovered at the intersection of runways 07/25 and 03/21.

1.2 Injuries to Persons

	CREW	PASSENGERS
FATAL INJURIES	3	7

N.B. A dog, which was on board, was also killed

1.3 Damage to Aircraft

The aircraft was completely destroyed by the impact and the subsequent fire.

1.4 Other Damage

At the threshold of runway 21, the runway surface was damaged for about 100 square meters. Four multidirectional runway lights were destroyed.

1.5 Personnel Information

1.5.1 Flight Crew

As specified in the Operating Manual, the flightcrew consisted of two pilots.

The first officer, in the left hand seat, was flying the aircraft and the captain was undertaking duties attributed to the pilot not flying. This configuration is in accordance with the procedures laid down in the operating manual (Company section).

Since the company, LEADAIR UNIJET, is based at Le Bourget, its pilots have extensive experience of this airport.

1.5.1.1 Captain

Aged 51, the captain had been a salaried employee of LEADAIR UNIJET since March 11th 1991.

1.5.1.1.1. Licenses and Certificates

Private Pilot's License - Certificate N° 18897 issued on June 26th 1966 ;Commercial Pilot's License - Certificate N° 4289 issued on April 14th 1972, valid until March 31st 1995.

Airline Transport Pilot's License - Certificate N° 5408 issued on September 30th 1994, valid until March 31st 1995.

Medically class 1 until March 31st 1995.

1.5.1.1.2 Ratings

- Instrument Rating obtained on July 6th 1972 ;
- International Radio Telephony rating obtained on July 20 1977 ;
- Class D (engine) rating obtained on September 21st 1990 :
- Type ratings :
    - BE 58 on July 6th 1972
    - BN2 on January 9th 1973
    - C310 on June 7th 1974
    - Fk27 on July 19th 1978
    - D 20 (Falcon 20) on September 21st 1990
    - BE 90 on March 6th 1991
    - D 10 on April 1st 1991

BE 10/20 on May 6th 1991.

1.5.1.1.3 Experience

FLYING HOURS	on all types of aircraft	of which on D 20
Total	6191	668
Last 90 days	69	18
last 24 hours	2*	0

* on D 10

D20 rating ground training course at FLIGHT SAFETY (Le Bourget) completed from 6th to 24th August 1990. In-flight training undertaken from September 15th to 20th 1990.

Ongoing checks and tests of competence were carried out in accordance with the legislation in force (Decree of November 5th 1987) :

- Last onboard check on a D 20 on May 19th 1994 ;
- Last ground check on D 20 on October 9th 1993 and on D 10 on July 20th 1994.

1.5.1.1.4 Flying Career

After following training courses in 1969, the captain worked as an instructor, then as a pilot in a private company and subsequently as an Air Transport Pilot for a variety of companies. His flying career was interrupted between 1984 and 1989, during which time he worked in a technico-commercial capacity.

He was subsequently employed by AIR ENTERPRISE INTERNATIONAL, based at Le Bourget, before being employed by LEADAIR UNIJET in 1991.

1.5.1.1.5 Conditions of Work

The conditions of work, as regards work schedules and rest periods, conform to existing regulations (Civil Aviation regulations). The captain had flown 31 hours in the preceding month and 12 hours in the month under consideration.

1.5.1.2 First Officer

Aged 51, the first officer had been a freelance employee of LEADAIR UNIJET since January 15th 1991.

1.5.1.2.1. Licenses and Certificates

Commercial Pilot's License - Certificate N° 4183 issued on February 10th 1972, valid until February 28th 1995.

Commercial Helicopter Pilot's License - Certificate N° 965 issued on February 10th 1977, license not validated.

Medically class 1 until February 28th 1995.

1.5.1.2.2 Ratings

- Instrument Rating obtained on September 26th 1991 ;
- International Radio Telephony rating obtained on July 20 1977 ;
- Class D (engine) rating obtained on May 17th 1988 ;

Type ratings :

MD312 on February 10th 1972
BE 10/20 on May 6th 1991
D 20 on January 25th 1992
ND 16 (Transall) on February 10th 1992

1.5.1.2.3 Experience

FLYING HOURS	on all types of aircraft	of which on D 20	on helicopters
Total	3130	451	2300
Last 90 days	15	15	
last 24 hours	0	0	

D20 rating ground training course at Le Bourget completed from 6th to 23rd January 1992. In flight type rating on January 25th 1992. In flight adaptation from January 30th to February 10th 1992.

Ongoing checks and tests of competence were carried out in accordance with the legislation in force (Decree of November 5th 1987) :

- Last onboard check on a D 20 on September 8th 1994 ;
- Last ground check on D 20 on May 7th 1994.

1.5.1.2.4 Flying Career

The first officer began his career in aviation in 1968 in the French Air Force, where he completed 2600 hours flying on aircraft (CM 170, T 33, MD 312, C 160, DHC 6) and 2300 hours flying helicopters (Alouette II, Alouette III and H 34).

He undertook PP1/FPC training at the Transport Crew Instruction Center (CIET-Toulouse) in 1974.

He was a former officer of the French Air Force.

1.5.1.2.5 Conditions of Work

The conditions of work, as regards work schedules and rest periods, conform to the Civil Aviation Regulations. The first officer had flown no hours during the month in question.

1.5.2 Cabin Crew

The cabin crew consisted of one person, aged 23, who had been an employee of the EXAIR company since November 6th 1994. She held the Safety and Rescue Certificate N° 2721893, issued on September 3rd 1993.

1.5.3 Air Traffic Control Personnel

1.5.3.1 Control Tower

Scheduled manning for Air Traffic Control consisted of five personnel plus one backup. Four air traffic control officers (ICNA) were present :

- in the LOG position (aircraft taking off and landing), on the 119,1 MHz frequency : an approach controller, 37 years old, duly qualified for this position ;

- in the LOC assistant position (telephone coordination, preparation of progress strip, transfer) : an approach controller, 38 years old, duly qualified for this position ;

- in the SOL position (aircraft taxiing and ground vehicle movements) on the 121,9 MHz frequency : an approach controller, 43 years old, duly qualified for this position ;

- in the PREVOL position (aircraft requesting startup clearance, negotiations for departure clearance with Roissy Charles de Gaulle approach for aircraft with IFR flight plans, ATIS updating) on the 118,4 MHz frequency : an approach controller, 32 years old, duly qualified for this position ;

The section chief was absent. In accordance with operating procedures, his functions were undertaken by the most highly qualified controller, in the LOC position.

The backup officer was sick.

1.5.3.2 ATC Office

The staff from the air traffic control organization on duty in the ATC office on January 20th corresponded to the duty roster for that day (on duty from 08.00 to 20.00 local time).

The ATC Office at Le Bourget is made up of two sections, the BIA and the BDP/CDP.

The functions of the BIA (Aeronautical Information Bureau, which deals with processing flight plans as well as the associated messages, notams) were covered by two people :

- the BIA section chief, aged 40 ;
- a multi-role officer, aged 39.

The functions of the BDP/CDP (ATC office, runway control, in charge of control of the runways and bird strike hazard prevention measures) were covered by three people :

- the BDP/BCP section chief, aged 37 ;

- a multi-role officer, aged 27.
- a multi-role officer, aged 32.

The ATC Office personnel, because of the specific responsibilities attributed to them in the domain of bird strike hazard prevention, had received training from the air traffic technical service (STNA). This training consisted, for each individual, of a theoretical course lasting approximately one hour and in practical work handling shotguns and alarm pistols.

ATC office (BDP) officers were also issued with a booklet published by the STNA entitled "Birds of French Airdromes - Bird Strike Hazard Prevention". This booklet of around 60 pages gave basic information to those responsible for bird strike prevention hazard about the majority of species present at airdromes. Apart from illustrations of sixty-seven species of birds, the booklet also gives advice on the most effective bird scare methods for each species, emphasizing those which represent the greatest danger for air traffic.

Appendix 2 reproduces the double page related to the lapwing.

In addition, in the more general context of bird strike hazard prevention, the head of the BDP/BCP at Le Bourget was designated "local coordinator" (ref. para. 1.16.1.1). In this role, he was the STNA's correspondent for the airport.

1.5.4 Rescue and Fire Fighting Service

1.5.4.1 Organization and General Functioning

The organization and functioning of the Rescue and Fire Fighting Service (RFFS) conform to the ministerial decree of September 5th 1979 and instruction N° 20943 DNA/2/G of September 11th 1979, as modified by complementary directives n° 1,2,3 and 4, directive n°4 being dated May 19th 1994.

The RFFS at Le Bourget forms a branch attached to the RFFS section of Roissy-Charles de Gaulle airport. This branch is equipped with a foam and dry powder fire fighting vehicle (VIM.P). The duty team consists of two officers.

1.5.4.2 RFFS Crew on January 25th 1995

In the afternoon, the crew on duty consisted of two firemen :

- a highly qualified firemen with the HQ qualification, known as the "base fireman", with a wide knowledge of the infrastructure and considerable experience of working at the airport. He spends half of his duty time at Le Bourget airport ;

- a second highly qualified firemen with the HQ qualification, working at Le Bourget once in twenty three missions, on average.

1.6 Aircraft Information

1.6.1 Airframe

Constructor : Dassault Aviation
Type : Falcon 20 E (D 20)
Constructor 's number : 225
Date of manufacture : June 1972
Registration - F-GHLN
Registration certificate N° B 21092 of July 10th 1991
Certificate of Airworthiness issued on September 14th 1993, valid until November 19th 1996 (V situation).
Last Type C maintenance visit in September 1994 at JET Aviation's center at Bâle Mulhouse.
Total aircraft time : 7,865 hours.

1.6.2 Engines

Constructor : General Electric Aircraft Engines USA (GE)
Type : CF-700-2D-2 (4500 lb.)
Fuel type used : JET A1 (kerosene)
Both engines were installed on F-GHLN on March 4th 1994 :
- the left engine had run 5092 hours on 3657 cycles ;
- the right engine had run 3171 hours on 2982 cycles.

1.6.3 Airframe Maintenance

The aircraft had been purchased by LEADAIR UNIJET in 1990 from its Australian owner, the aircraft having been based in Melbourne. Until January 1990, maintenance had been carried out by the Australian company JET CARE PTY-LTD based in Brisbane.

Subsequently, F-GHLN was maintained by LEADAIR UNIJET. This company is authorized to undertake all maintenance inspections specified in the Maintenance Manual. However, LEADAIR UNIJET had had the type C (6 years) and type Z (2 years) maintenance inspections carried out by other companies : DFS and JET AVIATION.

The Maintenance cycle for the Falcon 20 is based on 5 types of inspection :

- type A inspection (every 300 hours flight time or every 6 months) ;
- type B inspection (every 1200 hours flight time) ;
- type Z inspection (every 2 years or every 2400 hours flight time) ;
- type C inspection (every 6 years) ;
- a thorough corrosion inspection after 24 years.

Maintenance inspection follow-up at LEADAIR UNIJET is carried out using the ANDROMEDA computer software system (an application of the CAMP computer assisted maintenance system). This system allows for optimization of aircraft maintenance forecast management. It also issues the Job Sheets for each inspection according to the latest applicable standards at the time of the inspection. For each type of inspection, the following table indicates dates (and/or flight hours) of the last inspection performed and the next one scheduled.

TYPE OF INSPECTION	**PREVIOUS INSPECTION**		**NEXT INSPECTION**		**1st Limit**
	Date	**Airframe hr.**	**Date**	**Airframe hr.**	
A	26 Sep 94	7806	26 March 95	8106	Reached
2A	26 Sep 94	7806	26 March 95	8106	Reached
2A+	26 Sep 94	7806	26 March 95		
B	26 Sep 94	7806		9006	
Z	26 Sep 94	7806	26 Sep 96	10206	Reached
C	26 Sep 94	7806	26 Sep 2000		

In addition, flight reports indicate no events which might have any bearing on our understanding of this accident.

1.6.4 Engine Maintenance

Engine aging and the last maintenance operations on the engines are shown in the following table :

	LEFT	**RIGHT**
SERIAL NUMBER	304454B	304530B
HOURS RUN	5,279 hr.	3,357
NUMBER OF CYCLES	3,803 cycles	3,127
LAST GENERAL SECA* OVERHAUL	at 3,828 hr. in July 1989	___
LAST SECA * HOT SECTION INSPECTION	at 4,720 hr. on May 22nd 1991	at 2,925 hr. on August 31st 1992
LAST LEADAIR UNIJET INSPECTION	200 hour interval inspection at 5,198 hr. on May 31st 1994	400 hour interval inspection at 3,298 hr. on August 30th 1994

*** Société d'Exploitation et de Constructions Aéronautiques, Le Bourget**

1.6.4.1 Right Engine

<u>Record of engine N° 304 530 B</u>

This engine left the factory on December 20th 1979. It was installed on 6 aircraft of different nationalities before being acquired by LEADAIR UNIJET in 1990.

<u>Maintenance</u>

Recent maintenance of this engine is detailed above.

1.6.4.2 Left Engine

<u>Record of engine N° 304 454 B</u>

This engine left the factory on May 28th 1977. It was installed on the Falcon 20 N°361, registered SU-AYD belonging to the Egyptian Air Force. Maintenance was carried out by Egypt (routine maintenance) and by SECA at Le Bourget (Hot Section at 1000 hr. and General Overhaul at 4000 hr. maintenance) during the period .

It was taken in part-exchange by GARRETT (USA) when SU-AYD was re-engined with TFE-731's. At that time it had effected 5002.46 hours of flying time.

It was resold by GARRETT to the Swiss company DREAM-AIR.

It was then checked (performance tests) and repaired (following a vibration problem) by FR-AVIATION in Great Britain.

This engine was bought by LEADAIR UNIJET, when it still had 5002.46 hours of flying time, and was installed on Falcon 20 N° 314 on November 27th 1990. It was installed on F-GHLN on March 4th 1994.

<u>Maintenance</u>

The engine log-books were kept up to date by the operators and the maintenance companies concerned, which enabled us to retrace maintenance operations on the engine throughout its life.

The major maintenance operations on this engine, namely hot section parts inspection and general overhaul, were carried out by SECA. Routine maintenance was undertaken by the successive operators : the Egyptian Air Force and subsequently LEADAIR UNIJET.

1.6.5 Aircraft Weight and Center of Gravity

The aircraft's gross takeoff weight was 28,100 lb., which was close to the maximum allowable takeoff weight of 28,660 lb., and the aircraft balance of 22.8% of Mean Aerodynamic Chord (MAC) was within the envelope of the center of gravity limits. The aircraft had full tanks (8,800 lb.) for this flight. The aircraft was therefore within the maximum allowable takeoff weight limits.

1.7 Meteorological Information

1.7.1 Synoptic Weather Information

The situation was characterized by a strong westerly airstream generated by a depression situated to the north of Ireland, associated with an unstable cold front.

Over the Paris region, this area of instability was especially stormy with clouds massing between 2,500 and 1,700 feet and low cumulonimbus at 1,500 feet. Heavy rainfall and hail were associated with frequent storms.

1.7.2 Surface Observations at Le Bourget Airdrome

The crew had waited for the end of the storm (from 16.00 to 16.25) before taking off. Le Bourget observations at 16.30 gave the following information :

Wind 200°/20 kts, visibility more than 10 kms, 3 oktas of cumulonimbus at 2300 feet and 6 oktas cumulus at 2400 feet . Temperature 6°C, dew point 3°C, airdrome QNH 1013 Mb.

1.7.3 Weather Forecast Provided to Crew to Prepare Flight

Before departure, the airline's Operations service had provided a flight dossier for the pilots,. It contained, in particular, the 1430 hr. weather observation and the forecast for Le Bourget airport :

1430 METAR : Wind 220°/14 kts, visibility more than 10 kms, patchy tower cumulus at 3500 feet . Temperature 10°C, dew point 3°C, airdrome QNH 1012 Mb.

1.7.4 ATIS

Before engine startup, the crew had received "Juliette" information broadcast by the ATIS at 15.30, which announced : runway 25, standard departure 8C, transition level 50, wind 200°/16-20 kts, visibility more than 10 kms, SCT clouds at 1500 feet, temperature +9°C, dew point +3°C, QNH 1013 Mb, QFE threshold 1005 mb..

The "Kilo" broadcast at 16.00 differed very little from the previous one, except for a change in the QFE reading (1006 mb).

Note that neither "Juliette" nor "Kilo" contained any reference to bird strike hazards.

1.7.5 Solar Illumination

At Le Bourget, sunset occurred at 16.27 (F-GHLN takeoff at 16.30). Night flying conditions commenced at 16.57. However, luminosity was reduced by the presence of storm clouds.

1.8 Aids to Navigation

1.8.1 Ground Radio-navigation Installations

All of the radionavigation installations on the ground were operational at the time of the accident. However, as a result of the emergency to the aircraft, the crew established a visual flight path.

1.8.2 Radar Equipment

In the Le Bourget control tower, the controllers can use offset imaging to monitor movements in the area of the airport by radar. This radar information is supplied by Roissy - Charles de Gaulle computers, where it is also recorded. Thus, the aircraft's flight path, estimated according to observations made by witnesses and by location of the debris, could be confirmed by the recordings of the radar parameters. (see Appendix 1, 2D and 3D trajectories).

1.9 Communications

1.9.1 Radio Telephony

During preparation of the aircraft, and then during taxiing, takeoff and flight, the crew listened to the ATIS frequency and was in contact with the Le Bourget ATC. The messages broadcast on ATIS and the radio communications were recorded in the technical section of the control tower.

1.9.2 Emergency Transmission

In accordance with Operations Manual instructions, the controllers activated the crash alarm when flames were visible at the rear of the aircraft. The crash alarm, via special circuits and alarms, informs the ATC office, the air transport police brigade (BGTA) the DICILEC and the Le Bourget and Roissy-Charles de Gaulle Rescue and Fire Fighting Service.

1.9.3 Telephone

The Le Bourget control tower has a direct line to the RFFS at the airport and at Roissy. They were thus instantly informed of the emergency concerning F-GHLN.

Other dedicated lines (to the Regional Control Center, to Air Traffic organizations at Roissy and Orly, to the ATC office, to the Le Bourget meteorological station, to the organization overseeing flight plans) were used , notably to inform them of the closure of the installations to outside traffic after the accident.

1.10 Airdrome Information

1.10.1 General

As a Parisian airport, Le Bourget is operated by "Aéroports de Paris" (ADP) a public company with independent authority and financial autonomy, placed under the authority of the Minister responsible for Civil Aviation.

It is a civil airport which is open to public air traffic. Its principal function is to serve business aviation in the Paris region and, on the day of the accident, it was classified in Category 3 for the purposes of fire protection, safety and rescue. Several air charter companies as well as organizations with activities linked to aviation are based in the airport facilities. It also houses some organizations attached to the Ministry of Defense and the Ministry of Finance (a naval aviation base and customs).

The installations are situated at an altitude of 217 feet. The infrastructure consists of three runways equipped with regulation day markings and night lighting systems :

- runway 07/25, oriented to 071/251, 3000 meters long by 45 wide, illuminated at night by both low- and high-intensity lights ;
- runway 03/21, oriented to 028/208, 2665 meters long by 60 wide, illuminated at night by low-intensity lights ;
- runway 09/27, 1845 meters long, constructed but not yet in service.

Taxiways, illuminated at night by blue lights, link the runways to the parking areas.

Runway 07 is equipped with ILS instrument approach equipment, and runway 25 with LOC DME and VOR DME equipment. The standard arrival and departure routes depend on the available area radionavigation services and on the VOR DME at Le Bourget.

The airport is situated in class D airspace. In accordance with regulations applied to this class of airspace, all flights are subject to flight control. Le Bourget's controlled airspace is included in the class A airspace of the Paris region.

1.10.2 Services Provided by Air Traffic Control

Le Bourget's air traffic control organization provides air traffic control, flight information and warning services to aircraft in radio contact with or recognized by it, for approach control and airport control. These services are provided from the control tower on the following frequencies :

- LOC : 119.1 MHz
- SOL : 121.9 MHz
- PREVOL : 118.4 MHz
- ATIS : 120.0 MHz

In addition, a ground vehicle frequency of 71.7625 is attributed to runway vehicles.

For aircraft departing from Le Bourget, two organizations provide air traffic control, flight information and warning services, namely :

- Roissy-Charles de Gaulle Approach Control, for the class A airspace surrounding the Le Bourget airport zone ;
- Le Bourget airport control on control tower frequency 119.1 MHz, for the class D airspace around Le Bourget.

The ATIS broadcasts messages containing different elements of useful flight information , notably, the runway in service, the meteorological conditions, altimeter settings, and essential information for operations (presence of birds). At Le Bourget ATIS updating is the responsibility of the preflight (PREVOL) controller on duty.

Aircraft taxing on the ground is controlled on the ground (SOL) frequency.

Start up clearance and instructions relating to the departure flight path are transmitted on the preflight (PREVOL) frequencies.

1.10.3 RFFS Equipment at Le Bourget

The ministerial decree of Sept. 5 and the instruction number 20943 of Sept. 11, 1979 define the organization and the operation of the rescue and fire fighting services at airports.

The Le Bourget RFFS is equipped with a foam and dry powder vehicle (VIM.P.).

Its capacities are as follows :

- 5,400 liters of water
- 700 liters of emulsifier
- 300 kilos of dry powder

This capacity in the main extinguishing agents (water and foam) and in the complimentary extinguishing agent (dry powder) corresponds to Le Bourget's classification in category 5, ensuring level 5 protection.[2]

1.11 Flight Recorders

1.11.1 Recovery from the Wreckage

In accordance with applicable regulations, the aircraft was equipped with one protected recorder. This was a Cockpit Voice Recorder (CVR) manufactured by COLLINS, type 642-C1, reference 522 405 7001, serial N° 21. This recorder was found in its installed position in the unpressurized tail section of the aircraft.

1.11.2 Opening of CVR

The recorder showed signs of exposure to fire and some impact damage. Nevertheless the magnetic tape inside the protective container was not damaged.

The opening of the CVR and the copying of the original tape were carried out at the Bureau Enquêtes-Accidents (BEA) on January 21st 1995 in the presence of an officer of the judicial police. The officer, who brought the CVR duly sealed, took away the original tape and the CVR container newly resealed .

1.11.3 Copying and Readout

1.11.3.1 Transcription of Contents

<u>Methodology Applied</u>

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[2] The commander of Le Bourget airport, considering the classes of aircraft using the airport and the volume of traffic, requested an order to upgrade to level 5 as soon as was practicable, in order to reduce the gap between the real and the required level, without prejudging any measures to be put into effect as from Jan. 1,1996 (upgrade from level 5 to level 6 requiring that the airport be equipped with a minimum of 2 fire fighting vehicles manned by 5 firemen).

Two copies were made of the original tape : one on a quarter-inch four-track tape and the other on a one-inch eight-track tape. These copies were untreated, with no filtering or modification of the recording level.

The playing speed of the original tape was adjusted by spectral analysis of the interference from the onboard electrical system (400 Hz). The post-synchronization, carried out by comparing the relative times of the radio broadcasts with the air traffic control recording, presented no particular difficulty. It was then possible to define UTC from the recordings of the control tower communications .

The crew did not use hot mikes for communication. Their communications were recorded through the cockpit area microphone. Digital filtering techniques were used to improve comprehension of certain phrases. In addition, listening analysis was undertaken using several people who knew the pilots (notably the Chief Pilot of LEADAIR UNIJET). This facilitated identification of the voices and comprehension of the dialogues between the members of the crew, as well as distinguishing the different types of aural warnings on board the plane.

<u>The Contents</u>

This type of recorder functions by recording the last 30 minutes (in fact slightly more) before an electrical power cutoff. In the present case, the thirty minutes relate to the entire flight and accident.

Thus, by referring to the CVR time (noted as XX.XX in minutes and seconds) the successive stages of the recording are as follows.

- 00.00 to 17.00 aircraft at a standstill, electrical power on
- 17.00 engine start-up, taxiing, alignment
- 29.27 increased engine speed in preparation for takeoff, then beginning of roll
- 29.55 end of noise of roll, corresponding to takeoff
- 29.59 first thud followed by a decrease in engine speed
- 30.09 second thud followed by an increase in engine speed
- 30.16 fire alarm until end of recording
- 30.45 end of recording.

The transcription of the recording constitutes Appendix 4.

1.11.3.2 Spectrum Analysis

Up until 29.59, the recording contains no sounds which could indicate abnormal situations. The increase in engine speed during rollout or takeoff are well synchronized and perceived. The recording shows clear evidence of two thuds (CVR time 29.59 and 30.09) just after rotation.

The CF700 2D-2 engine is made up of a two stage turbine and a free floating fan assembly. This stage generates the greatest acoustic energy particularly during the rapid deceleration or acceleration phases. It is thus possible to determine engine rpm through the use of spectrum analysis.

The graph in Appendix 4 shows the deceleration then the acceleration in the speed of rotation of the fan disc. The relative time read on the CVR is given in minutes, seconds, one-hundredths of a second and the speed of rotation of the fan disc in revolutions per minute.

The first information on rotation speed is obtained from CVR time 29.59.90 at the time of the first thud. The speed then decreases very rapidly from 8,556 rpm to 3,840 rpm in slightly over one second.

At CVR time 30.06.50 the variation in the speed of rotation can again be determined : the fan disc accelerates from 6,660 rpm to 15,456 rpm in three seconds. At this time the second thud is heard with a total loss of information on rotation speed.

1.12 Wreckage and Impact Information

The aircraft struck the ground across the threshold of runway 21 at the edge of the paved surface. The shallow marks on the runway show that the aircraft struck the ground in a nose-down attitude at an angle of approximately 15 degrees to the left.

After this initial impact, the aircraft's trajectory on the ground curved slightly to the right to the point where it stopped.

By following the marks which the aircraft left in the grass, the rear part of the fuselage was found first (in B, appendix 1, illustration 2 of the photo appendix), sectioned at an angle from frame 38 to frame 40 to the right of the leading edge of the vertical stabilizer. The vertical stabilizer was found inverted, approximately 150 meters after the threshold of runway 21. The elevators and rudder were complete and did not appear to be damaged. There was significant fire damage on the left side of the rudder and, while the right hand vertical surface was practically intact, the left side, especially the undersurface, was in such a condition that the surface plates were deformed by the heat. The tail cone, containing the drag chute, was missing.

Examination of the interior of the rear part of the aircraft shows that the right side bore no traces of fire whereas the left side did. The fire detection system was ruptured in several places. The electrical cabling routed on the left side showed significant traces of overheating. The protection and insulation ducts were destroyed by the fire. The main electric cable bundle was badly damaged.

A few meters further on, the left engine tailpipe was found, relatively undamaged by the fire.

The radome was found 315 meters from the threshold of runway 21 (at C, Appendix 1).

The main wreckage (at D, Appendix 1) was found flat on the ground 430 meters from the point of initial impact. As can be seen in plate 2, it was completely destroyed by the violent fire which swept through the rear compartment, the cabin, the cockpit, the right wing and the right engine. The left wing and the left engine were comparatively less damaged.

The roof of the cabin and the cockpit were destroyed throughout their length, entirely consumed by fire. Between the cockpit and the cabin, the fuselage was partially severed vertically behind the passenger door. This door lay open, unlocked as a result of the partial breakup of the fuselage. At the rear of the cabin the pressure bulkhead was severely damaged, buckled towards the front with obvious traces of fire. Both the cockpit and the cabin were entirely destroyed by the fire. The instrument panel and the central console were in such a condition that the front of the instruments were burnt out : it was impossible to read out any parameters. Only the following items of information could be established :

- the flap control handle was set at 25 degrees ;
- the landing gear control was in extended position ;
- the standby electric pump selector was in intermediate left position (on the side of hydraulic circuit number 1) ;
- the four control switches on the fire warning panel board were in normal position (low position), the safety wires being intact ;
- the two fire shutoff valve handles were in the inactive position, that is to say not pulled towards the rear;
- the ram air scoop control was in closed position ;
- the two P3 shutoff valve control switches were in open position.

On the central console, the thrust levers of each engine were in the forward position, out of line but free. Taking into account the rescue attempts undertaken, the position of these levers cannot be considered as representative of their position at the time of accident.

The trailing edge flaps were in the intermediate position ; the leading edge slats and the airbrakes were extended.

The left engine remained attached to the fuselage by its pylon. The rear part (that is to say the fan rotor assembly, the outlet vanes, and the tail cone) had disappeared.

The following missing components were found on the airfield :

- the outlet vanes, the tail cone and some pieces of the disc blades were found on the runway or immediately next to it (see E and F, Appendix 1) ;
- the fan rotor assembly, in one piece but stripped of the majority of its blades, was found 515 meters to the left of runway 25 (G, Appendix 1) after a special search operation.

The right engine was stripped of its cowlings, which were completely melted. Superficially the engine appeared to be complete.

The two engines were sent to the CEPr engine test center (Center des Essais des Propulseurs) for expert appraisal.

The aircraft wreckage was placed in a hangar so that, in coordination with the manufacturer, detailed examination of the fuselage and disassembly of equipment whose condition allowed it, could be undertaken.

The results of these investigations are described in chapter 1.16.5.

1.13 Medical and Pathological Information

The seven passengers and the three crew members were killed in the accident. The passengers were found belted into their seats, the passengers seated on the left were leaning toward the aisle (see the positioning of passengers in the cabin in appendix 5).

The first officer in the left seat, the captain on the right and the cabin attendant on the jump seat were all buckled in. The pilots were not wearing emergency oxygen masks.

Certain bodies were completely carbonized while others showed no visible signs of serious burns. The occupants all breathed in at the seat of the fire.

Doctors who undertook the autopsies noted the presence of traumatic internal injuries or severe locomotor system injuries. Five victims, including the two pilots, had skull and brain or cardio-vascular injuries (in particular, ruptured aorta, ruptured right auricle). Three of the victims had fractured spines. Two of victims seated at the rear of the plane showed very few or no significant visible injuries.

1.14 Fire

The two firemen on duty at the Fire Station at Le Bourget (the station is situated near the control tower, see trajectory 2D in Appendix 1) were informed of the accident by the activation of the crash alarm at 16.30 (light and audible signals).

The firemen described the events in the following manner :

Manning their vehicle, the two firemen proceeded along the former runway 09/27. On their right they saw the aircraft, whose rear was on fire, begin to descend towards the left, a descent which they judged to be dangerous. From position H (see trajectory 2D, Appendix 1) they saw the aircraft strike the ground violently, "a ball of fire came from the plane," the rear part of the aircraft detaching itself as the aircraft slid along.

The fire truck took runway 03/21 then runway 07/25 and drove along with 4 wheel drive engaged to position itself to the west (downwind) to fight the fierce fire which was blazing throughout the airframe (position I). At this time they noticed the passenger door was open and that the upper part of the fuselage above the cabin was being penetrated by the flames. It was 16.23. The fire was extremely violent.

Using the turret hose, the firemen discharged all of the 6000 liters of foam concentrate at their disposal onto the seat of the fire. It was then 16.36. The notable decrease in the intensity of the fire then allowed them to approach the airframe and ascertain that its condition could not leave one to suppose that there were any survivors inside. The fire truck returned to the RFFS station to fill up with fire fighting medium by following the marks left by the aircraft on the ground, so as to be able to find any possible victims who might have been ejected from the aircraft.

At 16.44 the main fire truck from the fire brigade at Barges (which had been alerted by an alarm at 16.34) arrived at gate C at the airport. The firemen fought the flames which remained on the aircraft and the residual fires at the rear of the wreckage with two manual foam hoses. The Garges firetruck was then resupplied by a further fire truck arriving from Gonesse.

At 16.49 the first Paris/Aulnay fire brigade truck arrived at the rendezvous point Z1. At 16.55 the Le Bourget firetruck returned to the site and sprayed foam with the turret hose and the side hose.

At 17.08 the fire was totally extinguished, with a continuing presence of some smoke.

At 17.56 the crash alarm was transformed into a limited alert. The airport remained closed to air traffic.

1.15 Survival Aspects

The cabin and the cockpit (see paragraph 1.12) were completely destroyed by an intense fire.

The exposure to the kerosene fire during the 400 meters that the aircraft slid would be sufficient explanation of the cause of death of passengers who may have survived the consequences of the initial impact. It must be concluded that death was instantaneous, as a result of the very rapid propagation of the fire and of the temperatures reached.

1.16 Tests and Research

1.16.1 Organization of Bird Strike Hazard Prevention in Civil Aviation

1.16.1.1 General

In application of a decree relating to bird strike hazard prevention at airports under the tutelage of the minister responsible for civil aviation, the ministerial instruction of July 24, 1989 established the rules by which the bird strike hazard prevention should be undertaken at airports.

This decree is contained in appendix 6.

The instruction defines the central organization, in essence :

- the air traffic management division (DNA) develops the policy to be put in place for bird strike hazard prevention.

The air traffic technical division (STNA) carries out the policy defined by the DNA. It is, in particular, responsible for :

. the choice and follow up of countermeasures to be put in place at airports,
. local ornithological and ecological studies enabling action to be undertaken on the spot and equipment to be installed,
. studies and experiments on devices and methods designed to reduce the risk of bird strike on aircraft,
. basic training of all personnel concerned by bird strike hazard prevention at airports (with the cooperation of the national civil aviation school for the organization of certain courses) and of specific training and assistance of local bodies,
. assistance to airports in the installation and utilization of equipment,
. the setting up and updating of the list of equipment which should be used,
. an annual report on all bird strikes registered and the statistical analysis of incidents,

. participating in investigations related to aircraft accidents resulting from bird strike,
. the organization of specific operations at airports such as the poisoning of birds when this is judged indispensable.

Thus, each airport is attributed a minimum equipment stock. Chapter 5 of the instructions states :

"the local ornithological environment is defined principally by :

- the species of birds present
- the periods of bird activity, being either continuous, seasonal, or episodic
- the density of the bird population."

Analysis of the characteristics of this environment, of the volume of commercial traffic, and of the different types of aircraft leads to the attribution, for each airport at which it is necessary to establish bird strike hazard prevention measures, of a minimum setup (personnel and equipment) in the fight against bird strike hazard."

In this context, Appendix 1 of the instruction defined five groups (from A to E), group E being that which corresponds to the highest degree of bird strike hazard.

Categories of personnel responsible for bird strike hazard prevention include (paragraph 1.2 and 2.1 of the instruction) :

- a local coordinator, a public employee, with the necessary competence and who has an executive position within the air traffic control organization of the airport,

- air traffic control personnel responsible for controlling aircraft or for flight information,

- personnel (operatives responsible to the manager or in certain specific cases officers of the air traffic control organization), responsible for bird strike hazard prevention at the airdrome - personnel are either assigned exclusively to bird strike prevention or carry out another activity at the airfield,

Equipment used for the prevention of bird strike hazard is made up of mobile equipment (vehicles equipped with electroacoustic equipment to broadcast specific distress calls, the firing of crackle flares, selective shooting of authorized species with shot guns) and of fixed equipment (automatic bird scaring systems broadcasting specific signals designed to disturb the birds along the runway in order to prevent them settling.). The decision to install fixed equipment on an airfield is taken after a preliminary study undertaken by the STNA.

According to article 6 of the decree of July 24, 1989, bird strike hazard prevention measures are undertaken during the operating hours of the air traffic control organization of the airport, with the exception of night operations.

1.16.1.2 Bird Strike Hazard at Le Bourget

1.16.1.2.1 Airport Environment and Ornithological Situation

Le Bourget airport is situated approximately 15 kilometers north of the capital in a highly urbanized area. It is spread over an area of almost 800 hectares, of which almost half is not surfaced. These non-surfaced areas are covered by crops or grass. This situation encourages the presence on the airdrome of birds which are dangerous to air traffic (pigeons coming from Paris in summer, seagulls and lapwings in winter).

In order to remove the presence of birds which are dangerous to air traffic from the environment, the following actions have been taken since 1983 :

- the banning of crops considered to be attractive (wheat, barley, oilseed rape, sunflowers, peas...),
- the restriction of varieties to hoed crops, market garden crops, oats and corn,
- the upkeep of grassed areas (by the ADP maintenance department) to allow a minimum height of 20 to 30 cm containing no attractive plants (clover,...),
- the covering (in 1994) of the water reservoir by a net.

On the basis of statistical evidence transmitted to it, the STNA has noted an improvement in the ornithological situation of Le Bourget since 1990, the number of pigeons observed in summer has decreased substantially as has the number of lapwings.

However, an unfavorable event occurred in 1994 : work undertaken for the creation of a new runway and corresponding taxiways caused large shale movement of earth and the creation of bare areas which were resown only in the autumn. Numerous puddles appeared in the course of the winter, encouraging the arrival of gulls and lapwings. In fact, a NOTAM, applicable from December 19 1994 to February 22 1995, was issued warning of the presence of numerous birds.

We should also note the presence of several hundred rabbits near to the intersection of runways O7/25 and CEPr 03/21. This presence causes the almost total disappearance of vegetation again encouraging birds to settle in this area. Hunts are organized regularly in order to try to reduce this population.

In order to assess the ornithological situation of the airfield, we must also take into account the existence, outside of the airdrome of several zones over which the aeronautical authorities have no control, which are attractive to birds :

- the La Courneuve park situated to the South,
- a sewage treatment works on the approach to 03,
- cultivated areas to the north and the east,
- garbage dumps at Gonesse.

These various attractive elements create conditions for overflying of the airdrome by birds moving between roosting areas and feeding areas in the morning and the evening. These birds can also come and settle on the airdrome regularly, which gives them a certain tranquillity.

1.16.1.2.2 Statistics

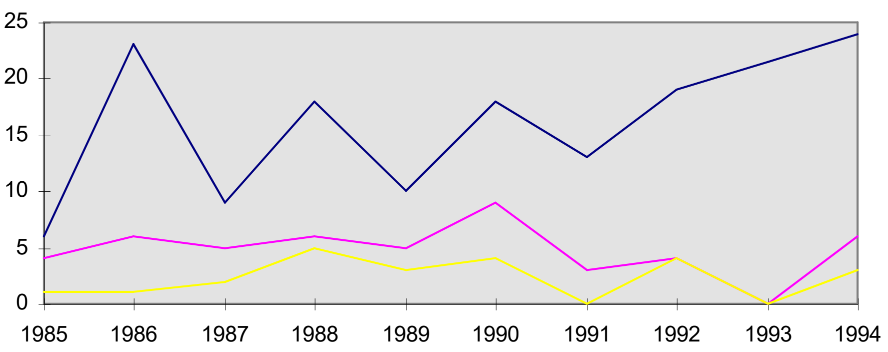
At Le Bourget

The first accident caused by birds occurring in France involving a civil aircraft happened at Le Bourget on December 6th, 1982 (collision between a Lear 35 with seagulls, causing aborted takeoff and runway excursion, an accident described in Appendix 7).

The following graph shows the evolution in the number of bird strikes at Le Bourget since 1985. According to the STNA, these statistics require the following remarks :

- the total number of collisions recorded after 1992 is mainly as a result of better collection of data,
- in 1993, no engines were damaged,
- in 1994, out of 24 incident reports[3], 10 were submitted by the control tower, based on dead birds found on the runway.

Annual incident rate at LE BOURGET



World Wide

A 1990 British study (CAA Bird Strike Committee Europe) lists all of the civil aviation accidents around the world caused by collisions with birds in the period 1960-1989 (see appendix 7).

This list gives rise to the following remarks :

- although some accidents happen during cruising, the majority take place during take-off,

- of 18 accidents recorded, 10 concern business aircraft, of which 3 were Falcon 20's. Of the 10 accidents to business aircraft, 8 involved the engines.

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[3] Analysis of the 24 incident reports concerning bird strikes at Le Bourget in 1994 gives the following breakdown of species :

TOTAL BIRD STRIKES
PIGEONS
LAPWINGS
FALCONS
GULLS
SWIFTSNON
IDENTIFIED
SPECIES24644325

1.16.1.3 Equipment

For the prevention of bird strike hazard, Le Bourget possesses the following equipment, corresponding to group D of the ministerial instruction of July 24, 1989 :

Mobile Equipment

- one 4WD vehicle equipped with electro-acoustic material to broadcast specific distress calls ;
- Two alarm pistols to fire crackle flares
- Two 12 gauge shotguns and cartridges.

This equipment was available on Jan 20, 1995.

Fixed equipment

The fixed equipment is made up of an automatic scaring system which broadcasts acoustic signals designed to scare off birds.

Runway 07/25 is thus equipped with a line of bird scaring loudspeakers 10 meters to the right of the edge of runway 25.

The line of loudspeakers is made up of 5 sections, each consisting of 16 loud speakers 35 meters apart. Behind each speaker a reflecting panel, 0.8 m X 1m, is positioned to serve as an anti-noise screen. This screen is intended to prevent dispersal of sound to the inhabitants of the nearby town (see appendix 3, photo of a loudspeaker and anti-noise kit).

According to the STNA and the airport manager, there had been numerous problems in maintaining this system in operational condition since it was put into service in spring 1992.

First of all, the proximity of the towns of Dugny, Garges Les Gonesse and, to a lesser degree, Bonneuil en France, obliged the authorities to reduce the volume broadcast in order to take into account the numerous complaints of the nearby inhabitants.

To overcome this difficulty, the airport commander requested, in 1992, that a control system linked to wind direction be installed in order to automatically diminish the volume of sound towards sensitive areas. In addition, during this period the loudspeakers nearest to Dugny were frequently not activated in order to diminish noise disturbance.

Moreover, the line of loudspeakers was regularly damaged each time a jumbo jet took off in 1992 and 1993. It was noted that the panels, which were too close to the runway, were very vulnerable to jet blasts from these aircraft. For the purposes of comparison, the same loudspeakers installed at Orly on runway 08/26 are not positioned 10 meters from the runway but 25 meters from it.[4]

[4] According to the initial project in Dec. 1988 the STNA had proposed equipping runway 07/25 at Le Bourget with a system of loudspeakers positioned 25 meters from the runway edge. In July 1991, ADP sent the STNA a description of the corresponding project, with the line of loud speakers placed 10 meters from the runway edge. At that time the STNA made no objection to the installation 10 meters from the runway edge

Unavailability was also caused by the numerous rabbits present on the site which gnawed the electric cables which were lying on the ground. This problem was solved in 1993 when the runway lighting was renewed.

In summary, it seems that, for a variety of reasons, the loud speakers were frequently unavailable following their installation. They were not in working order on January 20th 1995, and had not been for about one year previously.

The loud speakers, repaired and reinforced, were put back into service in February 1995 and now perform satisfactorily. In addition, the control system linked to wind direction, previously mentioned, was installed.

1.16.1.4 Operation

At Le Bourget, the bird strike hazard prevention service is the responsibility of the ATC office. It should be noted that, in letter number 022045 STNA/2N of April 3 1991, on the subject of instructions to be given to personnel engaged in bird strike hazard prevention service at certain airports in the Paris area, addressed to ADP operations, the STNA expressed reservations concerning Le Bourget airdrome, considering that the ATC office manpower was inadequate. The DNA increased the personnel of the ATC office in order to carry out this specific mission.

The ministerial decree of July 24, 1989 was applied through regulations in the following way.

Internal regulation number 298/0G-A-LB indicates :

"From Oct. 1,1991, where the duty roster allows it, two officers will be detailed everyday to undertake bird strike hazard prevention tasks in accordance with the new classification of Le Bourget airport. A half-day system will be adopted : in the morning from 08.00 local time to 1200 local time, in the afternoon from 1400 local time to 1800 local time.

Clearly, every day from 1200 to 1400 local time and on Saturdays and Sundays, as a result of manpower shortages in the ATC office, the airfield will be downgraded and bird scaring operations will be undertaken upon request. Information will be transmitted by Notam."

Internal regulation number 301/OG-A-LB/91 specifies :

"where the duty roster allows it, two officers will be delegated to bird strike prevention every day (see internal regulation number 298/OG-A-LB/91)".

It also adds :

"During the critical period between Oct. 1 and March 31, the duty periods of officers responsible for bird strike hazard prevention will be from 08.00 to 12.00 and 14.00-18.00 local time. From 12.00 to 14.00 local time and at weekends, bird strike hazard prevention will be carried out upon request."

In fact, on a day-to-day basis this service was undertaken in the following manner : according to the theoretical time table (08.00-12.00/14.00-18.00 local time) ATC officers undertook bird strike hazard prevention service successively without any of them being designated by name according to the half-day system. The ATC office duty chief designated officers according to circumstances.

The replacement of the officer coming off duty by the agent coming on duty was carried out in the ATC office. This procedure allowed for briefing time but implied discontinuity each time there was a shift change of approximately a quarter or a half an hour.

Article 6 of the ministerial decree of July 24, 1989 specifies that the bird strike hazard prevention service should be maintained, apart from the night period. According to the aeronautical understanding of this expression, this means that this service should be maintained from 30 minutes before sunrise until 30 minutes after sunset.

However, a certain ambiguity existed due to the fact that the STNA, when issuing instructions on bird strike hazard prevention in January 1993, referred to "calendar night". This anomaly was corrected subsequent to the accident.

1.16.1.5 The Situation at Le Bourget on Jan. 20, 1995

The organization of bird strike hazard prevention at Le Bourget has been described.

On January 20, not all of the equipment used in bird strike hazard prevention was available, since the line of loud speakers on runway 07/25 had been out of service for one year.

One of the officers on duty in the morning with the specially equipped vehicle had scared away some lapwings by firing 15 rounds at them.

Another officer had carried out the service from 1300 to 1500. He had observed, in the course of his first round, the presence of 300 to 400 lapwings, settled on a piece of plowed land near to the threshold of runway 25 between the holding fix and Taxiway 8N (see Appendix 1- 2D trajectory). At around 1400, he had fired 20 alarm flares, causing the lapwings to disperse towards the northeast of the airfield. Up until 1500 hours, patrolling the airfield, the officer no longer noticed any lapwings (which surprised him), either on the plowed piece of land from which they had been dispersed or on other areas of the airfield.

At 1500 this officer, feeling ill, had returned to the ATC office and had then gone home with the agreement of the duty chief.

From 1500 hours onwards, there were no further rounds. No unusual bird activity was reported by aircrew. In addition, an official of the ATC office who convoyed a tanker on runway 21 but did not observe the presence of any birds.

1.16.1.6 The Lapwing

The booklet "Birds of French Airdromes - Bird Strike Hazard Prevention", describes (see appendix 2) the characteristics and behavior of the lapwing.

We may note that these birds particularly favor open spaces, plowed land or areas with low vegetation (such as runway verges) where they group together in quite large numbers. They move both during the day and at night, in any direction with no particular logic. They land on runways in certain meteorological conditions (most notably after rainfall).

Concerning prevention, the booklet gives the following advice :

- simultaneous use of pyrotechnics and firing shot guns reinforces the scaring effect,

- wait after each operation, to make sure that the birds have in fact departed, since they can at times turn at high altitude and return as soon as the vehicle goes away,

- do not let lapwings settle in winter,

- harass all new arrivals,

- remain very vigilant in the morning and evening during their daily movements.

1.16.2 Aircraft Performance

1.16.2.1 The Aircraft

The Falcon 20 is an aircraft with a pressurized cabin designed to transport eight passengers and two crew in the standard version.

The fuselage is divided into two parts, the cockpit and the passenger cabin, separated by the entranceway.

Appendix 8, based on Dassault Aviation documentation, gives three views showing the dimensions of the aircraft.

Between 1965 and 1990, 476 Falcon 20's were constructed. Originally equipped with General Electric CF 700 engines, certain aircraft were re-engined with GARRETT engines (ATF3's for the Falcons of the US Coast Guard, TFE 731's for the Falcon 20-(X)5). 327 aircraft equipped with CF 700 engines are currently in service.

1.16.2.1.1 Description of Systems Concerned by the Accident

These systems are described in Appendix 8.

1.16.2.1.2 Fire Protection

There are 5 fire protection zones :

- each engine (compressor, accessory gear box, combustion chamber, fuel heater),
- the unpressurized rear compartment,
- the two main landing gear well compartments,
- the APU.

On the instrument panel, the left and right engine fuel shut off handles are positioned on either side of the fire warning panel, which contains the 5 fire warning lights corresponding to the protection zones previously mentioned (see Appendix 8, fire prevention). The four extinguisher switches are positioned immediately under these lights. The switches corresponding to the engines are of the three position type, while those which correspond to the rear compartment and the APU are of the two position type. They are fixed in the 0 position with safety wires.

1.16.2.1.3 Fuel Circuit

Appendix 8 shows the distribution of the Falcon 20's fuel tanks and their respective capacities.

The available tank capacity is 8832 pounds, distributed in the following way :

- wing tanks : 2 x 3686 pounds
- feeder tanks : 2 x 730 pounds.

Each of the two feeder tanks, which supply the engines by means of a low pressure electric pump, is made up of a bladder type tank contained inside a ventilated structural box. These feeder tanks are situated in the unpressurized section of the fuselage, at the rear, between the engines. They are pressurized by engine bleed air through a pressure reducer valve.

1.16.2.1.4 Flight Control System

Description of Primary Controls

The primary flight control system is a fully powered irreversible system. Control progresses from the cockpit through a system of push-pull rods and machined bellcranks to the dual barrel hydraulic servocontrols, one for the rudder, one for the elevator and one for each aileron. The actuators have two independent barrels, each supplied by a separate hydraulic system. Thus the airplane remains hydraulically controlled if either system should fail. Controls may be operated manually, with some loss of control effectiveness, if complete hydraulic failure should occur. Since no aerodynamic feedback is transmitted from the control surface to the cockpit controls, artificial feel is provided through springs. Spring tension is automatically changed, as a function of speed, to provide stiffer feel in the pitch and roll axes at high speeds. The control surfaces have no tabs of any kind but electrical trimming is provided on all three axes.

Horizontal Stabilizer

The variable incidence horizontal stabilizer is used to effect pitch trim on the aircraft and is entirely electrically controlled. Two control circuits, one normal (supplied by the primary bus) and the other standby (supplied by an auxiliary bus), control the movements of the horizontal stabilizer from the cockpit through separate cockpit switches and wiring.

With slats deployed, the travel range of the horizontal stabilizers with the normal control system is as follows :

0 degrees maximum nose down ;
7 degrees 45 nose up.

Aerodynamic Devices

Aerodynamic devices, as described below, are the trailing edge flaps, leading edge slats and airbrakes (spoilers).

Trailing edge flaps

The trailing edge flaps consist of four all-metal slotted sections, two on each wing, mechanically connected together. The flaps move aft and down in the extension process. They are electrically controlled and hydraulically actuated from No 1 system pressure. A single hydraulic motor operates a torque-drive linkage to one jack screw on each inboard flap section and two on each outboard section. Emergency extension is by means of manual crank operation. The socket for emergency crank operation is in the aft cabin aisle wall, parallel to the wing trailing edge. The manual crank is stowed at frame 7, behind the copilot's seat.

In the event of hydraulic failure of No 1 system, the flaps can be operated from the transfer jack using the "FLAPS EMERG" button on the pedestal.

Leading-edge Slats

The slats extend from the fence to the tip of each wing.

The slats are electrically controlled and are actuated by two hydraulic actuators supplied by No 1 hydraulic system pressure and located in each wing leading edge. Depending on the position of the control handle, the slats are either fully extended (25 degrees down) or fully retracted. Internal locks at the extend and retract ends of the actuator cause the actuators to retain the position they are in if a hydraulic failure occurs.

Extension of the slats is initiated by selecting the flap control handle from the Clean position to the 15 degree detent corresponding to the first flap deflection position.

Retraction of the slats is initiated by selecting the flap control handle from the 15 degree position to the Clean position. The slats start retracting when the trailing edge flaps have retracted (0 degrees flap deflection).

Airbrakes

The airbrakes consist of two panels mounted on the upper surface of each wing.

They are electrically controlled by a pedestal mounted control handle and they operate off No 1 hydraulic system pressure. In the event No 1 hydraulic system should fail, the transfer jack can be used for airbrake operation.

The airbrakes have two positions : extended (70 degrees or less according to speed) or retracted.

1.16.2.1.5 Electrical System

The airplane electrical system consists of both AC and DC power.

The basic 28.5 Volt DC[5] system is powered in-flight by two engine-driven generators, which double as starters, and two parallel-connected batteries, used under conditions of temporary overload or failure of both generators. One generator is capable of supplying the entire load requirements of the airplane in normal operation.

The standby electropump is connected to a non-loadshedding bar.

The two batteries are located in the rear compartment, in an insulated and ventilated container.

1.16.2.1.6 Hydraulic System

There are two independent hydraulic distribution systems which cannot be interconnected. Each system [6]is normally supplied by its individual engine-driven pump, with hydraulic fluid at 3,000 psi working pressure. A third pump, electrically driven, can by selected to provide stand-by hydraulic power, at 1,600-2,150 psi, to flight controls normally operating off the No 1 system or the flight controls and yaw damper normally operating off the N° 2 system.

N° 1 system supplies one barrel of the dual servo-actuator of each flight control surface through a check-valve.

N° 1 system is also used for operation of flaps, leading edge slats, airbrakes, normal brakes, nose wheel steering system and landing gear (extension and retraction).

N° 2 system supplies the other servo-actuator barrel of each control surface, the yaw damper, the aileron and elevator Arthur units (Q units), the emergency landing gear extension system and the emergency and parking brake system.

A transfer jack powered by No 2 system pressure is also provided to deliver a lower pressure usable for landing gear retraction or extension, or for operation of the airbrakes or for normal brake application at landing. The transfer jack can also be used for operation of the flaps (in lieu of landing gear or brakes) through a cockpit controlled solenoid valve.

<u>Stand-by electric pump</u>

This electric motor driven pump is supplied DC power from the main bus. It is controlled by a five-position selector on the center instrument panel. The selector is center-off and has a test and an operating position for each distribution system. In the "OFF" position, the pump is off, and supply and distribution are isolated.

When the selector handle is in the first detent position (test position) either left or right, the stand-by pump starts operating if the system pressure is less than 1,600 psi and it draws fluid from the emergency chamber of N° 1 or N° 2 reservoir. The stand-by pump accumulator is thus filled with fluid.

When the selector handle is placed to the full left position (operation position) the stand-by pump supplies pressure to the servo-actuator of No 1 system, the leading edge slats, flaps, landing gear operations and braking.

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[5] The CVR is supplied with DC current

[6] N° 1 hydraulic system driven by left engine
N° 2 hydraulic system driven by right engine

When the selector handle is placed to the full right position, the stand-by pump supplies pressure to the N° 2 system servo-actuators and yaw damper.

Transfer jack

The transfer jack consists of two separate chambers of different cross-sectional area, the larger on the No 1 system side, and the smaller on the No 2 system side. Due to the difference in area, the No 1 chamber is full when both systems are pressurized. When No 1 system pressure drops, the piston, forced by full pressure in No 2 chamber, drives the fluid from No 1 chamber to supply the selected systems at a maximum of 2,500 psi.

1.16.2.1.7 Air Conditioning and Pressurization

Pneumatic System

Air conditioning and pressurization of the cabin, cockpit, and nose cone is accomplished through compressed air bled from each engine compressor casing. Shortly after leaving the engine, a small part of the air is ducted off to pressurize the fuel tanks and hydraulic tanks and to allow, by means of a manually controlled valve, an emergency air supply for cabin pressurization and air conditioning. The greater part of the compressed air continues through the engine bleed valve and flow limiters to the air conditioning valve.

Engine bleed valve

Two engine bleed valves, one for each engine, are electrically operated through a pair of two-position switches on the pedestal or the instrument panel. They are open for normal operation and can be closed individually in case of engine fire or smoke.

Ram air scoop

For unpressurized flight or emergencies, the nose cone, the ventilation system, and the air conditioning system may be supplied with fresh air through a retractable ram air scoop which is extended either by a switch on the pedestal, or automatically when the fire extinguishers are discharged in the rear compartment.

The main pneumatic equipment (including the P3 line) is grouped together in the upper part of the rear compartment, in an area at the base of the fin.

The two pressure control valves which regulate airflow are located half way up the pressure bulkhead (see Air Conditioning and Pressurization plates in Appendix 8).

1.16.2.2 Engines

Design

The engine consists of a CJ 610 gas generator, with a free-floating, single stage , integral fan/turbine section added to the aft (see appendix 9, plate 1).

The fan section operates as a free-floating system. The fan is driven by the hot exhaust gases leaving the turbine, which then imparts velocity and pressure to free air ducted into the engine around the compressor section. The cold air stream is compressed in a ratio of 1.6 and flows out via outlet vanes. The thrust is thus increased by approximately 57% (4500 lb.) in comparison to that of the CJ 610 (2850 lb.) for a specific fuel consumption improvement of approximately 35%.

Control system

By design, only the gas generator is governed. The fan turns freely around the coupling shaft on which the disk is mounted (see appendix 9 plates 2 and 4). A censor measures rotation speed (gas generator and fan speeds are displayed in the cockpit as a percentage of the maximum speed).

Consequently, there is no other means of altering the rotation speed of the fan disk, other than by decreasing the disk generator speed by means of the throttle controls.

The respective rotation speeds of the gas generator and of the fan are shown in the following table.

	N1 gas generator	**N2 fan**
maximum speed (100%)	16,500 rpm	9,800 rpm
idle (46% +/- 1.5%)	# 7,800 rpm	2,550 rpm<N2<2940 rpm, or 26%<N2<30%

Protection

Engine control systems include the usual protection device, a mechanical overspeed governor for the gas generator. In case of turbine overheating, there is no automatic protection. This parameter is monitored by the crew.

In order to counter the possibility of a fan blucket failure, a steel blucket shield reinforces the casing (see appendix 9 plate 2). The risk of maximum blucket failure leading to penetration of the casing is covered by the following device : a tube linked to the gas generator pressure take-off (called the P3 tube) is positioned at the level of the fan disk in a groove in the blucket guard. When the tube is severed or penetrated, the P3 parameter is brought down to the ambient pressure, which has the effect of reducing engine speed to idle (see appendix 9, plates 2 and 3).

1.16.3 Certification

1.16.3.1 Falcon 20

1.16.3.1.1 The 1965 texts

The Falcon 20 was certified with the AIR 2051 regulations, the equivalent of the FAA CAR 4b regulations : Airworthiness certificate type 65 of June 9, 1965.

The certifications regulations manual summarizes all of the applicable texts of the AIR 2051 regulations, on the left page and, opposite, on the right page, the manufacturer's response.

The two main chapters concerning the installation of engines are reproduced below :

Chapter 5.01.4 AIR 2051 : Fan Blade Protection

Turbine rotor installations must include protections such that in the case of turbine blade failure in one engine, it will not affect the other engines and that the aircraft may continue to be used safely, unless the engine type approval certificate specifies that the turbine casing is capable of containing damage resulting from blade failure.

On the right hand page the corresponding answer is given : "This condition is satisfied, the CF 700 engine is certified with mention as to its resistance to blade failure (see CF 700 type certificate data sheet E7EA)."

Chapter 5.01.4 AIR 2051 : Turbine Disk Protection

Precautions should be taken in the design of the aircraft in order to diminish as much as possible the risk of endangering aircraft security in case of a turbine disk failure, unless the engine type certificate specifies that the following has been demonstrated :

- *that the turbine rotors shall be demonstrated to provide sufficient strength to withstand damage inducing factors such as those which might result from abnormal speeds, temperatures or vibration,*

- *that the design and functioning of engine control devices, systems, and instrumentation shall be such as to give reasonable assurance that those engine operating limitations which affect turbine rotor structural integrity will not be exceeded in service.*

On the right hand page the corresponding answer is given : "This condition is satisfied, the CF 700 engine is certified with mention as to its resistance to turbine disk failure (see CF 700 type certificate data sheet E7EA)."

1.16.3.1.2 Analysis of Fire Risk and its Consequences in the Rear Compartment

The manufacturer specified how the equipment located in the rear compartment had been designed and installed in order to counteract the risk of fire. This certification document (DTM #567) is reproduced in Appendix 10.

The document first describes the rear compartment and lists the equipment installed there (electrical, hydraulic and pneumatic equipment, the APU, the flight controls). Subsequently, it analyses the corresponding fire risks and defines the instructions to be given in the flight manual in case of engine fire or rear compartment overheating. These instructions, from the LEADAIR UNIJET operating manual, are included in Appendix 11, which also lists the instructions in case of engine failure on takeoff and the onboard procedures to apply.

In summary, the instructions in the case of rear compartment are :

Phase 1 - In the case of visual warning of "FIRE REAR COMP", or an aural warning :

- cut batteries 1 and 2,
- cut airframe ANTI-ICE,
- throttle back thrust levers
- close BLEED AIR switches (this prevents smoke from infiltrating into the cabin air conditioning system),
- cut APU,
- inspect rear compartment through inspection hole in toilets.

If there is a clearly a fire (smoke or flames visible)

Phase 2 - Place rear compartment fire extinguisher switch in position 1. This action causes both rear compartment extinguishers to discharge (see Appendix 8) APU cutoff and automatic extension of the ram air scoop.

The notes (section 2, sub-section 01, page 4) specify : "although the rear compartment is not considered as a fire zone, the presence of electrical cabling, and vital controls means that fire cannot be ruled out, which explains the possible utilization of the extinguishers normally destined for the engines."

1.16.3.1.3 Maneuverability of Aircraft in Case of Total Loss of Hydraulic and Electrical Power

The manufacturer gives details of the aircraft's capacity for maneuver in the 3 following cases :

- total loss of hydraulic power
- total loss of electrical power
- total simultaneous loss of hydraulic and electrical power.

This study, which corroborates certification data, covers the case of the aircraft configuration at the time of the accident (weight 28100 lb., balance, flaps extended to 25°, horizontal stabilizer set at - 4°, 4.5°, - 5.5°). The study is reproduced in Appendix 12.

In case of total simultaneous loss of hydraulic and electrical power, aircraft maneuverability is theoretically possible despite the high degree of effort required on the control column, as shown in the graph in Appendix 12.

1.16.3.2 The Engine

The CF700 2D-2 engine was certified by the FAA according to regulation CAR 13 Amendment 13.5 (engine type certificate # E7EA of September 18 1963), a regulation accepted by the French authorities.

Concerning :

- bird ingestion,
- overspeed protection,
- protection against fan blade rupture,

the engine manufacturer provided information concerning what were, at the time, the requirements specified by American regulations, and the technical solutions appropriate to meet them. Appendix 13 summarizes the regulations at that time (FAA requirement column) and the manufacturer's replies (GE substantiation).

Concerning turbine disks we may note :

13-216 Turbine rotors. To minimize the probability of failure of turbine rotors, the provisions of paragraph (a) and (b) of this section shall be complied with.
(a)Turbine rotors shall be demonstrated to provide sufficient strength to withstand damage inducing factors such as those which might result from abnormal speeds, temperatures or vibration.
(b)The design and functioning of engine control devices, systems, and instrumentation shall be such as to give reasonable assurance that those engine operating limitations which affect turbine rotor structural integrity will not be exceeded in service.

Note 9 of the engine type certificate # E7EA data sheet is reproduced here :

These engines meet FAA requirements for operation in icing conditions, for adequate turbine and fan disk integrity and rotor blade containment and do not require airframe mounted armoring.

Bird ingestion

At that time there was no specification which obliged engine manufacturers to demonstrate the engine's resistance to bird ingestion (see Appendix 13 page 1). However, GE undertook bird ingestion tests with the gas generator and the fan. A summary of the tests carried out in 1964 concerning the fan is included in Appendix 14.

Overspeed protection

GE's response to satisfy these requirements (see appendix 13 GE substantiation page 3) is as follows : in the case of a double failure of the engine fuel control system and of the overspeed governor, at the maximum gas generator speed of 19,140 rpm, the fan disk must be designed so as to be able to rotate at a speed of 10,380 rpm. The tests undertaken satisfy these criteria : disk speed of 10,950 rpm maintained during 5 minutes and 40 seconds.

Protection in case of fan blucket failure

The process by which engine certification was acquired is summarized below :

- GE undertook four blucket retention tests on another type of engine, the GE CJ 805-23[7] these tests having allowed the development of the blucket guard and the automatic power reduction system in case of blucket separation.

- On the basis of the positive results of these tests, the certification of the CF700 was obtained through its similarity to the CJ 805-23, of which the CF700 was a reduced scale design (see appendix 13 page 4 conclusion).

A summary of these four tests constitutes appendix 14.

1.16.4 Record of Events Caused by Bird Ingestion

1.16.4.1 Incident and Accident Statistics

The manufacturer provided the following information which summarizes events caused by bird ingestion. These statistics cover the period from 1964-1994 for engines installed on Falcon 20 and Sabreliner 75A (the rate is given per 100.000 takeoffs).

	Number of Events	**Rate per 100,000 takeoffs**
Bird ingestion in engine(s)	236 *	5.79
Engines changed (total)	188	4.61
One engine changed	174	4.27
Both engines changed	7	0.17
Accidents resulting from power loss on both engines (forced landings)	4 **	0.10

*** = estimation ** = 3 Falcon 20 accidents, 1 Sabreliner accident**

1.16.4.2 Consequences of Bird Ingestion

The manufacturer provided the following data which illustrate the consequences of bird ingestion on the different engine components. The following table refers to 147 engines damaged by bird ingestion since 1981.

Engine part damaged	**Number of events**	**%**
Damage limited to fan disk	24	16.3
Damage to both disk and gas generator	12	8.2
Damage limited to gas generator	71	48.2
Damage where engine part damaged is unknown	10	6.8
Damage in which neither the fan disk nor the gas generator was affected	30	20.5

[7] The last versions of the CJ805, a civil aviation engine, were developed from the J79 (military engine) around 1956. This engine is equipped with an aft fan. Note that the CJ805 was a forerunner of an engine design positioning the fan behind the gas generator, a solution used again on the CF700 in 1963

TOTAL	147	100

The manufacturer also indicated that approximately 80% of known bird ingestions caused damage to the engine.

Concerning the consequences of blucket rupture (compressor section of blucket), GE provided the following details collected by its Strother maintenance center (from 1986-1994). Of the 10 cases known to this maintenance center, the following observations were made :

- in 5 cases the number of ruptured bluckets was limited to 5 (the disk has 54 bluckets) ; in the other 5 cases, all of the bluckets ruptured,

- damage sustained by the gas generator was significant in 7 cases, but no data is available in the 3 other cases. In the 5 cases where all the bluckets ruptured, the gas generator sustained serious damage.[8]

- the fan casing was penetrated in the majority of cases corresponding to blucket separation, but the fragments were contained by the blucket guard which is designed to contain blucket fragments that penetrate the fan casing,

- the extent of damage caused by impacts on the exit guide vanes varies from low to significant (in cases where all of the bluckets ruptured),

- none of the 10 cases of blucket rupture showed signs of overspeed.

1.16.4.3 Brief summary of accidents caused by bird ingestion in both engines

The four accidents caused by a loss of power in both engines (see paragraph 1.16.4.1) as a result of bird ingestion are now briefly described.

These four accidents have the following in common :

- the engine failures were contained
- no fan rotor overspeed was reported.

<u>Falcon 20 N50CA on July 28 1968 in the USA</u>

On take off from Cleveland (Ohio), the aircraft collided with a large flock of gulls (average weight 450 grams). Both engines ingested birds. As a result of a loss of power in both engines, the crew made a forced landing in Lake Erie. There were no injuries.

Both air inlets were distorted and covered with bird debris. The gas generators and fans of both motors sustained serious damage (extent of damage not given).

[8] Experience shows that the blucket fragments can travel towards the front of the engine and can be ingested by the gas generator. However, in the 5 cases in question, it is not known if the significant damage sustained by the gas generator was due to reingestion of the bluckets or to the bird ingestion.

Falcon 20 LN-FOE on December 12 1973 in England (Norwich Airport)

Just after takeoff, the pilot avoided two flocks of black-headed and short-billed gulls (average weight 275 grams and 420 grams respectively) at around 200 ft., but could not avoid a third flock. Exhaust gas temperature and thrust fell on both engines. With the landing gear extended, the crew decided to make a forced landing after turning to the left. The aircraft avoided some trees and landed in a field. The landing gear collapsed and the aircraft came to a halt on its belly. The three slightly injured crew members and the six uninjured passengers were evacuated.

On the left engine, 11 bluckets were completely separated and 8 sustained partial separation. Severe damage to the gas generator caused the loss of power.

On the right engine the gas generator had ingested several birds which caused major damage to the compressor stages, which explains the stall and loss of power.

Sabreliner 75A on June 14,1975 at Watertown, USA

During take off from Watertown (South Dakota), the aircraft collided with a flock of Franklin gulls (average weight 260 grams). Both engines partially lost power. The crew made a forced landing in a plowed field. Six people were injured.

Both engines ingested birds. Details of engine damage is not known.

Falcon 20 N27R on Nov. 12,1976 USA

On takeoff from Naples (Florida), the aircraft collided with a flock of ring billed gulls (average weight 485 grams). As a result of the loss of power on both engines, the crew made a forced landing. The 11 persons on board were injured.

The right engine ingested 3 birds (damage not specified). The left engine was not damaged despite traces of bird ingestion on the air inlet.

1.16.5 Expert Analysis

1.16.5.1 The Aircraft

Fuselage

It must be remembered that the fuselage was swept by an intense fire, which made investigation difficult and limited the number of tests possible, a large number of items of equipment having been completely destroyed.

The rear compartment was examined in great detail. The illustration in Appendix 16 shows it in three views in the area of the engines and of their feeder tanks. This plate illustrates the result of the investigation undertaken : in the places marked 1,2 and 3 on the left feeder tank, and 4 on the right feeder tank, bluckets were found either in one piece or in fragments. The arrows indicate the paths which these high energy projectiles took to reach the interior of the feeder tanks after having penetrated the engine casing, the fuselage skin, and the feeder tank structural boxes. The paths taken by these projectiles are practically in the same line as the fan disk (in 4) or slightly forward or aft of it (in 1,2,3).

Flight controls

- the left and right flap power control units, the rudder power control unit and the elevator power control unit were in working order when checked on the hydraulic testbench,

- the control valve of the electric pump (situated in the rear compartment) was positioned in such a way that the notched cam of the valve control corresponded to the position of the instrument panel selector handle (left middle position, system 1 activated),

- the rudder trim was in working condition. The position noted on the actuator cylinder rod indicates that the trim was set at zero, which corresponds to a neutral rudder position,

- displacement noted on the horizontal stabilizer electric actuator rod permitted measurement of its angle of incidence, which was -4 degrees ; the actuator was in normal working condition,

- examination of the internal piston of the transfer jack indicated that it had not been activated (actuator in normal standby position (hydraulic system number 1 activated),

- examination of the left flap inner and outer actuators confirmed the position of the selector handle : the flaps were extended to 25°,

- the electric ram air scoop actuator was in the corresponding closed position,

- it was not possible, taking into account the condition of the wreckage, to be certain that the flight control linkage enabled manual flying in case of total loss of hydraulic power.

Fire protection

The condition of the wreckage meant that only the three extinguisher bottles could be examined, their respective circuits having been totally destroyed. Examination of the three bottles leads to the following conclusions :

- the three left engine fire extinguisher cartridges were ignited by the effect of the heat.

- the right engine number 1 fire extinguisher cartridge was no longer in place and the number 2 and 3 cartridges were ignited by the effect of the heat,

- the APU fire extinguisher cartridge was not ignited. The freon was emptied as a result of leakage following the impact with the ground.

Landing gear

Experts analysis show that the landing gear was at the beginning of the extension sequence.

1.16.5.2 The Engines

1.16.5.2.1 Left Engine

1.16.5.2.1.1 General

The engine was installed in its nacelle with its pylon linking it to the fuselage (plate 3 of the photograph appendix).

The engine was separated into two parts at the level of the fan rotor assembly. The fan disk, the two conical connecting shafts, and the rear part of the aft fan stage were separated from the engine (plate 4).

The left side of the nacelle was burnt along its length ; the right was also burnt though to a lesser degree.

The air inlet was flattened in its lower left section and distorted inside (plate 3).

Behind this stage, the turbine nozzle assembly was distorted and broken up. The outer skin of the fan casing was penetrated from the interior towards the exterior.

The number 4 bearing (in front of the forward shaft) was still in place ; the forward shaft was severed at the level of the bearing.

The fan disk was discovered in one piece in the grass (plate 5-disk in position G, 2D trajectory, Appendix 1).

The rear part of the fan stage was found on the runway, cut off at the level of the disk. The leading edges of the exit guide vanes were partially destroyed (plate 6).

The conical rear shaft was detached at the level of bearing number 5 and torn off of the disk.

The exhaust tail cone was completely flattened, doubtless at the time of the crash, at an almost vertical angle. The tail pipe was distorted. It was ripped off by the cowl, which was cut off at the level of the fan disk assembly.

Among the items subjected to expert analysis, the most significant are as follows :

- the blucket guard, broken in several places ;
- fragments of the fan rotor bluckets including 33 blade roots ;
- two pieces of the conical fan shaft with 4 fragments of the attachment bolts on the disk.

On the pylon, projected blucket fragments penetrated or cut into the body of the fuel heater, the fuel feed line upstream of the fuel heater and the head of a bolt on its base plate. These impacts are essentially situated in a line with the fan disk bluckets.

The fire shut off valve was three-quarters closed.

1.16.5.2.1.2 Analysis of Samples

Deposits made up of feather fragments and organic matter were taken from the hot and cold air passages, in particular from the gas generator inlet wall, from the compressor, and from the outlet vanes situated behind the fan.
Expert analysis of the feather fragments established that the ingested birds were of the lapwing species (Vanellus vanellus).

1.16.5.2.1.3 Condition of fan disk

Reference : part number 5002T40 PO1

Serial number : WYR-WDB 01491

General

The disk was still equipped with 18 blade roots broken off a few millimeters from their platforms (plate 5). A dimensional check of the disk (see below) clearly showed an expansion of the disk's diameter.
Three-quarters of the blade roots were situated on one half of the disk, the area with the fewest having only one blade root on a sector covering 120 degrees. The blade roots manifested a high degree of play within their slots. Apart from the positions still containing blade roots, all of the slots were damaged to a greater or lesser degree during separation of their respective blades (plate 7).

This damage was characterized by static shearing and scoring of the blade root dove tail slot lobes, particularly that found at the edge of the disk and on the side corresponding to the outer surface of the turbine airfoil blades.

This scoring, occasional or right along the rim, was often accompanied by the raising of the upper lobe towards the exterior, caused by the rotation or twisting of the blade in the opposite direction of disk rotation (see plate 8). The particular shapes and forms of this scoring allowed each blade root to be replaced in its initial slot in order to carry out the reconstitution of the disk as shown in plate 10.

Coloration of the material, darker towards the rim, did not indicate excessive levels of temperature. Slight dimpling was be noted on the surface near to the rim.

Traces of rubbing and scoring, almost tangential, mark the inside of the rim on both faces of the disk, in a sector going from position 30 to position 54.

The interior of the rim also has a distorted profile with ridges (see plate 8). The distances between ridges, measured diametrically, vary between 0.2 and 0.5 mn.

The attachment bolt holes are more or less elongated ; some were clearly distorted on the disk face side by the bolts before rupture (plate 9).

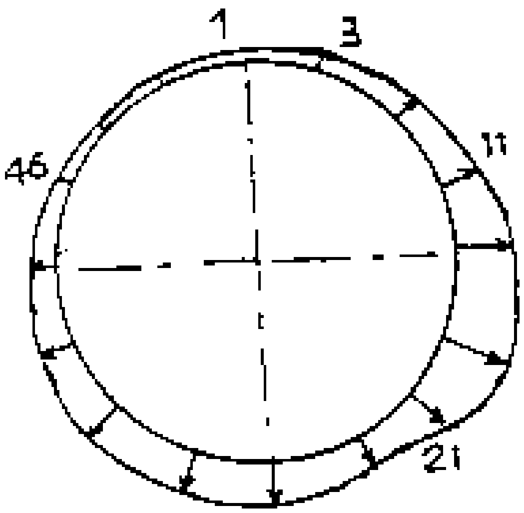
Tests

Dimension tests were carried out. In comparison to the original dimensions, the increase in the diameter of the disk was :

- 7.2 to 8 mm for the outer diameter of the disk,
- approximately 6 mm for the circle formed by the shaft attachment bolt holes.

In addition, these distortions are not uniform. The maximum distortion occurred in the sector of the disk corresponding to blades 11 to 21, and to attachment holes 5 to 8.

The minimum distortion is found in a sector which is not exactly opposite (blades 46 to 3 and attachment holes 18 to 2), as shown in the simplified drawing below.



A dye check indicated that the disk showed no signs of cracks or incipient failure.

Hardness tests carried out showed that the material's characteristics were in conformity with the manufacturer's specification, this being between 34 and 44 Rockwell C.

Analysis of the material was carried out on a sample of shavings obtained by milling the surface of the disk. The sample had a composition in conformity with that of the nickel based alloy called "WASPALOY".

1.16.5.2.1.4 Condition of fan bluckets

Different fragments of bluckets were found. The largest fragments consisted of the blucket root, the blade air foil (turbine) and the dividing platform (7 bluckets were found in this condition). All of the other bluckets found were broken into more than two pieces. These blucket fragments generally showed signs of multiple impacts.

All of recovered mid span platforms exhibited separation of the fan sections of the blucket immediately outboard of the platforms. No fan section fragments were found in the fuselage. The ruptures are of the static shearing type. Of the 54 fan bluckets only 33 blucket roots were found during inspection of the runway after the accident and during later searches of the wreckage and the airfield. They are made up of 18 blade roots which remained in place on the disk, 8 found on the runway, and 7 which had penetrated the feeder tanks. No trace of fatigue rupture was discovered : ruptures of the fragments examined are of shearing static type. Many of the bluckets were broken or distorted by impact with nearby components.

1.16.5.2.1.5 Blucket guard

The fan disk blucket guard disintegrated. The three pieces which were found do not make up the whole of the guard. These parts of the guard are unrolled and twisted. They show rips and indentations on the inside (see diagram and plates 11 and 12). Some of the mounting flange holes were apparently torn away by the bolts.

Only two parts of the forward blucket guard were found, neither of which shows impacts on the inner surface.

1.16.5.2.1.6 Fan coupling shaft

The two conical shafts ruptured with static shearing as a result of bilateral bending. The bearings forwards and aft turned freely.

1.16.5.2.1.7 Disk and shaft retaining bolts

A certain number of retaining bolt fragments were found at the site.

Some of these fragments are shown in plate 13. They all show bilateral bending and static shearing.

1.16.5.2.1.8 Examination of fan casing

Examination of the different pieces of the fan casing showed that the disk had separated from the engine in a direction close to 11'o'clock, as viewed from the rear.

1.16.5.2.1.9 Gas generator

Configuration

The bleed valves were open, the inlet guide vanes were in the closed position, the actuators were in the retracted position : this configuration corresponded to idle power setting.

Condition of gas generator

The gas generator was totally dismantled. It had suffered only minor damage. It was apparently in working condition.

1.16.5.2.2 Right Engine

The right engine was in one piece. Fire damage was more extensive than on the left engine. The nacelle was almost entirely burnt out (plate 14).

Configuration

The bleed valves were open, the inlet guide vanes were in the closed position, the actuators were in the retracted position : this configuration corresponded to idle power setting.

Gas generator

The rotation of the gas generator was blocked by a mass of aluminum alloy resulting from the fusion of the air inlet casing. The fan was in the same condition.
No significant damage was noted on the compressor inlet nor on the visible parts of the fan.

The rotors, compressor and fan showed minimal damage, none of which was significant. Rotation in each case was normal. There were no traces of contact. The turbine stages showed some traces of contact between the tip of the blades and the abrades. The second stage nozzle showed some burning on three blades. The surface of parts was altered by the fire : presence of soot, burnt oil deposits. Earth was found in the compressor, which indicates that it was running at the moment of impact with the ground.

The right engine was in normal working condition before impact with the ground.

1.16.6 Take off of Falcon 50 After Accident

The Falcon 20 F-GHLN entered into radio communication for the first time with Le Bourget preflight controller (PREVOL) at 1615 to request start up clearance. The accident happened at 16.32.

In the same time period, the Falcon 50 registered HB-IAT had obtained clearance for a flight to Geneva. It was positioned at the taxi holding position, on runway 25, immediately behind F-GHLN.

The crew of the Swiss aircraft thus witnessed the take off and the accident. At 16.31 it cleared the runway upon instructions from the control tower. At 16.35 the controller proposed that the captain takeoff from runway 21, avoiding using the northern part which was blocked by emergency and rescue vehicles.

Clearance for takeoff from runway 21, along with new clearance for the departure flight path, was transmitted to him at 16.41. Two minutes later, the captain informed the controller of a collision with some birds at the moment of takeoff, though he specified that this event had not provoked any discernible engine anomalies. The aircraft continued its flight towards Geneva where serious damage was discovered on the right engine. The engine fan had to be replaced.

1.17 LEADAIR UNIJET

LEADAIR UNIJET, an incorporated company with a capital of 24.1 million francs, based at Le Bourget, has, since 1978, been authorized to undertake charter air transportation throughout the world, with passengers, post, and merchandise. It is limited to 3.4 tons of freight and 20 passengers per flight.
On the day of the accident it had 63 employees (including 15 pilots) and operating a fleet of 7 aircraft (1 Falcon 50, 2 Falcon 20s, 4 Falcon 10s).

LEADAIR UNIJET has an authorized maintenance workshop allowing it to undertake the majority of maintenance operations on its aircraft itself.

The airline possesses all of the necessary statutory documentation to undertake passenger transport.

1.18 Additional Information

1.18.1 Eyewitness Evidence

Apart from the controllers on duty in the tower, numerous witnesses observed the accident :

- The crew of the Falcon 50 HB-IAT. The captain stated : "Just after rotation there was an explosion, with an incredible flame and a large quantity of black smoke".

  The crew observed the aircraft's flight path : "left turn, then the DA20 continued a tight turn in such way that it passed in front of us then continued with an angle of about 30-40 degrees and a pitch of about 15-20 degrees, nose down, until impact".

- The chief pilot and mechanics of Dassault Falcon Service, from the company's carpark. The chief pilot watched the aircraft from the beginning of its left turn until the end of its downwind leg, when the aircraft was hidden by one of the aircraft hangars. During this entire phase the aircraft was under control.

- The two RFFS firemen. They saw the aircraft "begin a descent towards the left, a descent which they reckoned to be dangerous".

1.18.2 Chronology of Events

From the control tower, the accident was experienced as described in the following table, where times are given as in the control tower.

To improve our understanding of the accident, the Falcon 20's trajectory (see 3D Trajectory in Appendix 1) is computed with elements taken from the dialogues and the essential events.

Control Tower Time	EVENTS
	F20 crew request start-up clearance
	The pre-flight controller (PREVOL) approves start-up and specifies the transponder code to use
16.20.45	F20 crew request taxi clearance
16.21.03	The ground controller (SOL) gives the F20 taxi clearance
16.27.09	The F20 crew announces that they are approaching the threshold of runway 25
16.27.12	The ground controller (SOL) has the F20 moved to frequency 119.10 (LOC controller)
16.27.30	The LOC controller lines up the F20 on runway 25 and has him wait
16.28.25	The LOC controller gives the F20 post-takeoff instructions (continue in the axis to level 100, contact Roissy Charles de Gaulle on 124.35)
16.28.48	The LOC controller gives the F20 permission to take off (runway 25, wind 220 degrees/20Kt. contact Roissy Charles de Gaulle)
16.29.10	The crew of the Falcon 50 HB-IAT say they are ready to leave
16.29.33	Decision by F20 to take off (the pilot announces "its 30") The approach controller (LOC) observes, immediately after rotation, the appearance of a flash of light by the left engine, then a flame at the rear of the aircraft.
approx. 16.30	LOC controller activates crash alarm
16.30.49	The pilot not flying of the F20 contacts the tower
16.30.52	The LOC controller informs the F20 crew of actions undertaken : fire service alerted, landing at the crew's convenience, wind 190/25 Kt
16.30.59	The F20 crew announce they will land on runway 25
16.31.00	The LOC controller requests the F50 crew to clear the runway immediately.
16.31.08	End of CVR recording
16.31.30	The LOC controller checks that the F50 has cleared the runway- affirmative response from F50 crew
approx. 16.32	The controllers and the F50 crew witness the accident
16.32.30	The LOC controller contacts the F50 crew and informs them of a delay before takeoff. He says that he will recontact them as soon as possible
16.35.30	The LOC controller proposes that the crew of the F50 take off from runway 21- the crew accept. There follows a dialogue between the F50 crew and the LOC controller to find the best way for the aircraft to reach runway 21, avoiding the north part which is blocked by emergency vehicles
16.41.10	The LOC controller clears the F50 for takeoff on runway 21
16.42.00	The F50 crew acknowledges receipt
16.43.10	The F50 crew say that "we took a lot of birds on takeoff". There follows a dialogue in which the F50 pilot describes a multiple collision with birds, which happened just after rotation, and gives some specific information requested by LOC controller, relating to the fact that he had witnessed the accident
16.54.00	Decision to close Le Bourget airport
17.56.00	The red alert is transformed into a restricted alert

1.18.3 Regulations Concerning the Transportation of Dangerous Material

Munitions in the cabin

The passengers were supposed to participate in a hunt. In the cabin there were 7 shotguns and rifles and different types of bullets and shotgun cartridges. Because of the limited size of the hold which could not contain all of the baggage (see appendix 5) the free seat in the cabin was used to stow some baggage, including cardboard boxes which contained the munitions.

The munitions (cartridges for small caliber weapons classed 1.4.S) are included in category 1 of dangerous material (explosive material and objects). The ICAO 9284 AA 905 document, titled "Technical Instruction for Safe Transportation by Air of Dangerous Materials" specifies (in Appendix 5 chapter 9) conditions under which such munitions may be transported by passengers on public transportation.

These conditions are the following :

- transportation to be undertaken with the approval of the crew,
- less than 5 kg per person,
- baggage to be registered,
- shipment in containers (the original packaging may constitute the container),
- incendiary or explosive projectiles excluded.,

The legal requirements for the transportation of cartridges were thus respected.

The effects of fire on the munitions

Some of the cartridges and bullets exploded in the fire. The brass casings opened up in a leaf shape due to combustion of the primer and the powder. Some lead shot was released. According to the police department laboratory specialists, the initial speed of the bullets and lead shot and of the casing fragments set off in such a fire would be too low to present any major danger either for the passengers in the cabin or for emergency service personnel. Many of the munitions, protected by their packaging, were not damaged.

2 - ANALYSIS

Immediately after take-off, after having ingested some lapwings, the left engine suffered an uncontained burst which caused the fire in the rear compartment. The crew tried, with a very tight circuit, to return and land. This attempt failed. The rapid arrival of the RFFS was not sufficient to save the occupants of the aircraft. The successive phases of this scenario are analyzed below. They are completed by an analysis of bird strike hazard prevention at La Bourget, and of the actions of the crew and the controllers.

2.1 The Uncontained Burst of the Left Engine

The study of the feather fragments found in the air passages of the left engine proved that the engine had ingested lapwings. This fact is coherent with the discovery of the remains of a lapwing in the left main landing gear wheel well, and of around 15 dead lapwings at the intersection of runways 07/25 and 03/21, as well as the collision with lapwings by the Falcon 50 taking off shortly afterwards from Runway 21.

Expert analysis of the left engine showed that it had been cut in two at the level of the fan disk, the disk itself having been found in one piece 500 meters to the left of the runway. Evidence from the tower controllers and from the crew of the Falcon 50 is confirmed by the CVR readout : the engine burst took place just after the aircraft rotation, between CVR time 29.59 - 30.09. During these 10 seconds we note the first thud, a deceleration of the fan disk, then, after leveling off, an acceleration from 6660 rpm to 15456 rpm in three seconds. At CVR time 30.09 a second thud is perceived.

Dimensional checks of the fan disk showed that its radius had increased between 3.6 and 4 mm, which could only be the result of overspeed and centrifugal force. In addition, expert analysis of the gas generator showed that it was in working condition at its rated speed.

On the basis of these factual elements, it is possible to establish the most likely process leading to the uncontained engine burst :

- Immediately after rotation the left engine ingested some lapwings, the distribution of which in the air inlet must have been such that they were sucked into the outer part (cold air stream) rather than into the gas generator (hot air stream). As a result, the gas generator remained intact, whereas the outer parts of the bluckets were wholly or partially broken off by the shock. This phase corresponds to the first thud. Subsequently the fan disk speed, slowed down by the ingestions, decreased, but the engine did not change to idle speed, which shows that the P3 line was not damaged by a ruptured blucket.

- Since the gas generator continued to operate at take-off power (the crew not having reduced it and the P3 line being intact), the fan disk, lightened by the disappearance of a significant number of bluckets, accelerated. Overspeed reached 15,456 rpm at the same time as an unbalance occurred.

- The overspeed induced loads which exceeded those existing during certification (the corresponding tests in 1963 showed that the disk resisted a speed of 10,950 rpm for 5 minutes 40 seconds). The mechanical specifications of the alloy of which the disk was made allowed it to dilate. The dovetail slots retaining the bluckets on the disk followed these distortions and some of them moved apart enough to allow the corresponding bluckets to detach under the influence of centrifugal force. These bluckets became high speed projectiles. Seven fragments, after having penetrated the casing, the engine cowling and the fuselage pierced the structural boxes and the fuel feeder tanks.

- Release of some blucket hot sections at overspeed conditions resulted in significant rotor unbalance. This unbalance, associated with overspeed, caused severe stress on the coupling shaft of the disk which buckled and sheared off. This allowed the disk, which had high kinetic energy due to the overspeed, to destroy the blucket guard and to escape. This phase of the engine burst corresponds to the second thud. From this analysis we note particularly that the P3 tube, designed to ensure automatic power reduction in case of fan blade failure did not fulfill its role.

2.2 The Certification of the Engine

CF 700 2D-2 description is characterized by the 1963 certification norms. At that time it was not specifically required that resistance to bird ingestion be demonstrated. General Electric, however, undertook such tests, the most significant of which was carried out with a gull weighing 1.1 kilos, with the engine running at 40 percent of its nominal power.

As far as fan blucket failure protection is concerned, fan blade containment demonstrations are specifically required by the certification regulations. In fact, the certification of the CF 700 was done by comparison with the similar CJ 805-23 engine, a more powerful engine of the same conception. Thus the definition of the CF 700 with its blucket guard associated to an automatic power reduction system was the result of a program of four tests on the CJ 805-23.

Test number 3 of Nov. 15, 1962 is particularly significant in that it presents great similarities with the present accident. In fact the fan disk overspeed reached 9,500 rpm (overspeed of 160 %) and the two coupling shafts of the disk buckled. The automatic power reduction system installed for the test functioned correctly but tardily, and through a particular combination of circumstances, following a fortuitous secondary affect. The manufacturer concluded that it was indispensable to add a reliable automatic power reduction system to the blucket guard. Test number 4 with a circumferential tube in line with the fan having been successfully completed, the unit combining the blucket guard with the automatic power reduction system was adopted for the CF 700.

2.3 Reaction of CF 700 to Bird Ingestion

Examination of data relating to bird ingestions shows that the present case of an uncontained engine burst resulting from disk overspeed is the first known case in 9.5 million flying hours by the Falcon 20 and Sabreliner fleets since 1963.

It is difficult, if not impossible, to make a technical interpretation of this data, since engine damage is of such great variety. Data is also somewhat inexact in that the weight and species of the birds which caused such damage are not known.

One particular point needs to be noted. Serious damage to the upper part of the bluckets was generally accompanied by serious damage to the gas generator (see 1.16.4.2) which, through consequent power loss, prevented overspeed occurring. However, on January 20 1995, the gas generator did not suffer damage.

Consequently, the only protection which could prevent overspeed is the P3 line, in the following circumstances :

- ingestion of a number of birds such that their weight be sufficient to cause damage on the majority of the fan bluckets (engine running at 100% and not 40% as was the case in the seagull test carried out during certification),

- distribution of the birds in the air inlet in such a way as to concentrate the ingestion into the cold air stream, thus leaving the gas generator in nominal operating condition, The present accident, which shows some similarities with the overspeed which occurred during test number 3 of the CJ 805-23 engine, shows that the automatic power reduction system can be inoperative. A rotor overspeed with blucket detachment is then possible.

2.4 Aircraft Fire

Evidence given by the controllers and the CVR readout situates the left engine malfunction immediately after rotation. As far as the fire is concerned, the controllers' evidence is coherent with that of the Falcon 50 crew : a significant fire broke out at the rear of the aircraft immediately after take off. According to all of the witnesses this fire increased with intensity as the aircraft continued its short runway circuit.

This fire swept through the left rear section of the aircraft, as is shown by the traces of fire on the left side of the rudder and the left side of the stabilizer.

The discovery of fragments of the fan disk bluckets inside the feeder tanks explains the fire : the ejected blucket fragments pierced the two feeder tanks, causing fuel leaks. Fuel vaporized in the wind and burst into flames upon contact with the hot sections of the damaged motor after ejection of the disk. The fire subsequently grew and developed with the fuel continuing to escape from the punctured tanks.

The rear compartment, though not considered a fire zone, is protected from fire risk by the possibility of discharging the engine fire extinguishers. We know that this option was not taken.

The spreading of the fire caused the loss of electrical power through destruction of the cabling and of both batteries as well as the total loss of hydraulic power. The fire also attacked the pressure bulk head. The pressurized zone, which was protected from the pollution from the fire by the existence of higher pressure compared to the nonpressurized rear compartment, was no longer protected when the diaphragms of the two pressurization valves installed on the bulkhead were destroyed. The pollution of the cock pit and cabin by smoke and vapors must have begun immediately after the destruction of these valves.

When the aircraft hit the ground, the pressure bulkhead, weakened by the fire, collapsed and the feeder tank structural boxes broke up. Fuel from the two feeder tanks (2 X 414 liters at the beginning of the flight) flowed forward into the cabin and into the cockpit. It then caught fire whilst the aircraft was sliding along the ground.

Expert analysis of the engine extinguishers showed that they discharged spontaneously under the affect of the heat. In such a generalized fire, these discharges could not be effective.

2.5 RFFS Action

The chronology of the attempted rescue mission was examined in section 1.14.

It established that the response was rapid (3 minutes after the activation of the crash alarm, 1 minute after impact). It was in accordance with the recommended tactics which give priority to the extinction of fuselage fire in order to facilitate any possible rescue action. It was frustrated in that, when the aircraft came to a halt, all of the occupants had already died as a result of the lightening spread of the fire and of the high temperatures reached.

2.6 Bird Strike Hazard

It has been shown that the uncontained burst of the engine was a direct consequence of ingestion of lapwings.

The Falcon 50 also suffered multiple collisions with the same bird species when taking off 10 minutes later.

The Falcon 20 accident and the Falcon 50 incident are therefore directly linked to bird strike hazard.

In the general context of preventive policies against this danger, the decree and the ministerial instruction of July 27,1989 defined the rules for the bird strike hazard prevention service, a service to be provided during the normal operating hours of the air traffic control organization, excluding the night period.

Le Bourget's internal regulations specify that the bird strike prevention service, in the critical period from October 1 to March 30 should be maintained during the week (where the duty roster allows it) from 07.00 to 11.00 and from 13.00 to 17.00. On Jan. 20, 1995, continuity of the service was not maintained after 15.00 hours.

The ATC officer on duty in the afternoon noted, at around 14.00, the presence of around 300 to 400 lapwings, and used crackle flares to disperse them. The birds flew away towards the northeast of the airfield. Subsequently, during his patrol, the officer noticed no further presence of the birds.

It is not possible to determine with any precision at what moment the lapwings returned to the air field. However, with reference to the STNA's booklet, it is probable that large groups of lapwings settled on or immediately next to the runways after the storm. When the pilot flying the aircraft, during taxiing, says "look at those birds there", this doubtless referred to lapwings. In any event, whatever time the flocks of lapwings returned, it is clear that the permanent presence of bird strike hazard prevention officers in the proximity of the runway could have prevented their return.

In addition, practical application of bird strike prevention measures at Le Bourget meant that the officers were replaced successively without one particular officer being designated according to the half-day principle. Briefings between the officer coming off duty and the officer coming on duty took place in the ATC office, causing interruptions in the service which could be as long as half an hour.

Examination of the conditions in which this accident happened also shows that the airport was not properly equipped with the complete range of equipment specified. In fact, the line of loud speakers along runway 25 had been unavailable for approximately one year, for a variety of reasons previously mentioned. The combined use of these loud speakers with mobile equipment and pyrotechnics was planned and would have increased the efficiency of bird strike hazard prevention measures.

All of the aforementioned leads us to think that bird strike hazard prevention measures were undertaken in an incomplete manner, this despite the increase in ATC office personnel subsequent to letter 022045 STNA/2N of April 3rd 1991 (Para. 1.16.1.4)

2.7 Crew Actions

The dialogue between the two pilots reconstituted from the CVR shows that the preparation of the flight was carried out normally. In summary :

- the crew took care to wait for the end of the storm before taking off
- check lists were carried out and no failures were detected
- instructions to be applied in the case of anomalies before and after V1 (CVR time 23.59) were carried out : the crew planned to carry out a short runway circuit in case of an anomaly after V1.

Chronological stages of the take off show :

- it was undertaken at CVR time 29.10 (16 hours 29 min 33 sec)
- the pilot not flying announces (CVR 29.39) that at 60 Kt parameters were normal
- the pilot not flying announces "VR" at 29.54 and vertical speed positive at 29.57,
- he announces "landing gear up" at 29.59 at the same time as the thud is produced by the decelerating left engine,
- the pilot flying announces "engine out". The pilot not flying says "keep going".

It was thus at 29.59, in other words approximately two seconds after takeoff that the crew were confronted with an in-flight engine failure. Their reaction was immediate and corresponds with what had been planned ("keep going"). We may note in fact that in the case of an engine failure occurring after V1, the flight manual provides for continuation of takeoff, and the operating manual specifies that in the case of engine failure, priority should be given to following the flight path and to stabilizing the aircraft before undertaking abnormal and emergency procedures - once having reached the minimum takeoff safety height. In the case of Le Bourget, this altitude is 600 feet.

In this context, confronted by an engine failure just after takeoff, the crew followed instructions. It is reasonable to assume that they wished to reach the minimum takeoff safety height before reducing thrust on the faulty engine.

However, events moved rapidly before the aircraft reached this height :

- CVR 30.09 second thud,

- CVR 30.16 aural fire alarm which continued to sound until the end of the recording,

- CVR 30.19 the pilot flying says "the landing gear",

- CVR 30.20 the pilot not flying answers "no no no, its the rear compartment".

This brief dialogue leads us to think that the pilot flying thought at first that there was a fire in the landing gear well, but that the pilot not flying, since he saw the red "FIRE REAR COMP" warning light illuminated, identified the area of the fire more precisely.

The crew was thus confronted, 21 seconds after the engine failure, with a second in-flight event identified as "overheating/fire in rear compartment".

We should note that in the case of overheating in the rear compartment, the flight manual recommends :

- cut batteries 1 and 2,
- throttle back the thrust levers,
- close the "BLEED AIR" switches,
- inspect the rear compartment through the inspection hole located in the toilet and, if fire is apparent, (flames or smoke visible) place the "COMP REAR" extinguisher control switch in position 1.

We know from expert analysis of the engine (chapter 2.1) how the fan disk overspeed after the bird ingestion caused ejection of fragments of the bluckets to puncture the feeder tanks. We thus understand how the fire started and developed in the rear compartment (chapter 2.3). We were able to establish a logical relationship between the engine burst and the fire.

The crew had no means of analyzing the situation in the same way. It is clear that they very rapidly identified a failure of an engine two seconds after the thud which preceded the engine deceleration. Confirmation of the reality of this failure came from inspecting the engine parameters. In fact, N2 (fan rotation speed) fell whilst N1 (generator rotation speed) remained stable. Subsequently, 10 seconds later, N1 accelerated and the second thud occurred which corresponded to the destruction of the left engine through ejection of the disc.

On a purely theoretical level, reduction of the engine speed by throttling back the thrust levers of the left engine just after bird ingestion (from CVR time 29.59), in a time span of far less than 10 seconds, could have avoided the fan disc overspeed and thus avoided the accident.

However, a crew in flight is not in a position to develop theories. They are in an operational context in which one applies strict procedures in order to deal with specific cases. In the present case there were two successive in-flight failures, the first (engine failure) at the beginning of the flight, the second 29 seconds later (rear compartment fire alarm) to be dealt with in addition to the first. What is more, the corresponding instructions are incompatible or inapplicable to takeoff. In particular, there is an incompatibility between the phase of flight and the positioning of the left engine thrust levers in the idle position (engine failure) or, of throttling back both thrust levers (rear compartment fire). As to inspecting the rear compartment through the inspection hole located in the toilet, this instruction, feasible during cruise, is clearly totally impossible during take off. With regard to instructions in the case of certain in-flight failures, this accident shows that they should be improved in order to be better adapted to the critical situation of takeoff. This is the case in particular of the "overheating rear compartment" procedure, which should be made applicable through all phases of flight.

Thus, confronted by two successive failures whose overall management exceeds cases mentioned in applicable procedures, the crew gave priority to the essential elements, as defined in the operating manual. They gave priority to maintaining flight path in order to return and land on runway 25 as soon as possible, in accordance with the option initially selected. Holding to this flight path focused all of their attention in order to succeed in making a short circuit, with a heavy aircraft, in gusting winds and poor visibility conditions. They prepared for landing. In fact, the landing gear control lever was in the down position and the flaps were extended to 25 degrees. In addition, the stand by electric pump selector handle was in the middle left position, which shows that the crew had determined which of the two engines had failed and that it was thus the number one circuit which required assistance through pressurization of the electric pump. The question as to why the extinguishers were not activated can be raised here. One plausible explanation, apart from the high workload mentioned above, is that the crew were not sure that the “Fire Rear Comp” warning corresponded to a real fire (the Flight Manual, featured in Appendix 11, mentions the possibility of overheating, whose most likely cause would be a leak from the engine hot air bleed ducts). In such an uncertain situation, the crew would not have activated the extinguishers. We may presume that, in any event, the activation of the fire extinguishers would not have proved effective. Analysis of the risk of fire in the rear compartment did not take into account a case such as this, of an uncontained engine burst : the fire protection system could not be expected to perform efficiently to control a fire which stemmed from a situation whose existence the engine manufacturer considered impossible.

The extension of the fire in the rear compartment caused loss of electrical power (a loss established by the cut off of the CVR at 30.45). The precise moment when total loss of hydraulic power occurred could not be determined.

The aircraft remains theoretically flyable in the case of simultaneous loss of hydraulic and electrical power : according to the manufacturer's studies, in this configuration, control of the aircraft can be maintained by mechanical control surface displacement from an initial control surface and stabilizer position given by trim of the three axes at the moment of the incident. The parameter which limits maneuverability in this case is the effort required on the control column to displace the control surfaces. In this situation, the principle effort required is in pitch due to the necessity to maintain the permanent effort on the control column in order to ensure balance and control of the aircraft. In reality, the situation was apparently made even more difficult by the loss of the left engine and the probable subsequent drag effects.

According to eyewitness evidence, the aircraft appeared to be in control in the down wind leg of its flight path. However, the last phase of flight, just before impact, constituted an abnormal descent.

It is impossible to know at what moment the crew underwent the transition from assisted to manual flying. We may conclude, however, that the uncontrolled descent was a consequence either of the incapacitation of the crew by vapors coming from the rear, or of a rupture in the flight control linkage resulting from the extension of the fire.

2.8 Airport Control

Chapter 18.2 describes how the accident was experienced by the controllers on duty in the control tower and the actions which they undertook relative to sounding the alert. We may note that the controllers witnessed the accident from takeoff until impact with the ground and that the sight of the aircraft on fire certainly caused a sudden nervous tension.

Activation of the crash alarm was almost instantaneous, which allowed the firemen to be ready whilst the aircraft was still in flight.

The controller assisted the crew by removing all constraints concerning airport traffic (at 16h 30m 52s, firemen alerted, landing of your choice, as you wish, wind 190°/5 Kt). We may note that the message does not specify that a fire is visible on board.

The controller removed HB-IAT from runway 25 (at 16h 31m 00s), then nine minutes after the accident gave permission for takeoff from runway 21, without the captain having been informed that the rescue and fire fighting services were no longer available.

Despite the stress, the distressing situation was thus well controlled, in particular concerning activation of the crash alarm, with the possible exception of departure of HB-IAT.

3 - CONCLUSIONS

3.1 Findings

- Aircraft F-GHLN had a valid Certificate of Airworthiness.

- The flight crew were properly licensed and medically fit to conduct the flight.

- Aircraft maintenance (in particular that of the fuselage and the engines) had been carried out in accordance with the regulations in force.

- Engine certification mentioned its resistance to blucket rupture and this had been taken into account in the design of the aircraft.

- The bird strike hazard prevention service was not operational after 15.00 hours.

- The line of loudspeakers on the edge of runway 25 had been out of service for several months.

- Immediately after takeoff at 16.32, the left engine ingested some birds of the lapwing species.

- This bird ingestion resulted in fan disk overspeed, causing an uncontained engine burst, which resulted in the projection of blucket fragments and subsequently in the expulsion of the disk itself.

- Blucket fragments, propelled at high velocity, penetrated two feeder tanks causing the fire in the rear compartment.

- The crew attempted to return and land on runway 25 by performing a very tight circuit, whilst the fire was spreading.

- This maneuver could not be completed.

- The aircraft, which was out of control, struck the ground near the intersection of the two runways and slid for 400 meters.

- The intervention of the fire service, which followed the crash alarm activated by the control tower, did not succeed in saving the occupants of the aircraft, who were all dead when the aircraft came to a halt.

3.2 Causes

This accident is the result of a combination of two events which led to a fire on the aircraft :

- Massive ingestion of lapwings by the left engine, after rotation ;

- Uncontained burst of the left engine following non-functioning of its fan rotor overspeed protection system.

The rapid spread of the fire caused loss of control of the aircraft in the last phase of the attempt at an emergency landing.

4 - RECOMMENDATIONS

Analysis of this accident leads to the following recommendations.

4.1 Preliminary Recommendations

Two preliminary recommendations required urgent application and were issued before the publication of this report. These recommendations are listed below.

4.1.1 Recommendations Concerning the Organization of Bird Strike Hazard Prevention at Le Bourget

"We may note that Le Bourget airport :

- according to the ministerial instruction of July 24, 1991, belongs to category D in terms of equipment, a category which corresponds to a sensitive ornithological environment, as established by the STNA,

- as a privileged center for high quality business aviation, has a volume of traffic amongst the highest in France.

Bird strike hazard prevention measures are undertaken by the ATC office whose manpower has been increased in order to take into account this specific task. However it seems that better results may be obtained in this area by officers specialized in this type of mission.

The organization is of course in conformity with the previously mentioned regulations, which allow for bird strike hazard prevention measures to be undertaken, in certain specific cases, by officers of the air traffic control organization rather than officers from the management structure (see chapter 2.1).

However, it should be noted that the Paris airport authority (ADP) organized bird strike hazard prevention at Roissy, Charles de Gaulle and Orly airports in a different manner. Bird strike hazard prevention measures at those airports are undertaken by specialized officers of ADP who are attached to the general services department, and for whom it is their principle role.

Consequently, the Bureau Enquêtes-Accidents recommends :

- **that ADP reorganize bird strike hazard prevention measures at Le Bourget as soon as possible so as to model it on that of Roissy Charles de Gaulle and Orly airports, unless it appears that the results obtained at these two airports are comparable to or inferior to those obtained at Le Bourget."**

Following this recommendation, ADP put in place a new organization at Le Bourget. The bird strike hazard prevention service is no longer provided by officers from the ATC office but by specialized ADP officers seconded daily from Roissy Charles de Gaulle[9] under the duty officer of the ATC office who takes overall operational responsibility.

4.1.2 Recommendation Relative to GE CF 700 Engines

"In its present configuration the GE CF700 engine (all types) is inadequately protected against fan rotor overspeed. The January 20 1995 accident showed that in certain circumstances a fan rotor overspeed could occur, with uncontained detachment of the bluckets, without the installed protection systems reacting adequately.

The BEA considers that this phenomenon could recur. Consequently, it recommends :

- **that the certification authorities of France and of the USA (FAA) order, in coordination with the engine manufacturer, the modification of the CF 700's fan rotor overspeed protection system so that it conforms with note 9 of the engine type certificate data sheet E7EA."**

The FAA, in a letter dated September 14 1995, addressed to the National Transportation Safety Board, officially accepted this recommendation.

A certification program was launched for an improved containment system which would ensure conformity with note 9 of the engine certification documents.

This modification will be the subject of an Airworthiness Directive, (the American equivalent of a "Consigne de Navigabilité") to be issued to all operators. This Directive was due to be signed in January 1997 and will be published in the Federal Register. It is based on GE Service Bulletin (CF 700) 72-154.

[9] ADP undertook new recruitment during the summer of 1995 in order to be able to provide bird strike hazard prevention service at both airports.

4.2 Other Recommendations

4.2.1 Recommendation relative to follow-up of bird strike hazard prevention service

In the context of organizing bird strike hazard countermeasures, the STNA is responsible for carrying out policy defined by the DNA in the overall context of the ministerial instruction of July 24 1989.

In accordance with this mission, the STNA recommended, in 1992, the installation at Le Bourget of a fixed system of loud speakers, a system which for many reasons (technical choices, installation, problems concerning neighboring communes) could only be used sporadically after its installation. In order to improve the manner in which the difficulties of airports can be dealt with, it would seem reasonable to follow the model applied to other types of aeronautical equipment. In his context, the Bureau Enquêtes-Accidents recommends :

- **that the STNA set up a formal follow-up system to determine the availability of equipment and manpower used in bird strike hazard prevention service and to assess any possible difficulties. This service could include periodic checks at certain airports.**

In addition, the investigation demonstrated that one of the reasons for the non-functioning of the fixed loudspeaker systems was their installation ten meters from the edge of the runway, without any specific precautions being taken, which led to regular damage to the loudspeakers during takeoff by jumbo jets. Consequently, the BEA recommends that :

- **in the course of adaptation of fixed equipment to an airport's specific characteristics, during the definition phase, account should be taken of all types of aircraft which might use the airport, even when such usage might seem to be exceptional.**

4.2.2 Recommendation Concerning Falcon 20 Emergency Procedures

Analysis of this accident showed the necessity of revising certain emergency procedures on the Falcon 20 so that they may be better adapted to the critical case of takeoff. Such revisions would also improve commonality of emergency procedures on aircraft from the same manufacturer, which are often operated by crews with double or triple type qualifications (Falcon 10, 20 and 50 for example).

Consequently, the Bureau Enquêtes-Accidents recommends :

- **that certain emergency instructions in the Falcon 20 flight manual be revised in order to be better adapted to the critical case of takeoff, and to provide better commonality between the different types of aircraft from the same manufacturer ;**

- **that the attention of the primary certification authorities and of manufacturers of other aircraft be drawn to the possible existence of the same problem.**