No. 31

Air France, SE 210 III Caravelle, F-BJTB, accident near Rabat-Salé Airport, Morocco, 12 September 1961. Report released by The Minister of Foreign Affairs, Morocco.

Circumstances

After a normal flight from Orly Airport, Paris, Flight 2005, Paris-Rabat-Casablanca, reported over the Rabat - Salé Airport, where meteorological conditions were unfavourable owing to thick, low fog which reduced horizontal visibility and ceiling. The pilot reported his intention to attempt a break-through over the non-directional beacon; the control tower immediately replied that that facility was not in line with the runway, but the message was not acknowledged. The aircraft crashed to the ground at 2109 hours GMT killing all 77 persons on board, including 6 crew members. The aircraft was completely destroyed by impact and the fire which followed.

Investigation and Evidence

The Aircraft

The aircraft's certificate of airworthiness was dated 23 May 1961. Since construction F-BJTB had completed 688 hours of flying. It had undergone the following inspections:

T2 inspection	:	31 August 1961
block "	:	7 September 1961
T1 "	:	11 September 1961

Loading and trim

On take-off from Orly the aircraft had weighed 45 367 kg. (The maximum allowed was 46 000 kg.) The estimated landing weight was 37 408 kg for an authorized 43 800 kg. Its centre of gravity was within limits.

Crew Information

Aboard the aircraft were 6 crew members - the pilot-in-command, a co-pilot, a flight engineer and 3 cabin attendants.

The flight crew's experience was as follows:

Pilot-in-command

He held an airline transport pilot's licence and had logged a total of 10 693 hours, 344 of which were on Caravelles. He had made 31 landings at the Rabat/Salé Airport.

Co-pilot

He held a senior commercial pilot's licence and had logged a total of 3 858 flying hours, of which 988 were on Caravelle aircraft. He had made 3 landings at Rabat/Salé.

Flight engineer

He had a flight engineer's licence and had flown 6 553 hours of which 173 were on the Caravelle.

Weather

On departure from Orly Airport the flight was provided with landing forecasts for Rabat/Salé Airport. While en route, the flight called the Air France unit at Casablanca at 2040 hours on the airline frequency and was given the following aeros for 2030 hours.

Rabat/Salé : wind 360°/2 kt; visibility 500 m; fog; ceiling 7/8 at 300 m;

Casablanca : wind 360°/4 kt; visibility 6 km; ceiling 7/8 stratus at 150 m; variable

Tangiers : wind 360°/12 kt; visibility 20 km; ceiling 1/8 cirrus at 7 000 m

The airline operations agent then suggested that the pilot head for Casablanca passing over Rabat in order to get the latest weather there and informed him that Tangiers was a sure alternate.

The pilot acknowledged receipt of the foregoing messages indicating that he would, as suggested, head for Casablanca flying direct over Rabat/Salé. He also requested the forecasts for Marrakech Airport, which were received later.

At 2046 hours the Casablanca Regional Control Centre, with which the aircraft had just made contact, gave it the latest observations for Rabat/Salé and Casablanca. One minute later the aircraft requested and received the new meteorological observation for Rabat from the Casablanca ACC. At 2048 it received the latest observation for Tangiers from the same control centre. The area control centre notified the aircraft, six minutes later, of information from Rabat/Salé that visibility was then 500 m because of fog patches, increasing at most to 1 km when at its best; the aircraft acknowledged the message.

At 2055 the Air France agent contacted the aircraft on the airline frequency and reported, with reservations, the following information which had been obtained from Rabat/Salé by telephone: Rabat/Salé field was then clearing, with several kilometres' visibility and clear sky. These latest conditions at the field were due to the sporadic passage of fog patches. The aircraft acknowledged. One minute later the Casablanca control centre indicated that the Casablanca meteorological station foresaw neither a worsening nor an improvement at the field; the aircraft acknowledged the message.

Conditions at the aerodrome at the time of the approach and of the accident

The weather report transmitted to the aircraft by Rabat/Salé control tower at approximately 2100 hours indicated:

wind 360°/2 kt; horizontal visibility: 500 m; ceiling 2/8 at 300 m; QNH pressure 1015 mb, QFE 1005 mb

The aircraft was then over Kénitra aerodrome (Port Lyautey), and the captain asked at once if the supporting pylons for the antennae of the radio station, some 15 km north of Rabat/Salé, were clear. The controller indicated, in reply, that the antennae were not visible from the tower; he added that fog patches were drifting over the Rabat/Salé field and that at the moment the entire runway was clear.

A few minutes later, at the request of the control tower, the aircraft reported over the town of Rabat. On his own authority the controller informed the aircraft that conditions had worsened. This was later confirmed by the meteorological observation for 2110 hours which follows:

wind 360°/2 kt; visibility 500 m; ceiling 8/8 at 30 m.

The Flight

The aircraft departed Orly Airport, Paris at 1826 hours GMT on a scheduled flight to Rabat, Morocco. It carried enough fuel for four hours.

Following a normal flight from Orly the aircraft began its descent at 2052 hours, estimating Rabat at 2104 hours, and was transferred to the control tower (Rabat) at 2100 hours. There was no indication from the crew of any malfunction.

The aircraft then reported as being over Kénitra at an altitude of 15 000 ft, descending at an indicated speed of 285 kt. At 2102 it passed almost over KJ the non-directional radio beacon of Rabat/Salé

Airport. At 2109 when over the town of Rabat, and having been notified of a deterioration in the meteorological conditions, the pilot announced his intention of attempting a break-through by means of beacon KJ. The tower immediately notified the aircraft that the beacon was not on the runway alignment. That message was not acknowledged.

The aircraft had struck the ground, probably in a slightly left bank, at the end of a left turn. The landing gear collapsed, and the aircraft bounced, touched ground again, then jumped a deep gully bordered on the left by a gorge, and crashed against the opposite side. The wreckage slipped to the left towards the gorge and broke up, ejecting seats and passengers.

The wreckage site was 8.4 km from the threshold of runway 04 and 1.4 km to the left of the extended centreline. The elevation of the accident site was 87.5 m. This point is near a place called Douar Doum.

Technical examination

Further to the examination of the wreckage which proved that the landing gear was down and locked, the flaps were down at 10°, the airbrakes were "in", the elevator trim was at zero, the master cut off switch was "on" (safety cover locked), the autopilot control was "ready to engage", technical examination of recovered equipment revealed the following:

Engines At the time of the accident the two engines were at low thrust, probably idling, although a valid figure could not be suggested.

Servo controls The elevator, rudder and left aileron found practically intact, worked satisfactorily at the testing bench before they were disassembled. Their correct operation was confirmed after disassembly. There was no sign of binding, even partial, in the distributors. The right aileron servo control was so damaged on impact that it could not be examined.

Altimeters Very little correct information could be gained from from the pilot's Kollsman altimeter, which had been badly damaged by impact and fire. After examination of the stop mechanism the only conclusion was confirmation of the setting in the area of 1005 mb.

The co-pilot's altimeter was not as badly damaged, and its setting showed a pressure reading of 1005 mb.

Radio altimeter All electronic components were destroyed, but it can be stated that the radio altimeter was turned on and set to 1 000 ft on the sensitivity scale. The pre-selector was set to 50 ft; in spite of major damage, both the pointer and the switch catch confirm that setting. It can, therefore, be concluded that at the time of the accident the radio altimeter was on, set to 1 000 ft on the scale and to 50 ft on the blinking lights of the altitude preselector.

Discussion

Meteorological conditions

There is no doubt but that the pilot was aware of the unfavourable conditions prevailing at the airport and around Rabat.

This type of weather, which is frequent on the coast, often arises very quickly without the possibility of any forecast, even of short-term validity.

According to the first statement by the tower controller, the observation by the Rabat/Salé meteorological service of the latest deterioration in conditions ("sky covered 8/8, ceiling 30 m") was telephoned to the control tower at 2110 hours and retransmitted to the aircraft at 2112 hours during the last conversation; it is, however, certain (after examination of the flight recorder) that the accident occurred at 2109:20, and the evidence shows the time of the observation to have been 2110 hours.

It can, therefore, be considered that this official message, indicating worsening conditions, was certainly transmitted to the aircraft but after the crash, and that it is probable that the controller indicated to the aircraft, during the last conversation, that the situation was rapidly becoming more unfavourable.

At the time of the accident there was no magnetic recorder for radio communications in the Rabat/Salé control tower.

Progress of the flight from the air traffic (control) point of view

Since the communications were not recorded, the Commission relied on the testimony of the controller who was on duty in the Rabat/Salé tower on the night of 12/13 September.

It should be noted that as soon as radio contact was established, control indicated the runway in use, but no landing clearance was either requested or given in the course of the exchanges of communication.

Based on examination of the last part of the flight, and following processing of the tape, it is almost certain that the controller's watch was 2 to 3 minutes fast at the time of the accident, which would explain some chronological contradictions in the statement of events made by him.

Reconstruction of the final phase of the flight - analysis of flight recorder information

The flight recorder was recovered intact. All parameters were perfectly legible. The only exception was that the tape speed was too slow* to permit a very accurate reconstruction of some parameters, *particularly the rate of descent.*

Nevertheless, the Test Flying Centre was able to plot the flight path of the aircraft up to the point of impact by constructing at each point the known speed vector in amount and direction.

Such a reconstruction is the more accurate when the wind is light, as was the case on the night of the accident.

The pilot practically followed the coast from Kénitra, over which he passed at 2100 hours, at an altitude of some 15 000 ft and descending, at an indicated airspeed of 285 kt.

At 2102 the aircraft was approximately over beacon KJ, about 800 m west of the aerodrome.

The aircraft made a 360° turn and at 2107 hours was over the town of Salé at an altitude of 1 650 ft, at an indicated airspeed of 230 kt.

Between 2107 hours and 2108 hours *the aircraft was over the town of Rabat.* At 2108 hours its altitude was 1 240 ft, its indicated airspeed 190 kt, and its rate of descent 410 ft/min.

From 2108 hours to 2108:32 the altitude remained at 1 200 ft; the outbound leg terminated at 2108 hours when a 180° turn was initiated (heading at 2108 hours - 236°).

From 2108:32 to 2109:21 hours, altitude, speed and heading varied in accordance with the following table:

Time	Altitude	Speed	Heading	Average rate of descent	Comments
2108:32	1 200 ft	160 kt	156°		
2108:48	900 "	152 " (Speed constant)	108°	1 230 ft/m	
2108:55	720 "	152 " (Speed constant)	87° (Heading constant)		
2109:12	430 "	152 " (Speed constant)	56° (Heading constant)	1 100 ft/m	
2109:21	260 "	152 " (Speed constant)	56° (Heading constant)		Impact

Comment: On the basis of the recording tape it may be assumed that flaps were extended 10° at 2108 hours, altitude 1 240 ft, indicated airspeed 190 kt.

* Flight recorders are now available with two speeds, including one high speed for the take-off and landing phases.

Configuration at impact

During the last 20 seconds the aircraft's landing gear was down, and the flaps were extended about 10°. It was in continuous descent at a rate of 1 200 to 1 300 ft/min.

The question, therefore, arose as to what the aircraft's attitude was, and what thrust was needed to propel it.

Sud Aviation carried out a test which showed that the attitude was probably slightly negative, from -1° to -2°, and the engine thrust of the order of only a few hundred kilogrammes, that is corresponding to a rather fast idling of both engines.

Those conclusions are partly confirmed by the fact that the first tracks of the aircraft on the ground were made by the small front wheels, which touched ground before the main landing gear, as the central tracks of the front landing gear start at the same point as those of the main landing gear.

Nothing could be checked regarding engine thrust as no engine parameters were recorded. However, the technical examination of the engines at the Hispano Suiza plant seemed to offer confirmation; in particular, the pitch of the intake guide vanes and the deposits on the engines were evidence of a condition close to idling.

In this connexion, it should be pointed out that the positions of the throttle controls on the pedestal were of no value as evidence of conditions at the time of first impact and during the slide preceding the final crash, because the connexions between the throttle controls and the engines were cut in the final break-up.

The question whether the pilot attempted to re-apply power immediately after the wheels touched ground, will never be answered with certainty, because the time during which the aircraft remained almost unbroken (at least as regards engines, cabin and wings) was of the order of 3 seconds at most, since it covered about 200 m. Engine pick-up from idle during that time could only have been very slight, since this type of aircraft requires 8 to 10 seconds to resume full power from idling. Re-application of power would have been of no avail after the first impact because the landing gear collapsed on first contact with the ground.

Hypotheses and Conclusions

Equipment failure

Failure of an essential structural element

There was no evidence nor anything in the radio messages (the last of which was sent between 10 and 30 seconds before the accident) to support the theory of failure of an essential structural element or breakage of a vital part.

Another reason for discarding this theory is that the speed during the final stage remained constant.

Failure of servo-controls, control gear or linkage

The fact that the aircraft struck the ground could, at first sight, be taken as an indication of control or servo-control failure, but the following reasons call for rejection of that theory. The reconstruction of the flight path, and the attitude of the aircraft at the time of impact show that all parameters - bank, speed on course and glide path slope - were absolutely consistent; an aeroplane deprived of the use of a single control would not show such a regular pattern, and, in particular, a failure at any part of elevator linkage would result in major and rapid variations of the speed vector in amount and in slope; such variations would be evident in the reading of the recorder tape. Such was not the case, and all the above-mentioned parameters were perfectly regular.

Failure of a servo-control, control gear or linkage is, therefore, excluded.

At the time of the accident the flaps were extended 10°, as shown by an examination of the position of the flap roller carriages on their screws. All carriages were found at the 10° position.

The position of the flaps confirmed the theory that the pilot believed he was at a higher altitude; naturally if the pilot had believed he was on final approach, the flaps would certainly have been extended to a greater angle.

Engine failure

The testing of the engines in the workshop clearly showed that at the time of the accident, both engines were operating at low rpm, very close to the rate required for the speeds and rates of descent in the few seconds before impact occurred.

Failure of airborne instruments

Altimeters: manual setting devices

The co-pilot's altimeter was found set to 1 005 mb, the pressure transmitted to the aircraft by the control tower. Examination of the pressure setting stop mechanism on the altimeter of the pilot-in-command showed a pressure setting in the area of 1 005 mb.

Altimeters: mechanical, static or dynamic devices

The destruction of machinery and pivoting units precluded any check on the possibility of a shift (by a gear jump) of the pointer showing hundreds of feet. Furthermore, the technical examination did not permit any estimate of the readings on the drum for thousands of feet. The theory, therefore, cannot be verified.

Failure in static generation, causing simultaneous aberration of both altimeters on the instrument panel, cannot occur, since each altimeter is connected to different ports right and left, on the sides of the fuselage, and it is impossible for both double ports to ice at the same time; furthermore, at Rabat the temperature near the ground excludes the possibility of icing.

However, the pilot and co-pilot can still operate a valve to switch from the fuselage static ports to one, near the lower door, with better de-icing, and, as a final resort, there is always the possibility of connecting with a static port on the engine nacelle, where de-icing is assured by reason of the engine temperature.

As for the (SFIM) flight recorder, its static port is on the artificial feel antenna, which is also under an engine nacelle. There was nothing abnormal in that area, especially as the flight recorder continued to operate after impact.

Radio altimeter

The setting of the radio altimeter to "on" and "low altitude range" appeared to indicate that the crew had intended to use it.

If the lamp setting to 50 ft was intentional, that also would indicate an intention to watch the altitude on final approach.

It may be noted that at the rate of descent of the aircraft, it required only 2 to 3 seconds from lighting to touchdown, which seems to confirm the assumption that the pilot believed himself to be higher than his actual altitude.

Miscellaneous incidents

Battery explosion

This has never occurred aboard a Caravelle, and, in addition, aircraft of this type are equipped with Saft iron-nickel batteries, in which the electrolyte, a soda solution, has none of the disadvantages of the sulfuric acid in lead acid batteries. Furthermore, the battery compartment is well ventilated and far enough from the crew for complete protection in case of an explosion.

Explosion in flight

The accounts of witnesses, some of whom saw or heard the aircraft almost up to the time of impact, and the examination of the wreckage and of the flight recorder, appear to rule out the theory of explosion in flight.

Fire in the cabin could only have been electric or electronic, slow-spreading in its early stage; the crew would certainly have reported it by radio, and the engineer was provided with a cabin extinguisher that was effective for that type of fire - a very unlikely theory.

The engines were idling, therefore, the actual compression ratio was low, and the ratio of exhaust to intake temperatures also remained low.

Other equipment

At no time, either while in contact with Casablanca (the conversation was recorded) or while in contact with Rabat/Salé tower, did the crew report any malfunction or difficulty, either of a mechanical nature or with radio equipment. In particular, the main electric switch was found locked, with its guard in place.

The possibility of sudden failure in a circuit or in technical equipment during the final phase appears unlikely, since the flight recorder was still working after the impact.

Personnel failure

Physical failure

This possibility was considered groundless, because of the presence of both a pilot and a co-pilot aboard the aircraft.

Error in instrument reading

The aircraft's approach procedure, as reconstructed from the SFIM flight recorder and from testimony, seemed in line with a normal attempt to break through and land. Taking into account the speed on the flight path, the vertical speed, the heading and its variation, the rate of turn, and if the altitude parameter had been good and followed suitably in its development, i.e. increased by 1 000 ft, the aeroplane's flight path would have intersected the ground on the aerodrome or very near, in front of the approach end of runway 04 in use.

The theory of an error of 1 000 ft appears probable but could not be verified.

Probable Cause

In the opinion of the board of inquiry of all the theories listed above, those related related to material failure appear the least likely. On the other hand, the theory regarding an error in instrument reading appears more probable than the others.

Therefore, the Board explained the failure:

1) by the fact that reading of the Kollsman window altimeter, with which this Caravelle was equipped, may be delicate, as demonstrated by some systematic tests carried out by highly trained crews of various European airlines;

2) by the possibility that the pilot made that error of 1 000 ft at the beginning of the descent, retaining it, then gave his full attention to reading the pointer, which seemed to him to be of prime importance, in order to bring in the aircraft at the minimum authorized altitude.

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