

Department of Trade

ACCIDENTS INVESTIGATION BRANCH

**Cessna 310 G-APTK
Report on the accident at
Norwich Airport, Norfolk,
on 25 October 1974**

List of Aircraft Accident Reports issued by AIB in 1976

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Department of Trade
Accidents Investigation Branch
Shell Mex House
Strand
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27 February 1976

The Rt Honourable Peter Shore MP
Secretary of State for Trade

Sir,

I have the honour to submit the report by Mr P J Bardon, an Inspector of Accidents, on the circumstances of the accident to Cessna 310 G-APTK which occurred at Norwich Airport on 25 October 1974.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch
Aircraft Accident Report No. 7/76
(EW/C503)

Aircraft: Cessna 310 G-APTK
Engines: Two Continental O-470B
Registered Owner: M Hennessey
Pilot: One - Killed
Passengers: Nil
Place of Accident: ¼ mile east of Runway 28 at Norwich Airport
Date and time of Accident: 25 October 1974 at 1552 hrs

All times in this report are GMT

Summary

The aircraft was making a private flight from East Midlands Airport to Norwich Airport. After joining the circuit at Norwich the pilot received a clearance to approach Runway 28. Whilst the aircraft was turning left on to the final approach it was seen to roll out of the turn and to continue rolling to the right until the wings passed the vertical position. The nose of the aircraft then dropped and the aircraft pitched down and dived vertically into the ground. There was no fire but the pilot was killed. The accident was caused by a loss of control following the sudden retraction of the starboard flap due to a drive failure.

1. Investigation

1.1 History of flight

The aircraft was returning to Norwich from a flight to East Midlands Airport where it had flown to earlier in the day. It had departed from East Midlands at 1513 hrs with the pilot in charge as the sole occupant.

On arrival at Norwich, the aircraft was cleared to join the circuit for a landing on Runway 28. The weather conditions were good with the wind from the north-west at 10 knots.

Whilst the aircraft was turning left on to its final approach at a height of about 600 to 700 feet agl it was seen by the pilot of a following aircraft to roll out of the turn and continue rolling until it reached a vertically banked attitude. The nose then dropped and the aircraft dived vertically into the ground.

The aircraft was destroyed on impact and the pilot was killed. There was no fire.

1.2 Injuries to persons

<i>Injuries</i>	<i>Crew</i>	<i>Passengers</i>	<i>Others</i>
Fatal	1	—	—
Non-fatal	—	—	—
None	—	—	—

1.3 Damage to aircraft

Destroyed.

1.4 Other damage

Destruction of electrical boundary cable surrounding a paddock.

1.5 Pilot information

Pilot	Aged 54 years.
Licence	Commercial Pilot's Licence valid until 19 July 1976. There was no current certificate of test or certificate of experience contained in the licence.
R/T Licence	Restricted to VHF only.
Instrument rating	Valid until 15 November 1975.
Aircraft rating	Commercial Pilot: Part One, Pilot in command Proctor variants and PA23 aircraft. Private Pilot: Part One, Pilot in command Group A & B.

Total flying hours	1,382 hours.
Hours on type	2 hours 45 minutes.
Total in last 30 days	4 hours 15 minutes.
Medical certificate	Valid until 5 November 1974 with limitations that the holder to have available spectacles which correct for near vision.

1.6 Aircraft information

(a) Manufacturer	Cessna Aircraft Company, USA.
Date of manufacture	1957.
Certificate of Airworthiness (C of A)	General Purpose Category valid until 21 August 1975 subject to maintenance in accordance with the approved maintenance schedule ARB/GPS/FW 1971 or as amended.
Total hours	2,511 as of 30 September 1974.
Last check 4 Inspection	22 August 1974.
Estimated weight at time of accident	4,150 lb.
Maximum permissible weight	4,600 lb.
Accident Centre of Gravity	37.37 inches aft of datum (within limits).
Fuel type	Avgas (petrol) 100L.
Estimated fuel quantity at time of accident	92 galls (US), (80 imp/gal).

- (b) The check 4 inspection referred to above required only a functional check of the flap system and this was done. No defect was recorded. The aircraft was also flight tested immediately after the inspection, for C of A renewal purposes, and the time taken for the flaps to operate was noted in the flight test report.

1.7 Meteorological information

Weather was not a factor in the accident. The actual weather at Norwich Airport at 1450 hrs was:

Wind	North west 10 knots.
Weather	Nil.
Visibility	10 km.
Temperature	11°C.

1.8 Aids to navigation

Not applicable.

1.9 Communications

The aircraft had been in normal communication with Norwich Airport up to the time of the accident.

1.10 Aerodrome and ground facilities

Not relevant.

1.11 Flight recorder

None required and none fitted.

1.12 Examination of wreckage

1.12.1 *On site examination*

The aircraft had struck the ground approximately 1 kilometre to the east of the threshold of Runway 28 and some 350 m south of the extended centre line. The initial impact was taken by the starboard wing-tip. The attitude of the aircraft was slightly over the vertical nose down. The landing gear was in the extended position.

The trailing edges of both mainplanes had undergone spanwise compression, indicating that the wings had been forced back on impact by the wing-tip tanks striking the ground first. The compression of the trailing edges had caused the ribs which separate the ailerons from the flaps to move inboard. On the starboard side, the 'top hat' stiffener on the rib could be seen to have impinged on the outer edge of the starboard flap. There were no corresponding indications on the port side. As the damage to the starboard flap was indicative of flap asymmetry being present at the time of impact, a detailed examination of the flap drive mechanism was made. It was found that the end link of the chain driving the starboard flap in the downward direction had fractured where it attaches to the turnbuckle eye piece. One side of the failed link had fractured and half of it was missing together with its associated split pin. Neither of those two items could be found. The other side of the chain link was substantially bent as was the turnbuckle eye piece itself.

The other three chains in the flap actuating mechanism, that is the starboard 'up' chain and the two on the port side were undamaged.

An examination of the cockpit area established that the magneto switches were in the ON position and the fuel was selected to MAIN tanks. There was evidence of fuel having been present in the engine fuel line. All fuel tanks had been ruptured on impact.

The needles of the dual engine rpm gauge were both registering 2,500.

The flap gauge, which was undamaged, was registering in the de-energised position and its needle was off the scale.

1.12.2 *Subsequent examination*

(a) Port inboard aileron hinge

A detailed examination of the flying control system found all the damage to be consistent with impact forces with the exception of the port inboard aileron hinge. One of its four securing lugs, which attaches the hinge to the rear spar, had fractured. This fracture was shown by metallurgical examination to be of the fatigue type originating from severe corrosion pitting of the magnesium alloy of which the hinge was constructed. The remaining three lugs of the hinge had failed during impact. There was no evidence of partial detachment in flight of the port aileron, which from witness marks on its mass balance, could be seen to have been slightly 'trailing edge up' on impact.

(b) Other flying controls

The lateral trim jack was still attached to the port aileron and by comparison with another aircraft of the same type, it was established that half of the trim had been applied to lift the port wing. The rudder and elevator trims were in the neutral position.

(c) Determination of flap position at impact

Tests were made on another aircraft and it was found that with the position cam in the flap actuating mechanism placed in exactly the same position as that found in G-APTK, the flap position registered on the indicator was 27°. The full range of the flaps is 0-45°.

(d) Limit micro switches

The two limit micro switches which cut the electrical supply to the flap motor when the flaps have reached the limit of their travel were examined. It was found that the limit micro switch which should prevent over extension of the flaps in the down sense was not in contact with the cam. This was because the trip-strip which held the roller contact had broken off. Both limit micro switches were otherwise serviceable.

(e) Flap motor

The condition of the electric flap motor and associated gear box was satisfactory. Both drive legs were secure on the output shaft.

(f) Flap motor circuit breaker

The circuit breaker in the 'down' circuit was found intact and had not tripped. It was rated at 5 amps and tests were conducted to establish its correct functioning with the following results:

<i>Voltage applied</i>	<i>Current applied</i>	<i>Time to trip</i>
26 v	5 amps	Did not trip
26 v	8 amps	135 seconds
26 v	10 amps	55 seconds

(g) Engines and propellers

Both engines and propellers were stripped. All the damage found was considered to be consistent with impact forces.

1.13 Medical and pathological information

A full post mortem examination was carried out on the pilot and no pre-existing disease was discovered and there was no evidence of intoxication by carbon monoxide or drugs. Death was instantaneous due to multiple injuries.

1.14 Fire

There was no fire. The Norwich Airport and the County fire service were dispatched to the site and foam was applied to the wreckage as there was a risk of fire following the release of fuel from the ruptured fuel tanks.

1.15 Survival aspects

The accident was non-survivable.

1.16 Tests

In order to establish if the flap motor, with a rated horse power of 0.12 at 4,000 rpm, was capable of over-stressing the drive chain in the absence of a serviceable limit micro switch, a rig was constructed which simulated as closely as possible the flap operating mechanism in the aircraft.

On the first test, after 7 operating cycles which in each case were allowed to overrun the normal fully extended position, one side plate of the starboard flap drive where it attaches to the turnbuckle eye piece fractured. Two later tests produced exactly similar results and the damage to the drive chain was identical to that found on the chain recovered from the aircraft. The 5 ampere circuit breaker did not trip at any stage during the tests.

1.17 Other information

1.17.1 *Previous instances of flap drive failure*

No record of any previous instances involving the failure of a flap drive chain on Cessna 310 aircraft was found in either the United Kingdom, the United States, Australia or Canada.

It was the aircraft manufacturer's opinion that the flap drive motor would be unable to develop sufficient torque to break a drive chain. Furthermore it was considered that should the 'down' travel limit micro switch fail, then the drive would jam at the end of the chain.

1.17.2 *Magnesium aileron hinge*

In March 1967, the aircraft manufacturer issued a Service Letter (67-17) stating that there were still a number of Type 310 aircraft which had not been modified in compliance with an earlier Service Letter (310-60 dated May 1961) which established a programme to replace the magnesium inboard aileron hinges with aluminium hinges. The 1967 letter went on to state that it was important that all magnesium hinges be removed from service immediately.

On 21 January 1975, the United Kingdom Civil Aviation Authority classified the 1967 letter as mandatory and required that all affected Cessna 310 aircraft be modified with aluminium aileron inboard hinges by 31 March 1975.

1.17.3 *Airworthiness requirements*

The aircraft type was certificated in the United States in 1957 in accordance with the Civil Airworthiness Requirements (CAR) and the particular requirement pertaining to the flaps at the time of manufacture was CAR 3. This was later replaced by FAR (Federal Airworthiness Requirement) 23 which is virtually identical with CAR 3. CAR 3 stated the following:

CAR 3.338 wing flap controls

- (a) The controls shall be such that, when the flap has been placed in any position upon which compliance with the performance requirements is based, the flap will not move from this position, except upon further adjustment of the control or the automatic operation of a flap load limiting device'.

The aircraft was certificated in the United Kingdom under the reciprocal validation procedure between the United States and this country which applies to aircraft of 6,000 lb all maximum up weight authorised or less. In any case British Civil Airworthiness Requirements (BCAR) Section K, which specifies the requirements to be met with respect to asymmetric operation of the flaps, was not current at the time of the original certification of the Cessa 310 and the UK Civil Aviation Authority has stated that it was not retrospective.

The BCAR referred to above is K4-8 2.24(a) which was published in 1966 and this states:

- (a) The design of the system shall be such that any reasonably possible single failure of the wing flap actuating mechanism and their controls will not result in hazardous symmetrical or hazardous asymmetrical operation of the wing flaps. Unless the aeroplane is demonstrated to have safe flight characteristics while the wing flaps are fully extended on one side and fully retracted on the other the motion of the wing flaps on opposite sides of the plane of symmetry shall be synchronised by mechanical or equally reliable means.'

2. Analysis and Conclusions

2.1 Analysis

The observed behaviour of the aircraft points quite clearly to a sudden loss of control in roll during the turn on to the final approach. Though the speed of the aircraft at that moment could not be determined, there is no evidence to suggest that the loss of control was due to an inadvertent stall.

Similarly, there was no evidence that the fractured aileron hinge was a factor in the accident, as it could be seen that the component was still retained by three of its four lugs up to the moment of impact. There was clear evidence that the aileron itself was not displaced from the hinge line during flight.

The evidence however that the loss of control was due to the sudden retraction of the starboard flap is conclusive. There were positive indications from the wreckage examination that at the moment of impact, the starboard flap was up and the port flap down.

The only explanation for this is the broken drive chain, though the sequence of events which lead to its failure could not be determined. The bench tests showed that by overtensioning the flap operating mechanism, using the flap motor alone, one of the side plates of the chain link attached to the turnbuckle eye piece could be made to fail without the linkage becoming totally disconnected. This is contrary to what was expected by the manufacturer. Also the test showed that the overtensioning could readily occur if the flap drive motor was not cut out by the limit switch when the flap reached full extension.

It was observed on another aircraft of the same type that, when the flaps were fully extended, the flap position indicator did not register fully down. It would not be unusual therefore for a pilot, seeing this indication, to continue to keep the spring loaded flap switch depressed for a short while to ensure that full flap was achieved. Provided that the limit switch was serviceable, continued operation of the flap selector switch would have no effect on the motor. However, when the limit switch is defective, as it was on this occasion, then continued operation of the flap selector will cause the motor to continue to run and thus overtension the system.

The circuit breaker in the flap operating system is designed to protect the motor, but not necessarily prevent overtensioning of the linkage. As happened on this occasion, the circuit breaker did not operate though it was found to be serviceable. Even then, the time taken for it to trip on test seems to have been inordinately long.

It is concluded therefore that the most probable sequence of events leading to the accident was as follows:

- (1) The limit micro switch failed at some undetermined time.
- (2) On landing at East Midlands Airport, the pilot selected full flap and held the switch down.
- (3) Due to the defective limit switch, the flap motor continued to run after the flap had reached full extension and the linkage was overtensioned.
- (4) One of the side plates of the chain link where it attaches to the turnbuckle eye piece on the 'down' side fractured, though the chain itself did not part completely.

- (5) The pilot's subsequent retraction of the flaps was normal as the 'up' side of the operating linkage was unaffected. The take off for the return flight to Norwich was most probably made with the flaps up.
- (6) On arrival in the Norwich Airport area, the pilot selected 27° of flap whilst on base leg.
- (7) A short while later, the partially broken chain link completely separated, and the flap slammed up under airloads.
- (8) The pilot did not recognise the cause of his control difficulties, probably because they did not occur coincidentally with his operation of the flaps. He therefore did not recognise in the short time available that the only possible corrective action was to raise the port flap. Instead he tried unsuccessfully to contain the rolling movement by use of the aircraft's flight controls. When the bank angle became almost vertical, the nose dropped and the aircraft entered a steep dive.

The circumstances of the accident demonstrated quite clearly that the aircraft type does not meet current British Civil Airworthiness Requirements and nor is it required to do so. The aircraft had been certificated some years before the date of issue of the BCAR concerned with hazardous flap operation. In any case, certification flight tests would not have been conducted to ensure compliance even at a later date as, being under 6,000 lb AEW, the aircraft would have been accepted under the reciprocal validation procedure that exists between the United Kingdom and the United States.

At first sight it would appear that the aircraft did not meet the CAR current at the time of its original certification in the USA, particularly CAR 3.338 which stated unequivocally that 'when a flap has been placed in any position the flap will not move from this position'. However it is understood that the United States Federal Aviation Administration only applied the CAR to meet the case of a flap creeping from the position necessary to comply with performance requirements. It was not applied to meet the case of a flap abruptly retracting due to a failure in the linkage system.

It is considered certain measures ought to be taken to ensure that there is no repetition of this type of accident on Cessna 310 aircraft. These measures should include more frequent inspection of the drive chains and limit switches. The possibility of installing a second limit switch should also be examined. Additionally it is considered that a circuit breaker of improved design which operates to closer limits should be substituted for the one now installed.

2.2 Conclusions

(a) Findings

- (i) The pilot's licence was not properly valid as it did not contain a current certificate of experience.
- (ii) The pilot had little experience on type though his overall flying experience was adequate.
- (iii) There was no evidence that the pilot mishandled the flap system or could reasonably have prevented the accident.
- (iv) The aircraft had been maintained in accordance with an approved maintenance schedule, though the provisions of a manufacturer's Service Letter had not been complied with in respect of the inboard aileron hinges.

- (v) The defective aileron hinge had no bearing on the accident.
- (vi) The starboard flap operating linkage failed at an intermediate setting whilst under airloads, causing the flap to retract suddenly.
- (vii) The sudden retraction of the starboard flap caused a strong rolling movement to the right which could not be contained by the pilot's use of the flying controls. The aircraft subsequently went out of control and dived into the ground.
- (viii) It is possible that the 'down' drive chain to the starboard flap partially failed on a previous flight when it was overstressed due to the continued operation of the flap motor after the flaps had reached the limit of their normal extension.
- (ix) The pilot probably continued operating the flap motor because the flap position indicator did not register the maximum flap angle when it had in fact been achieved.
- (x) The flap motor was able to continue to run even though the flaps had reached the normal limit of their extension due to the failure of the limit micro switch.
- (xi) The design of the flap operating mechanism was such that a single failure would result in a hazardous asymmetric operation.
- (xii) The aircraft did not meet current British Civil Airworthiness Requirements, nor was it required to do so.

(b) *Cause*

The accident was caused by the failure of the flap operating linkage in flight resulting in a sudden retraction of the starboard flap which led to a loss of control near the ground.

3. Recommendations

It is recommended that consideration be given to improving the reliability of the protection devices in the flap operating mechanism of the Cessna 310 type aircraft and that more frequent inspections of the existing system be instituted.

P J Bardon
Inspector of Accidents

Accident Investigation Branch
Department of Trade

February 1976