No. 5

Caledonian Airways Ltd., DC-7C, G-ARUD accident 2 km from Douala Aerodrome, Cameroon, 4 March 1962. Civil Aircraft Accident Report of the Commission of Inquiry, Federal Republic of Cameroon, released by the Ministry of Aviation (United Kingdom) as C.A.P. 202.

1. Historical

1.1 Circumstances

G-ARUD was on an international non-scheduled flight (CA 153/154) from Luxembourg to Luxembourg via Khartoum, Lourenço Marques, Douala and Lisbon. The flight departed Luxembourg on 1 March 1962 and arrived at Lourenço Marques on 2 March where there was a stop-over period of 36 hours 55 minutes. The aircraft left Lourenço Marques on 4 March and arrived at Douala at 1645 hours GMT after a flight of 8 hours 45 minutes. The flight up to the arrival at Douala was made without incident. There were 10 crew members and 101 passengers aboard when the aircraft left the ramp at Douala at 1805 hours. The taxiing instructions gave the take-off runway 12 (QFU 12), the altimeter setting 1010 mb (QNH) and the wind 220°/8 kt. G-ARUD held clear of the active runway for landing traffic and during this period witnesses heard the engines being run up. The aircraft lined up on runway 12 and took off at 1820 hours. (Night take-off. Evening twilight ended at 1756 hours). According to the controller on duty at the control tower the aircraft's landing lights were not on during the take-off. The aircraft lifted off runway 12 after what appeared to be an unusually long run of approximately 2 400 m (of 2 850 m available) after release of the brakes and gained height with difficulty. The anti-collision light was seen at a low altitude and then disappeared behind the trees. Five seconds later the sky was lit up by a fire. The left wing and left side of the fuselage struck the first trees of the forest at a height of about 22 m above the elevation and about 2 300 m beyond the threshold of runway 30. After the initial impact in a near level flight attitude and with the aircraft slightly banked to port, it then went progressively into a dive with the left wing low and sheared the tops of the trees over a traversed distance of about 130 m before final impact with the water of a creek. The attitude of the aircraft on final impact was approximately 25° nose down with the same angle of left bank. The aircraft exploded on impact. The fuel and oil spread over the surface of the water and ignited. The fire destroyed the unsubmerged parts of the wreckage. The accident occurred at 1821 hours GMT.

1.2 Damage to aircraft

The aircraft was destroyed by the impact, the fire or submersion.

1.3 Injuries to persons

All occupants (10 crew and 101 passengers) lost their lives.

2. Facts ascertained by the Inquiry

2.1 Aircraft information

The Certificate of Airworthiness was valid until 28 November 1962. Maintenance of the aircraft met the approved maintenance schedules. The take-off weight of the aircraft at Douala was within the prescribed limits for the circumstances. The computed centre of gravity was well within the prescribed limits.

2.2 Crew information

The pilot-in-command, age 41, held a valid airline transport pilot's licence properly rated for the flight. He had a total of 11 587 hours flying time of which 287 hours were on DC-7C aircraft. In the preceding 90 days his flight time was 199 hours 35 minutes.

The co-pilot, age 39, held a valid airline transport pilot's licence properly rated for the flight. He had a total of 10 249 hours flying time of which 227 hours were on DC-7C aircraft. In the preceding 90 days his flight time was 185 hours 05 minutes.

The second co-pilot, age 39, held a valid commercial pilot's licence properly rated for the flight. He had a total of 7 187 hours 30 minutes flying time of which 187 hours 30 minutes were on DC-7C aircraft.

The three engineers held valid flight engineers' licences. One held a first engineer rating for DC-7C aircraft, another held a second engineer rating for DC-7C aircraft, and the third held no rating for DC-7C aircraft. The first engineer had 2 772 hours experience on DC-7C aircraft and the other flight engineers had 242 and 28 hours of DC-7C time respectively.

The remaining crew members were the navigator and three female cabin attendants.

2.3 Weather information

Meteorological conditions prevailing at Douala Aerodrome at the time of the aircraft's take-off were:

Temperature	28.8°C
humidity	79%
wind	260°/5 kt
visibility	15 km
cloud	400 m 3/8 Fc
	600 m 2/8 Sc
	1 500 m 2/8 Cb (to the southwest)
QNH	1010 mb

The aerodrome and line of approach for runway 30 were reported as being clear.

2.4 Navigational Aids

ILS, VOR, MF beacons. In view of the flight phase and the meteorological conditions at the time of take-off, these items can be discounted.

2.5 Communications

HF, VHF. Take-off clearance was given to the aircraft. No recording of tower communications was made.

2.6 Aerodrome Installations

The aerodrome and ground facilities were fully adequate.

2.7 Fire

Fire occurred after impact and explosion. Fuel and oil on the surface of the water ignited and destroyed the unsubmerged part of the wreckage.

2.8 Wreckage

The wreckage trail commenced at the location of the first trees struck by the aircraft which showed that initial impact was on the bottom left-hand side of the fuselage at the left wing root. The trail of the wreckage indicated the aircraft's direction of travel was 110° - some 14° to port of the QDM of the runway (124°). The violence of the final impact with water caused the wreckage to disintegrate into a large number of parts some of which were heavily deformed by contact with the trees and mangrove roots. On certain parts a very clear line of demarcation between the area destroyed by fire and the intact area shows these parts were submerged and that destruction by fire was due to fuel burning on the surface of the water. No trace of fire was found on any of the submerged parts.

3. Comments, findings and recommendations

3.1 Discussion of the evidence and conclusions

The following hypotheses were examined in detail:

a) act of sabotage;
b) failure of one or more power plants;
c) control surface flutter;
d) incorrect operation of the undercarriage and flaps;
e) untimely or asymmetrical retraction of the flaps;
f) structural failure;
g) erroneous indications of the instruments;
h) electrical failure;
i) incident in the cockpit;
j) crew fatigue;
k) inadequate fuel characteristics;
l) errors in the load sheet.

Insufficient evidence was found to corroborate any of these hypotheses. In discussing the abnormally long take-off run before lift-off (about 2 400 m, instead of about 1 500 m), several causes were analysed including failure of a power plant, excessive flap setting for take-off or deliberate holding down of the aircraft above a speed higher than V2. In the Commission's opinion the most suitable explanation for the long ground run is provided in the theory of "difficulties arising at the time when V2 was reached causing the crew to delay either deliberately or involuntarily, the lifting-off of the

wheels". There was no evidence of smoke in the cockpit or fire which might have distracted the crew and caused a delay in rotation of the aircraft. During the technical examination of the wreckage the mechanism of the right elevator spring-tab was found jammed in such a manner as to prevent the movement of the spring-tab in the nose-up direction of the control surface. In view of the similarity of friction markings found in the same mechanism of other DC-7C aircraft, and information received of an abandoned take-off at V2 of a DC-7C in April 1961*, flight tests were made which revealed that with one of the two spring-tabs jammed, a pull force of 40 - 45 kg (as opposed to a normal 14 - 16 kg) has to be applied to cause the desired rotation of the aircraft. This could provide an explanation for the increase in the ground run prior to lift-off.

3.2 Probable causes

The facts on which the Commission can base its conclusions are as follows:

1 a) The operator, Caledonian Airways, held an Air Operator's Certificate in order and valid.

1 b) The DC-7C aircraft, G-ARUD, had a valid Certificate of Airworthiness on the day of the accident.

1 c) The crew of G-ARUD held the necessary valid licences and qualifications.

The Commission of Inquiry has good reason to think that the co-pilot, a captain, who held -

- a valid airline transport pilot's licence,

- a qualification for aircraft commander in the DC-7C since 17 January 1962,

was carrying out a route qualification under the control of the pilot-in-command during the flight Luxembourg - Lourenço Marques - Douala - Lisbon - Luxembourg.

The Commission deduces from this that during the take-off from Douala the co-pilot was probably in the left-hand seat and the pilot-in-command in the right-hand seat.

The pilot-in-command acquired his flying experience with a major international carrier, a European international operator and two companies in the United Kingdom. He was well experienced on four-engined aircraft. As for DC-7C experience - he made 13 flights during training and 20 take-offs as pilot-in-command, including 14 at night. He was reported to be a very competent and capable pilot.

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* This incident caused Douglas to issue an SSTR, dated 1 May 1961, suggesting, but not requiring, the checking of the spring-tab mechanisms.

Although the co-pilot had a total of 5 844 hours as pilot-in-command, it was mainly time flown on DC-3 and Bristol 170 aircraft. His experience as pilot-in-command on four-engined aircraft and DC-7Cs was fairly limited. On DC-7Cs, as pilot-in-command, he had carried out about 15 take-offs, including 6 at night. He was considered to be a very capable pilot and had gained his experience while employed by an airline in the United Kingdom and while training with a European international operator.

The flight engineer had good experience on the DC-7C before joining Caledonian Airways. He had flown 2 594 hours with a major international carrier from October 1957 to October 1961 and was reported as being a capable and competent engineer officer.

The Commission is, therefore, led to conclude that the crew of G-ARUD held valid licences and qualifications and that it corresponded to the average crew of a four-engined aircraft, with nothing exceptional. The DC-7C experience of the pilot-in-command and the first officer was relatively limited, however.

1 d) The pitch of the propellers on impact was about 37° for the four engines, which eliminates the hypothesis of the failure of one of the engines. The first reduction had not been made.

From consideration of the curves V = f (pitch, power) provided by Hamilton, it can be deduced that the speed on impact was about 170 kt (V2 = 126 kt, V2 + 15 = 141 kt), which for practical purposes eliminates the hypothesis of a stall.

1 e) At the time of the impact, the undercarriage was retracted.

1 f) The first impact with the trees took place at 22 m above the aerodrome elevation of 11 m.

The point of first impact is about 5 100 m from the point of release of the brakes at the beginning of runway 12, i. e. about 2 300 m from the threshold of runway 30 and 475 m to the left of the runway centre line.

The angle of deviation to the left is therefore 11°, measured from the end of the runway, and 21° 30' measured from the position of the middle marker.

At the time of the first impact, the aircraft appears to have been slightly banked on the port side and the pitch attitude was far nearer to level flight than to even a shallow dive.

1 g) The accident occured at 1821 hours GMT; the sun set at 1735 hours and twilight ended at 1756 hours. The aircraft's landing lights do not appear to have been used on the take-off of G-ARUD at Douala. On the other hand, the anti-collision light functioned until the crash.

1 h) The corrected weight of G-ARUD on take-off from Douala was 139 266 lb, and the Commission has no reason to doubt the centre of gravity of 29. 5% calculated by the crew. In any event, it has ascertained from the calculations of the Air Registration Board that the effective centre of gravity could not have been further to the rear.

The Commission has also to take into consideration the following points:

2 a) the starboard elevator spring-tab of G-ARUD was found jammed when the wreckage was examined in France where it had been taken for expert examination.

Several members of the Commission think that this jamming took place before the impact. The Commission recognizes unanimously that such jamming was possible, and in view of the facts established by the Commission, the Douglas Company subsequently issued a service bulletin recommending a modification similar to that which several well-known international companies using the DC-7 are applying.

2 b) Although the flap control lever was found in the position of 10°, examination of the surfaces of the flaps and the corresponding expert examination of the jacks, hinged connection cover plates and guides give the Commission reason to believe that at the time of the impact the flaps were retracted or in a position very close to the retracted position. If this is so, it can be concluded that everything must have been normal when the pilot-in-command ordered the retraction of the flaps, the speed then being V2 + 15 = 141 kt, and that a few seconds at most before the impact and about 10 seconds after the flaps had been previously retracted the control was replaced to the position of 10°, the crew having observed an abnormality of some kind or other.

2 c) Flight tests were carried out at the request of the Commission of Inquiry by the French Flight Test Centre at Istres in October 1962, and then at Brétigny in May 1963. The object of the tests was to compare the behaviour and control forces of the DC-7C on take-off and during the first climb phase, more particularly during the retraction of the flaps, with the same load and centre of gravity as that of G-ARUD at the time of the accident, in the following two cases:

- one elevator spring-tab jammed

- the two elevator spring-tabs free

The main facts revealed by the report of the Flight Test Centre and by the annexed interpretations are as follows:

A) With a centre of gravity position, further to the rear, of 28.5%, approximating that of G-ARUD at Douala, the stick forces on the lifting-off of the nose wheel and on take-off, with a spring-tab jammed, are surmountable but still sufficiently high to explain the abnormal length of the take-off run of G-ARUD which, according to the evidence of the Tower Controller, was still running along the ground when it blocked the observer's view of the light of the glide path transmitter.

B) In all cases and with all centre of gravity positions, the retraction of the flaps is accompanied by a fairly considerable variation in stick force, and in order to maintain a constant speed, attitude or altitude during the retraction of the flaps, the pilot must always exercise a pull force on the control column if he does not operate the trim tab.

With the centre of gravity and weight of G-ARUD at Douala, the stick forces on the retraction of the flaps to maintain constant flight attitude are:

- approximately 5 to 10 kg when the control surface is normal
- approximately 10 to 17 kg when one of the spring-tabs is jammed.

Even when the control surface is normal, the forces may be sufficient to produce a not inconsiderable risk of negative rate of climb with all the resultant dangers if the aircraft is not at a sufficient altitude. The risks of negative rate of climb are obviously aggravated if a spring-tab is jammed.

2 d) It is therefore regrettable, in the case of the Douala accident, that the take-off and climb procedure for the DC-7C applied by Caledonian Airways did not include a minimum altitude for flap retraction, apart from a reference to the necessity of being clear of obstacles, as opposed to the procedure adopted by other operators which stipulated that this operation should not be begun at night before 400 ft.

The Douala approach chart available to the crew of G-ARUD did not show any obstacle on take-off on runway 120 except the building of the middle marker, 10 ft high, 1 070 m from the end of the runway, and the aerial of the radio beacon, 138 ft high at a distance of 6 km.

It was, therefore, theoretically sufficient that the minimum gradient of climb of 1.2% should be guaranteed from 50 ft onwards which the aircraft should have reached at the end of the "take-off distance". The aircraft would thus have been at an altitude of 160 ft (approximately 50 m) on passing the point of impact.

The crew of G-ARUD, which had landed at Douala at about 1630 hours, could not have been unaware of the presence of the trees along the edge of the take-off flight path area on a bearing of 120°. Moreover, they are shown on the visual landing charts published by ASECNA which the crew could easily have seen at the aerodrome local control; but these charts give no indication of the height of the trees along the edge of the take-off flight path area.

2 e) The climb procedure adopted by Caledonian Airways included a minimum cooling speed of 160 kt IAS. It emerges from statements in agreement with one another of the crews of Caledonian Airways and of the pilots of another international carrier that the cooling speed adopted when clear of obstructions was 180 kt. It is highly probable that the crew of G-ARUD applied this rule, and this seems to be confirmed by the evidence of the Tower Controller who stated that the climb had been very slow.

2 f) The Commission is, therefore, led to think that G-ARUD deliberately remained at a low altitude after its take-off. It notes that the aircraft does not appear to have reached 180 kt.

2 g) It is improbable that the aircraft's deviation to the left of the extended runway centre line was the result of a deliberate action on the part of the crew. The crosswind and possible asymmetry of engine power are not sufficient to explain the deviation. It may have been the result of a defect either in the pilot-in-command's flight director (HZ. 1) or the emergency horizon (H6B6), which would have affected the indications of the instrument. If the pilot chose to follow the indications of the instrument at fault without checking those indications by the indications of the basic instruments - altitude, heading, pitch - he may have been sufficiently misled to make the deviation found at the wreckage.

The Commission notes that:

- nothing was found of the HZ. 1 and that the expert examination of the pilot-in-command's emergency horizon H6B6, which was recovered from the wreckage, has not made it possible, in view of the damage sustained, to establish whether or not there was a defect in the instrument;

- the failure of a horizon is no explanation of a decision by the crew to re-extend the flaps;

- during flight tests in the DC-7C at the Brétigny Flight Test Centre, when the crew was careful to maintain a given speed, attitude or altitude, involuntary changes of heading far greater than that of G-ARUD were observed.

3.3 Recommendations

The Commission considers that during the Inquiry certain abnormal facts were established or revealed by the evidence and statements of witnesses. Although some of these facts are not connected or are only indirectly connected with the accident, the Commission considers that it is its duty to formulate the following recommendations.

Recommendations regarding the aircraft

The Commission considered it regrettable that the constructor did not design a modification to the elevator spring-tab control mechanism, to eliminate the possibility of accidental jamming, immediately after the abandoned take-off incident to the DC-7C which led to the SSTR of 1 May 1961; this SSTR was so drafted that it minimized both the possible consequences and the nature of the incident and did not attract sufficient notice of the users.

The Commission has noted that, perhaps as a result of its action, Douglas subsequently designed such a modification and on 16 October 1962 issued Service Sketch No. 513, referring to the preceding SSTR and recommending the modification. The Commission thinks that this modification, or any other designed to achieve the same purpose, such as those applied by other major international carriers should be made mandatory as soon as possible.

Recommendations regarding personnel

Although there is no reason to think that training may be a direct factor in the accident in question, the Commission considers that it is essential to remind operators of complex modern aircraft of the necessity for a qualification of a very high standard for their crews: to obtain a qualification truly commensurate with such a standard, a minimum number of hours of training in flight and on the simulator must first be completed.

The Commission also considers it essential to remind the instructors responsible for the issue of type ratings of the responsibilities which devolve upon them. The Commission considers that when a rating is granted with training which is inadequate in respect of either its length or its results, a heavy responsibility lies with the instructor issuing the rating.

Recommendations regarding infrastructure

The Commission has noted the measures taken by the Cameroon services to ensure the co-ordination and efficiency of all personnel responsible for safety at the aerodrome. Tracks which can be used by cross-country vehicles have been made at 50 m intervals at right angles to the runway centre line along the take-off flight path area, in order to give access to the undergrowth and creek. A landing stage has been built on the creek, which still has some depth of water even at low tide, and a boat is kept there permanently.

An anemometer system has been installed near the middle marker for comparison with the Tower.

At the outer marker, 6.7 km from the threshold, three white lights have been installed at a height of 40 m, the light of which will give a visual fix along the runway centre line.

The Commission has asked the Cameroon services to check the height of the trees along the edge of the take-off flight path area on a bearing of 120° and if necessary to correct the Douala approach and landing charts. This work is in progress.

Recommendations of a general nature

The Commission recommends the systematic study, by operators, constructors and official services, of all incidents reported during operations, in particular those which might have led to an accident or have provided an explanation of an accident.

In view of the similarities between the Douala accident and other previous accidents to DC-6 and DC-7 aircraft during the same flight phase, in particular those occuring at Orly, Shannon and Bordeaux, the Commission suggests that the Cameroon Government examine the possibility of communicating the present report and its detailed annexes to the appropriate State authorities concerned.

The Commission recommends urgently that all multi-engined transport aircraft be equipped with flight recorders which will give basic data in the case of an accident.

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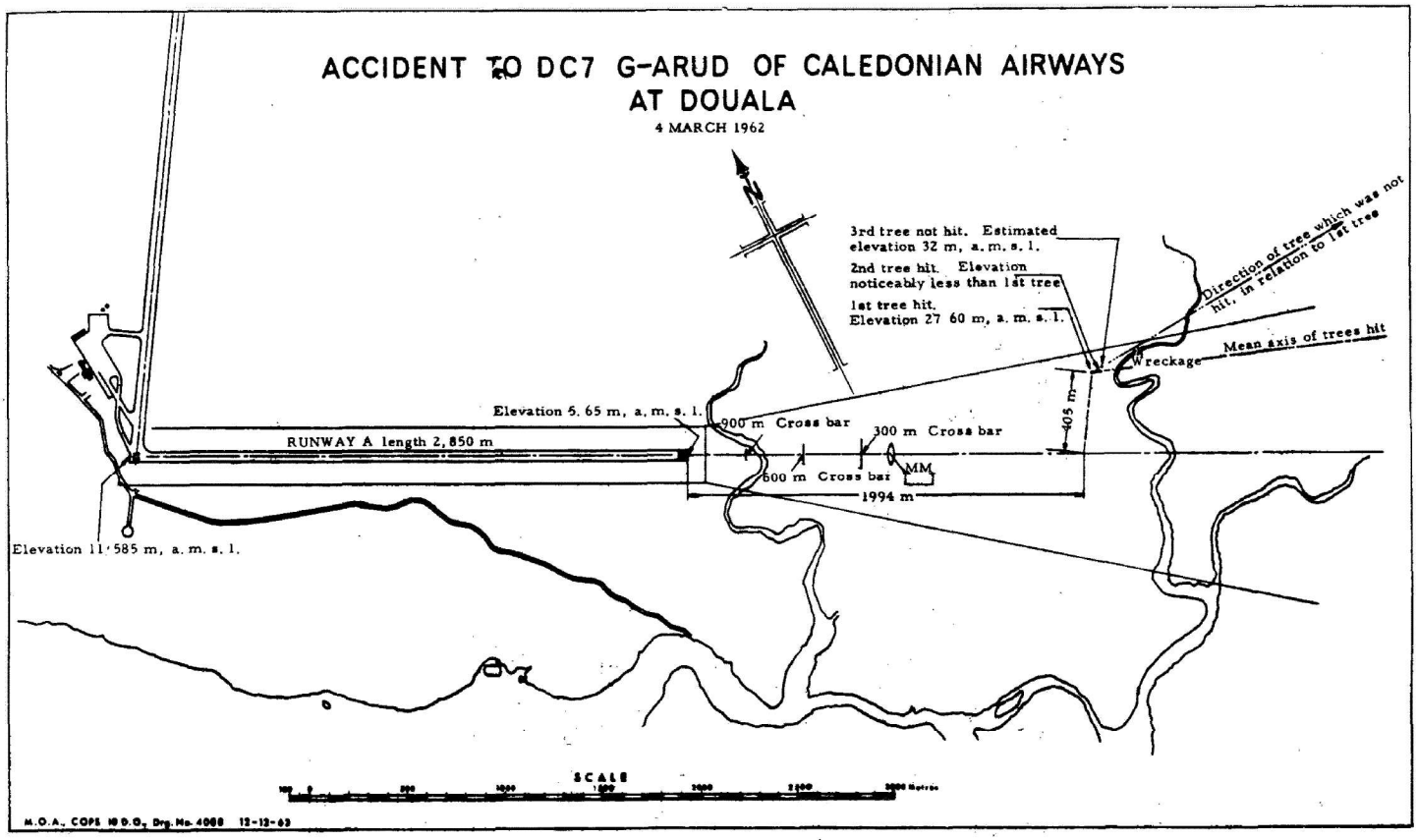
ACCIDENT TO DC7 G-ARUD OF CALEDONIAN AIRWAYS
AT DOUALA
4 MARCH 1962
3rd tree not hit. Estimated elevation 32 m, a. m. s. l.
2nd tree hit. Elevation noticeably less than 1st tree
1st tree hit. Elevation 27 60 m, a. m. s. l.
Direction of tree which was not hit, in relation to 1st tree
Mean axis of trees hit
Wreckage
405 m
Elevation 5. 65 m, a. m. s. l.
900 m Cross bar
300 m Cross bar
RUNWAY A length 2, 850 m
600 m Cross bar
MM
1994 m
Elevation 11 585 m, a. m. s. l.
SCALE
M.O.A., COPS H.Q.O., Drg. No. 4088 12-12-63

FIGURE 3