Department of Trade

ACCIDENTS INVESTIGATION BRANCH

Cessna 421 G-AYMM

Report on the accident near Stansted Airport, Essex, on 4 September 1978

Air Investigation Branch

Aircraft Accident Report 6/80
ISBN 0 11 5131 744

ERRATA
please correct as detailed below

1 page 4 sub para 1.6.1 line 6
for 1979
read 1978

2 page 4 sub para 1.6.1 line 12
for 1979
read 1978

3 page 11 sub para 1.17.2 line 5
for pilot
read pilots

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List of Aircraft Accident Reports issued by AIB in 1980

No.	*Short Title*	*Date of Publication*
1/80	Strojirni Prvni Potiletky Super Aero 145 G–ASWS Lydd Airport July 1978	May 1980
2/80	Piper PA 28 (Cherokee) Series 140 G–AYMJ Carlisle Municipal Airport Cumbria November 1978	August 1980
3/80	Fuji FA 200 G–BEUB Fowey, Cornwall July 1979	August 1980
4/80	Cessna F150L G–BAZP Socata Rallye 150ST G–BEVX Biggin Hill Aerodrome Kent November 1978	November 1980
5/80	Cessna F 172 L G–BFKS Wycombe Air Park December 1979	January 1981
6/80	Cessna 421 G–AYMM Stansted Airport Essex September 1978	
7/80	Piper PA–34 (Seneca) G–BFKO Beaulieu Heath Hampshire November 1979	
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Department of Trade
Accidents Investigation Branch
Kingsgate House
66- 74 Victoria Street
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5 January 1981

The Rt Honourable John Nott 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 421 G–AYMM which occurred near Stansted Airport, Essex, on 4 September 1978.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch

Aircraft Accident Report No 6/80
(EW/C636)

Operator:		Pye of Cambridge Ltd
Aircraft:	*Type:*	Cessna 421
	Model:	B
	Nationality:	United Kingdom
	Registration:	G–AYMM
Place of accident:		Near Stansted Airport, Essex 51° 52'N° 00 14'E
Date and Time:		4 September 1978 at about 1518:30 hrs
		All times in this report are GMT

Synopsis

The accident was notified by the London Air Traffic Control Centre (LATCC) to the Accidents Investigation Branch at 1530 hrs on 4 September 1978.

The aircraft was engaged upon a flight test for the renewal of its Certificate of Airworthiness. The sole occupants were the pilot and an observer. Following an ILS approach to runway 23 at Stansted airport an overshoot (go-around) was initiated and at about 200 feet the starboard engine cut out. The commander attempted unsuccessfully to restart the engine by use of the starter motor. The aircraft lost speed and height and crashed just outside the airport. The observer was killed and the pilot injured.

The report concludes that the cause of the accident was the pilot's decision not to take the appropriate action to feather the propeller and raise the flaps when the starboard engine stopped. A contributory factor is considered to have been the absence of any prescribed procedure in the Flight Manual to cover the eventuality of an engine failure during an overshoot manoeuvre.

1. Factual Information

1.1 History of the Flight

G–AYMM was engaged upon an airworthiness flight test associated with the renewal of its Certificate of Airworthiness (C of A). The test was being conducted in accordance with a Civil Aviation Authority (CAA) flight test schedule. The aircraft carried a crew of two; the commander, in the left front seat, being one of the Pye company's pilots and the other crew member, in the right front seat, an airline pilot who was acting as a flight test observer.

The aircraft took off from its base at Cambridge Airport at 1410 hrs. The fuel selectors were both set to MAIN TANKS and left there for the whole of the flight. On becoming airborne radio contact was established with Eastern Radar on 134.3 MHz and the aircraft climbed through cloud which extended from about 3000 to 7000 feet. At 1433 hrs it levelled off at flight level 150 where engine control tests and radio equipment checks were satisfactorily completed. At 1437 hrs a dive to Vne* was commenced, an Indicated Air Speed (IAS) of 275 mph being achieved. The aircraft was then levelled off at flight level 85, the pilot having decided to commence the required single engine climb test from that height instead of lower down so as to keep clear of the cloud.

The starboard propeller was feathered (the auxiliary fuel pump switch being put to OFF) and the port engine was set at maximum continuous power (39.5 in Hg/2275 RPM). The pilot stated that he carried out the climb test with the port engine operative instead of the starboard as required by the test schedule because he believed the starboard engine to be the less reliable due to a history of fuel flow problems. A single engine en-route climb at 124 mph IAS was then attempted but the aircraft would not climb. The starboard engine was then re-started without difficulty and the pilot decided next to carry out the stall tests. He stated that the first two of the three stalls required by the test schedule were carried out without incident. The third stall was carried out with the landing gear down and flaps at the landing setting. Power was set at 21 ins HG/1850 RPM with the mixture controls slightly leaned off; these settings had also been used in the previous two stalls. During the recovery from this stall the starboard engine stopped firing suddenly and the aircraft rolled to starboard. During the subsequent dive the engine picked up and again ran normally. The pilot stated that at the time he thought the cause of the engine cut was probably fuel icing as he had been told that the type of engine was prone to it. However he had never experienced fuel icing during the four years he had been flying G–AYMM and the approved anti-icing fuel additive was used at all times.

The pilot then decided to carry out an approach and overshoot at Stansted Airport to check the aircraft's ILS equipment, and to follow this with another single engine climb test when the aircraft would be lighter. He contacted the Stansted Special Rules Zone Controller on 125.55 MHz at 1504 hrs whilst at FL100 and was positioned by radar on the ILS localiser of runway 23, 8 miles from touch down and at an altitude of 2000 feet.

**Vne – Maximum authorised airspeed*

The approach was carried out with the landing gear down, the flaps at the 30° setting, the mixture controls leaned off by about 1½ to 2 ins, the propeller RPM set at 1850, and the manifold pressure of 23 to 24 ins Hg to maintain the glide path. The aircraft performed satisfactorily up to the moment the overshoot was commenced, at which time it was at about 200 feet and at an IAS of 130 mph. The pilot stated that he initiated the overshoot by moving the mixture levers fully forward and immediately opening the throttles. When the throttles had been opened to give overshoot power and whilst the pilot was about to select the landing gear up the aircraft rolled and yawed violently to the right and he realised the starboard engine had stopped firing. He stated that he then applied left rudder and aileron, selected landing gear up, and moved the propeller levers and throttles fully forward. The flaps were left at 30 degrees.

The pilot stated that since he was certain from the result of the single engine climb test carried out earlier in the flight that the aircraft would not be able to climb on the port engine alone he decided to try to re-start the starboard engine instead of feathering its propeller. He ensured the port engine was at full power, and then pressed the starboard engine starter button. However the engine did not re-start and the pilot realised that the aircraft was turning to the right and also losing airspeed and height.

The aircraft was seen by witnesses to describe a gently curving and descending path to the right of the runway. It passed between the control tower and the runway at about 50 feet above ground level (AGL). It then gained height to barely clear a wood, and crashed into a field just outside the west boundary of the airport on a heading of 240° (M) at about 1518:30 hrs. The pilot recalled seeing an IAS of 100 mph at some time, and also hearing the stall warning horn sounding as the aircraft cleared the wood.

He stated that he did not consider landing on runway 23 instead of continuing the overshoot because firstly,he was mentally prepared for an overshoot, secondly because the engine stopped suddenly with no warning, and thirdly because when the engine stopped the aircraft banked to the right and he lost sight of the runway. Also there were airfield buildings and trees ahead which he felt he had to get over, since it did not appear to him that he could turn sufficiently to fly round them.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	–	–
Serious	–	–	–
Minor/None	1	–	–

1.3 Damage to aircraft

The aircraft sustained extensive damage to the fuselage nose area, particularly in the co-pilot's position. The starboard wing was severed at the root, and the port outer wing and engine nacelle suffered damage by impact and post crash fire.

1.4 Other damage

There was no other damage.

1.5 Personnel information

1.5.1 Commander: Male, age 40

Licence:	Commercial Pilot's Licence valid until 27 April 1988, endorsed for the Cessna 421 type as pilot in command
Instrument rating:	Last renewal test on 12 August 1978
Medical Certificate:	Last medical on 4 August 1978, Class I no restrictions
Competency check:	Last check on 7 August 1978. It was carried out in G–AYMM and included a practice failure of the right engine at 200 feet after take-off, a single engine circuit and overshoot, and a single engine landing
Total pilot hours:	3,113
Total hours on Cessna 421:	1.401
Total hours in last 28 days:	33:35 hours

1.5.2 Observer Male, age 40

Licence:	Commercial Pilot's Licence valid until 26 February 1980, endorsed as pilot in command for Auster variants, Cessna 310 and 337, and Trident HS 121
Experience on Cessna 421	8 flights as observer

1.6 Aircraft information

1.6.1 General description

The aircraft was a standard Cessna 421B, serial number 421B – 0033, manufactured by the Cessna Aircraft Corporation, Wichita, Kansas, USA, in 1970. It was initially issued with a British Certificate of Airworthiness (C of A) on 15 February 1971, and had been registered in the name of Pye of Cambridge Ltd since 10 November 1972. A private category C of A was first issued on 4 June 1973 and renewed annually, the last occasion being on 3 September 1979, when a Check I was carried out.

The aircraft was equipped with two Continental GTSIO–520–H turbo-supercharged and fuel injected engines rated at 375 SHP. The engines were each fitted with a McCauley three bladed, variable pitch, fully feathering propeller incorporating a propeller un-feathering system. It had a retractable electrically operated landing gear, and electrically operated split flaps with settings of 0, 15, 30 and 45 degrees.

The aircraft had flown a total of 2472 hrs up to 3 September 1979. Both engines had flown 2240 hrs since new and had been installed in G–AYMM with a flight time of 1060 hrs each.

1.6.2 Flight Manual information

1.6.2.1 Single engine performance

The single engine en-route climb performance, with a propeller feathered and flaps and landing gear retracted, as derived from the British Supplement to the FAA approved Flight Manual is as follows:

(i) At FL85, OAT + 1 °C (ISA + 3 °C) weight 7000 lbs: 200 feet per minute

(ii) At 500 feet AMSL, OAT + 18 °C (ISA + 3 °C) weight 6932 lbs: 350 feet per minute

1.6.2.2 Engine inoperative procedures

'2 Engine Failure After Take-off – Speed above 120 MPH IAS

a. Mixtures – RICH
b Propellers – FULL FORWARD
c Throttles – FULL FORWARD (39.5 in Hg)
d Landing gear – UP
e Inoperative propeller – FEATHER
f Establish bank – 5° TOWARD OPERATIVE ENGINE
g Climb to obstacle – 120 MPH IAS
h Climb at best single engine climb speed – 124 MPH IAS
i Trim tab – ADJUST (5° bank toward operative engine)
j Inoperative engine – SECURE
k As soon as practical – LAND'

'6 Engine Inoperative Go-around – Speed Above 120 MPH IAS:

a Throttle – FULL FORWARD (39.5 in Hg)
b Landing gear – UP
c Flaps – UP (if extended)
d Climb at best single engine climb speed – 124 MPH IAS'

1.6.3 Loading

The aircraft's fuel and ballast load was determined by the pilot in conjunction with the charge hand of the Light Aircraft Section of Marshall's of Cambridge (Engineering) Ltd, who maintained the aircraft for Pye.

The pilot stated that he carried out the weight and balance calculations for the test flight on a plain piece of paper since Pye did not use printed load sheets, but no trace of this paper was found after the accident.

The main, auxiliary and locker tanks were all filled, and five 58 lb bags of ballast were put aboard. One bag was placed on each of the two bucket seats and secured by the seat belts. The other three bags were placed on the aircraft floor in the rear baggage area of the cabin and were left unsecured because, it was stated by the chargehand, there was no convenient way of securing them. The pilot was aware that the bags on the floor were unsecured. The aircraft's weight and centre of gravity was calculated to have been as follows:

At start-up	7,184 lbs and 154.66" aft of datum
During the SE climb test	7,000 lbs
At the time of impact	6,932 lbs and 154.75" aft of datum

The aircraft's weight and centre of gravity limits are given in the Flight Manual as follows:

Maximum take-off weight authorised	3288 Kg (7250 lbs)
Maximum landing weight authorised	3264 Kg (7200 lbs)
Maximum zero fuel weight	3054 Kg (6733 lbs)

'1 Most forward C G 373.63 cm (147.10 in) from datum (13.0% MAC) Weight 2766 Kg (6100 lbs)

2 Most forward C G 385.47 cm (151.76 in) from datum (20.3% MAC) at maximum weight 3288 Kb (7250 lbs)

3 Most rearward CG 397.99 cm (156.69 in) from datum (28.0% MAC) Weight 3107 Kg (6850 lbs)

1.7 Meteorological information

A weather observation taken at Stansted Airport at 1520 hrs was as follows:

Surface wind:	040° at 7 knots
Visibility:	14 kilometres
Present weather:	Nil
Cloud :	3 oktas at 3,500 feet
Temperature:	+ 18 °C
QNH:	1011 mb
QFE:	999.2 mb

An aftercast of the weather in the Cambridge–Stansted area for the period 1400 to 1530 hrs was provided by the Meteorological Office, and it was established that the air temperature at FL 85 (the height at which the single engine climb test was made) was + 1 °C.

1.8 Aids to navigation

All radio aids at Stansted, including the ILS on runway 23, were serviceable and operating at the time of G–AYMM's approach. The ILS glide path angle was 3°.

1.9 Communications

Tapes were obtained of all radiotelephony (RTF) communications between G–AYMM and Cambridge Airport, Eastern Radar and Stansted Airport. Communications were normal up to 1516 hrs. At this time MM reported that it was inside the outer marker and was cleared for a low approach and overshoot.

Nothing more was heard from the aircraft until 1517.57 hrs when the observer's voice was heard to say: 'This thing won't climb' Stansted replied: 'Mike Mike Stansted do you read' at 1518.15 hrs. The observer's voice replied: 'Standby' at 1518.17 hrs, and again 'We're going in' at 1518.19 hrs. This was the last transmission received from G–AYMM.

1.10 Aerodrome and ground facilities

Runway 23 at Stansted Airport is 3,048 × 61 metres. The threshold elevation is 347 feet AMSL, and the elevation of the other end of the runway is 323 feet.

1.11 Flight Recorders

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, nor were these required to be fitted.

1.12 Wreckage examination

1.12.1 Inspection of the accident site showed the aircraft to have struck the ground starboard wing low and slightly pitched nose-down whilst on a heading of 240° (magnetic). The impact caused the aircraft to yaw to the right and it then skidded sideways in the direction of 280° (magnetic) for some 30 yards before colliding with trees in a small copse at the corner of the field.

The fuselage nose-section had collapsed in compression back to the forward cabin area after impact with a tree. The port outer wing-tip tank area had been severed and the starboard wing had also suffered over-stressing failure at its root area.

The port main (tip) tank and auxiliary tank had ruptured and had been damaged by ground fire. The starboard main (tip) tank had also ruptured on impact, but had not caught fire. Fuel samples were taken for analysis from the port locker tank (located aft of the engine fire-wall) which was almost full and from the small quantities of fuel remaining in the starboard locker and auxiliary tanks.

A small-scale fire had affected the port engine accessory-area forward of the fire-wall.

The port propeller showed evidence of power at impact, whilst the starboard propeller did not. The rudder trim-tab and associated trim control indicator in the cockpit were found in positions near 'full left rudder' trim.

Some five bags of ballast were found in the cabin, with evidence that two of these had been placed on the two aft (bucket) seats and secured by the associated lap-belts.

The four engine magneto switches and two auxiliary fuel pump switches were found at 'on'. There was no evidence that any attempt had been made to shut down either engine in flight. The landing gear switch was at the 'up' position and in its detent.

1.12.2 A detailed examination of the wreckage was carried out and it was established that the configuration of the aircraft at the time of impact was as follows:

- the landing gear was up and locked
- the flaps were extended to 30 degrees
- both engine fuel controls had been selected to main tanks

1.12.3 *Examination of the port engine*

The spark plug electrodes of this engine had a normal dark colouration. The magneto timing was correct and both magnetos and plugs functioned satisfactorily on rig-test at Rolls Royce Motors Ltd. The port (outboard) exhaust manifold rear expansion 'bellows' assembly had a 3.75" circumferential crack which laboratory examination suggested was pre-existing. The turbo-charger 'spool' was stiff to hand-turn, whilst that on the starboard installation rotated freely. This was due to carbonaceous coking of the turbocharger turbine zone causing turbocharger 'drag'. The oil filter was clean and the sump had the required quantity of oil. Post-strip dimensional inspection of all cylinders, piston/rings and valve gear showed all exhaust guides to be worn beyond service limits and two exhaust valves (Nos 2 and 5) were badly eroded under their heads. No 2 cylinder was also found to be down on compression (76%) compared with the other cylinders which were 87% to 94%.

1.12.4 *Examination of the starboard engine*

The spark plug electrodes of the starboard engine also exhibited a normal dark colouration and a check of magneto timing showed the right magneto to be set at 22° BTDC compared with the service manual requirement of 20° BTDC, to which the left magneto had been set. Both magnetos and spark plugs were subsequently rig-tested satisfactorily.

The engine driven fuel injection pump, when rig tested was found to have an almost total loss of output fuel pressure at low RPM and reduced pressure throughout its range. This was due to foreign matter contamination of a relief valve seat within the pump.

In addition the associated fuel metering valve permitted an excessive output flow rate on rig-test, which could be improved by adjustment of the associated air/throttle/fuel metering value input lever link-rod. Several small non-magnetic metallic particles were found on the fuel metering valve inlet fuel filter-screen and also on both aircraft fuel system strainer-filters.

The oil filter was clean and the sump had sufficient quantity of oil.

A one inch long crack was found on the upper crankcase, just above the No 2 cylinder (aft/inboard) and extending up from the cylinder/crankcase upper/aft attachment nut. It had not extended beyond a red-line which marked its extremity and beside which was a date (also marked in red) '11.7.78'. There was no evidence of oil-leakage associated with this crack.

Full strip examination of the basic starboard engine revealed no evidence of pre-crash mechanical failure and the general condition of this engine was satisfactory.

The starboard auxiliary fuel pump electrical circuit was checked for electrical continuity and the associated starboard pressure switch had been set to actuate at 5 psi. Both low boost resistors were checked electrically and found satisfactory.

1.12.5 Fuel sample analysis

Laboratory analysis of the fuel samples showed these to be satisfactory and to include the correct quantity of the anti-icing additive Shell 06A. The fuel type was AVGAS 100LL.

1.13 Medical and pathological information

A full post-mortem and toxicological examination was carried out on the observer. No evidence of a medical factor which might have caused or contributed to the accident was found.

1.14 Fire

Four appliances from the Stansted Airport Fire Service reached the site about five minutes after the accident. On arrival they found the aircraft's left wing and engine burning intensely and the adjoining scrubland alight. The fires were extinguished rapidly with the use of a hosereel and the sidelines from a Chubb rapid intervention vehicle (RIV). Fifteen gallons of light water foam and 10 gallons of fluro-protein (FP) foam were used.

Inspection of the fire damage showed that the port tip tank and associated outer wing area, including the auxiliary tank, had been badly damaged by the ground fire. The port engine area had also suffered ground fire damage, particularly between the rear of the engine and the firewall. The firewall had prevented the fire from affecting the port locker fuel tank, which was almost full of fuel. The rest of the aircraft was unaffected by fire. It was apparent that the fire in the port engine area started because of fuel spillage onto the hot exhaust system as a result of the impact induced failure of the engine-driven pump and fuel metering valve outlet unions.

1.15 Survival aspects

First to arrive at the accident site were two employees of an aviation company at the airport, closely followed by three men from a nearby motorway construction unit. The pilot released himself from the wreckage and tried without success to free the trapped observer. The five men assisted him and were attempting to free the observer when members of the Stansted Airport Fire Service arrived and took over.

The Stansted Airport Fire Service had been called out by Stansted ATC at 1520 hrs,

and four fire/crash vehicles together with a staff car reached the accident site in about five minutes. Pumps from the Essex and the Hertfordshire Fire Services, and two ambulances from the Essex Ambulance Service also attended. The Stansted crew found the observer to be still breathing though badly injured. First aid was rendered but he died after a short time.

Inspection of the cockpit seats and harnesses, which were of the continuous lap belt and shoulder diagonal inertial reel type, showed the seats had remained in position during the impact and the anchorages and belts of both harnesses to have held.

Although the pilot survived the accident the right side of the crew compartment was severely damaged and this caused the fatal injuries to the observer. These injuries were the result of considerable crushing of the compartment and rearward displacement of the instrument panel.

1.16 Tests and research

During an early stage of the investigation, it was considered possible that the stoppage of the starboard engine during overshoot may have been due to the auxiliary pump in the starboard main tank operating in the high speed mode, thus causing overfuelling of the engine. It was considered that the pump could have automatically reverted to the high speed mode when the starboard engine cut during the stalling tests with the resultant drop in the fuel pressure at the outlet from the engine driven fuel pump. A major proportion of the time spent on investigating this accident was therefore devoted to arranging for tests to be carried out to establish the feasibility of this theory and some considerable delay was incurred in finding suitable aircraft on which to conduct the tests.

The first test was conducted on the ground in May 1979 and the results appeared to confirm that the engine would not run other than at high boost settings with the mixture fully rich when the auxiliary pump was in the high speed mode. However the engine could be made to continue to run if the mixture was leaned off. A simulation of the accident circumstances with the pilot concerned operating the engine controls appeared to reproduce exactly the symptoms he experienced during the overshoot manoeuvre.

However it was recognised that the ground test was not wholly representative of the airborne case since it did not allow for propeller loading effects. After some delay, another Cessna 421 B was located which the owner agreed could be used for flight tests, which were eventually conducted in December 1979. Essentially the same programme as used on the ground test was followed, but on this occasion it was found that the engine would still continue to run when the auxiliary pump was in the high speed mode and the mixture control was selected to full rich.

The possibility therefore that the auxiliary pump in the starboard main tank had at some time during the flight reverted to the high speed mode and subsequently caused the engine to cut due to overfuelling when the mixture control was selected to full rich had to be discounted.

1.17 Other information

1.17.1 Certificate of Airworthiness

G–AYMM had been issued with UK CAA Certificate of Airworthiness No 3744 in the private category on 4 June 1973. As the validity of the C of A extended to 2 September 1978 arrangements were made by Pye and Marshall's for the CAA to grant a renewal by that date.

On 1 September 1978 a CAA surveyor inspected the aircraft and then wrote to Marshall's enclosing the C of A re-validated with effect from 3 September 1978, but adding the following statement:

'A condition of this renewal is that the aircraft be subjected to an air test IOW Flight Test Schedule No 5 Issue 1 as soon as practicable but no later than 10 September 1978, and the results of the test forwarded to the above CAA Area Office'.

Pye and Marshall's then agreed that the air test would be done in the afternoon of Monday 4 September. On the morning of 4 September G–AYMM flew from Cambridge to Eindhoven and back with passengers on board. The chargehand of Marshall's Light Aircraft Section, who dealt with the re-certification procedure on behalf of Pye, stated that in his experience over the previous three years the CAA surveyors had allowed a leeway of up to one month between the ground inspection of the aircraft and the flight test if the aircraft concerned has been maintained and based at Marshall's Cambridge base, and that on these occasions the C of A had been renewed even though the flight test had not yet been carried out.

Since the accident the CAA has confirmed that the flight test is not now regarded by them as an integral part of the procedure for the renewal of C of A and surveyors are permitted to renew certificates before a flight test has been carried out. The CAA were asked to comment on the apparent contradition between BCAR Chapter A2-5 Para 3.4 and BCAR Chapter 5-2 Para 6.1. They agreed that these paragraphs should be reconciled and stated that action was in hand.

1.17.2 Approval of test pilots

The CAA system for denoting the acceptability of pilots to carry out C of A flight tests is laid down in the following two documents:

(a) BCAR Chapter A5-2 Flight Testing of Aircraft, which states in

'6 Airworthiness Flight Tests

6.4 The test pilot shall consist of persons who are familiar with the type of aircraft concerned and must be acceptable to the ARB for conducting the test laid down in the Airworthiness Flight Test Schedule".

(b) CAA leaflet 9/30/IDF/50 Issue 2, Pilot Briefing on Airworthiness Flight Testing of Light Aeroplanes, which states in part:

'2 A pilot must be acceptable to the Surveyor-in-Charge of the local Area Office of CAA (AD). He should also have been briefed on airworthiness flight testing, and be currently in practice on the type, or on one closely similar'.

Whilst G–AYMM's pilot had conducted the airworthiness flight test carried out on the aircraft in 1977 with Pye's chief pilot acting as observer, he stated that he had never been put forward to the CAA for approval as a test pilot, and that the CAA had never either signified or questioned his acceptability. However, the pilot has since stated that in 1975, 1976 and 1977, verbal approval was given on the telephone and that he believed the necessary permission had been obtained for him to conduct the 1978 test.

1.17.3 The test flight

The observer had flown some eight flights in Cessna 421s, including two flights on the morning of the accident. In preparing for the test flight the pilot had available a copy of the CAA pamphlet 'Pilot Briefing on Airworthiness Flight Testing of Light Aeroplanes' (9/30/IDF/50 Issue 2) and a copy of CAA Airworthiness Flight Test Schedule No 5, Issue 1, dated April 1976, including a Radio Flight Test Report, which covered twin piston engined pressurised aeroplanes up to 5,700 kgs maximum all up weight. He also had the completed flight test schedule used in the 1977 C of A renewal flight test, for use as a guide.

The pilot stated that he ensured that the observer was familiar with the procedures for airworthiness flight testing, briefed him on the flight, and gave him a blank copy of the flight test schedule together with the copy of the 1977 flight test report. During the investigation these schedules were recovered from the aircraft and it was found that whilst the new schedule was still blank, certain figures indicative of likely readings taken during the accident flight were pencilled on the 1977 schedule. It was confirmed that the pencilled figures were in the observer's handwriting and that the other were in the writing of Pye's chief pilot who had acted as observer in 1977. The pilot stated that it had been originally his intention that the blank schedule would be completed during the course of the flight, the 1977 schedule being used only as a guide. However, after becoming airborne, the observer said he was confused about exactly how to fill in the forms and asked whether it would be all right if he wrote the figures down by the side of those on the 1977 schedule, and the pilot agreed.

Examination of the new schedule showed that no recordings at all had been made on it. Even readings to be taken on the ground such as aerodrome altitude, temperature and QFE, and others under the headings Pre-Flight, Ground Tests and Taxying had been left blank. Examination of the same parts of the 1977 schedule revealed no data which appeared to have been recorded on the accident flight, only recordings made in 1977 being found.

Later test items had been annotated on the 1977 schedule in pencil from place to place. These were item nos 8 Climb Performance, 9 Stalls, 10.2 Engine Control at Altitude, 11 Dive to VNE, 12.3 Wing Flaps, and 12.4 Landing Gear – Normal Operation. Where figures had been filled in they were almost always different from the 1977 ones, which suggested that if the same result was obtained no new note was

made. Overall the standard of the flight test record was well below that called for in para 5(b) of 'Pilot Briefing on Airworthiness Flight Testing of Light Aeroplanes' which states that: 'The observer should record the results with accuracy and care and they should be monitored by the pilot'.

Although the test schedule required that the climb performance test be carried out with the port engine shut down the test was done with the starboard engine inoperative. The pilot has since stated he did this because he believed the starboard engine to be the less reliable of the two. The test schedule called for three stalls to be carried out each with propeller controls selected to fully fine and the throttles closed. The first was to be with the landing gear and flaps up, the second with the landing gear up and flaps at the take-off setting, and the third with the landing gear down and flaps at the landing setting. The pilot believes all three stalls were carried out at a manifold pressure of 21 ins Hg. This was because he understood that the engines had a tendency to stop at the idle setting. The 1977 test schedule copy that was being used carried pencilled figures in the observer's handwriting in the columns for the second and third stalls showing the speeds at which the stall warning horn operated and also that the stall speeds were between 3 and 5 knots lower than the 1977 figures. No pencilled figures were found in the column relating to the first stall.

2. Analysis

The accident happened when the pilot, who was experienced on the type, lost control of his aircraft after the starboard engine cut during an overshoot (go-around) manoeuvre. This analysis is therefore mainly directed towards a consideration of the pilot's actions that may have led to his loss of control. Also considered is the pilot's conduct of the flight test and the background to C of A renewal flight tests. Finally some of the possible reasons for the failure of the starboard engine are examined.

2.1 The pilot's actions

The stoppage of an engine at any stage of flight is an emergency for which all pilots are prepared and trained to meet right from the outset of their flying careers. Simulated engine failures are commonly practiced by all professional pilots not only as part of their periodic base checks, but also on initial conversion to type. Though with hindsight it is easy enough to say what the pilot should have done on this occasion, it is perhaps more constructive to examine the possible reasons why he lost control of the situation. Considerable assistance with this aspect of the investigation was provided by a psychologist on the staff of the RAF Institute of Aviation Medicine by whom the pilot agreed to be interviewed.

It is probably true to say that engine failures are more usually simulated during or immediately after take-off and in the cruise. It would seem comparatively rare for a failure to be simulated during an approach to land or whilst overshooting, though asymmetric approaches with a previously simulated failure are common enough. This is reflected in the Engine Inoperative Procedues detailed in para 1.6. It can be seen that though there is a procedure to be followed in the event of an engine failure after take-off and also for the overshoot manoeuvre following a single engine approach, there is no specific procedure to cover the case of an engine failure during overshoot. This is not unusual and in effect the actions necessary in the latter event are an almagam of the other two procedures. Nevertheless it is for consideration that one of the basic underlying reasons for the accident was that the pilot was presented with an emergency which he had not practised nor been required to practise. The CAA view, however, is that the requirements of the periodic test for the renewal of his licence should have adequately prepared the pilot for any single engine emergency he faced. The Authority considers that the pilot should have first carried out the Engine Inoperative Go-Around procedure, which includes raising the landing gear and the flaps, and followed this with the Engine Failure After Take-off Drill. This would certainly have established the aircraft in the optimum condition to attempt a climb on one engine. However, the pilot did not follow this procedure because he believed that the aircraft would not climb at all on the port engine alone. He considered that his best course of action was to attempt to restart the starboard engine. Since it had cut in a similar fashion earlier in the flight, it was not unreasonable that the pilot should believe that it would restart as readily as it did on the previous occasion. In the event, it did not do so and by the time this was apparent the aircraft had lost both speed and height, not only because the flaps had been left down, but also because of the effect of the windmilling starboard propeller. By that stage, the pilot's sole concern was to avoid the obstacles that lay in his flight path. Thereafter, the accident was probably inevitable.

Since it could not be established precisely where the aircraft was in relation to the runway threshold either when the engine cut or when it was apparent to the pilot that it would not restart, no firm conclusion can be reached as to whether or not it was a viable proposition to attempt to put the aircraft down on the airfield as an alternative to continuing the overshoot. It was not a possibility that the pilot himself considered, and the reason for this is probably because, when the engine cut, the aircraft rolled rapidly to the right and the pilot lost sight of the runway. The visual cue that might otherwise have prompted him to attempt a landing was therefore absent at the moment of decision and thereafter was never presented to him.

The pilot's belief that the aircraft would not climb on the port engine alone, which seems to have determined his actions when the starboard engine cut, stemmed from his experience earlier in the flight when the aircraft did not climb during the single engine climb test at 8,000 feet. According to the Flight Manual the aircraft should have climbed at 200 feet per minute on one engine at that height and at 350 feet per minute at sea level. It follows from this, therefore, that if the aircraft's single engine rate of climb at 8,000 feet was zero, it can be argued that there should have been some residual climb performance at sea level.

In conclusion, it is considered that the underlying cause of the accident was the pilot's choice to attempt to restart the starboard engine instead of taking action to raise the flaps, feather the starboard propeller and bank slightly towards the live engine, which might well have averted the accident.

It is unclear why the pilot elected to make the ILS approach without having first completed the Before Landing Checklist or if it was his habitual practice to make approaches to land with the mixture other than fully rich. He states that this was in accordance with his company's practice. Suffice it to say that on this occasion had the Before Landing Checklist been completed fully before the approach was commenced, as it would normally be, the right hand engine may then have stopped at 2000 feet instead of 200 feet when full rich mixture was applied and it is unlikely in that event that an accident would have occurred.

2.2 The flight test

The evidence as to the unsecured ballast, the unsatisfactory recording of the flight test results – which the pilot had a duty to monitor, and the stalls being done at 21 ins Hg manifold pressure instead of with the throttles closed, together indicate that the pilot's conduct of the flight was not in accordance with the standard required by the CAA and below that which a pilot of his experience should normally have been capable of achieving.

The unsatisfactory recording of the flight test results by the observer, both when the aircraft was on the ground and during the flight, was probably due to his being insufficiently familiar with the requirement of the test schedule because the flight test was not fully planned beforehand. The main responsibility for this must rest on the pilot both in his capacity as commander and also because of his familiarity with the aircraft and its operation.

2.3 Renewal of the C of A

G–AYMM's Certificate of Airworthiness was renewed by the CAA with effect from 3 September 1979 and was valid at the time of the accident. However the renewal procedure had not been carried out strictly in accordance with that laid down in BCAR Chapter A2-5, or in the CAA booklet 'Airworthiness Certification'.

Firstly the air test had not been completed and the results analysed at the time the C of A was renewed. It is understood that this was a common procedure at the time, known to and accepted by the CAA. It is clearly undesirable that the C of A renewal procedure should differ from that laid down. This point was raised with the CAA who undertook to revise instructions accordingly. However it is for consideration that G–AYMM, having made two passenger flights since the C of A was renewed subject to the satisfactory completion of the air test, should on that test have exhibited a poor single engine climb performance on the port engine and suffered two stoppages of the starboard engine. It would seem on that basis that there was some wisdom in the former procedure which required the aircraft to be test flown before its C of A was formally renewed.

Secondly, the pilot had not been approved by the CAA Surveyor-in-Charge, contrary to the rules stated in BCAR Chapter A5-2, para 6.4, and also in the CAA leaflet 'Pilot Briefing on Airworthness Flight Testing of Light Aeroplanes', para 2. Whilst the pilot had ample experience to conduct a C of A flight test in a Cessna 421 and so would no doubt have been accepted by the CAA no formal approval was sought or given. In the event the flight test was not carried out to the standard required. It is possible that had the approved procedure been followed, discussion between the CAA surveyor and the pilot might have resulted in him carrying out the test more closely in accordance with the CAA's requirements.

2.4 Port Engine

The findings of the post-accident strip examination were not abnormal for a high-time engine, and this engine was within 20 hours of the end of its authorised 1200 hour overhaul life.

It is not considered that the cracked exhaust bellows or the turbocharger 'drag' due to turbine 'coking' would have caused any appreciable reduction in port engine performance though it may well have resulted in some loss. The crack in the exhaust system could have led to carbon monoxide entering the cabin via the air pressurisation supply had the alternate-air control been operated in flight, but this was not the case.

2.5 Starboard engine

The aircraft had, according to the log books and the evidence of the associated maintenance personnel, shown no significant engine performance problems during 1978. This indicates that the excessive output fuel flow exhibited by the starboard engine fuel metering valve on rig-test after the accident was not seriously affecting starboard engine performance.

There were no reported indications of an engine problem prior to take-off from Cambridge on 4 September 1978 or during the climb-out. The absence of any problem

prior to take-off suggests that the contamination of the engine driven fuel injection pump relief valve may not have occurred at that stage of the flight, since its presence could have led to a low unmetered fuel pressure (ie engine driven fuel injection pump delivery pressure) at idle below the 'threshold' of the starboard auxiliary fuel pump pressure switch (5 psi), causing that auxiliary pump to trip into high-speed after the associated switch had been selected to 'on' for take-off, causing a 'rich-cut' of the starboard engine.

The subsequent in-flight restart of the starboard engine, after the attempted single engine performance climb check on the port engine at 8500 feet is reported by the pilot as having been normal, with no recollection of roughness or sluggish acceleration.

It was during the stall-checks which followed that the starboard engine first stopped firing – ie during the last stall carried out in the landing configuration with gear down and flaps at 45°. However, the starboard engine quickly resumed apparently normal operation during the dive-recovery from this stall.

The possibility was considered that this transient power-loss was associated with the starboard engine driven fuel injection pump problem found during the rig test. The main problem with this possibility is that the stall was carried out at 21" manifold pressure and 1850 rpm, according to the pilot, and not with both throttles closed and engines at flight idle. Under these conditions, the starboard engine driven fuel injection pump, in spite of the contamination of the relief valve, would be expected to deliver a reasonable output fuel pressure, since the variable orifice (aneroid) valve would be governing delivery pressure. The main function of the relief valve is to govern pump output pressure (ie unmetered fuel pressure) at idle, when the variable orifice valve cannot control output because of low fuel flows. This aspect was checked during the fuel system checks on the aircraft used for the flight test at Rogers Aviation, Cranfield. It was found that a large fuel pressure loss through the relief valve does, as expected, affect engine operation at idle but only if the associated auxiliary pump low boost pressure is removed. At the 26" manifold pressure setting the engine would continue to run satisfactorily without low boost, with only 1 psi difference in unmetered fuel pressure (as opposed to approximately 4 psi drop at idle) and some 17 lbs/hour drop in fuel flow. With low boost pressure – as the aircraft normally has in flight – almost no change in unmetered fuel pressure and flow occurred.

It is thus apparent that the contamination of the relief valve seat in the starboard engine driven fuel injection pump cannot by itself, account for the unexpected power loss suffered by the starboard engine during the last stall and at the time overshoot action was taken, though the engine's acceleration response may well have been affected by it.

A full strip examination of the starboard engine at Rogers Aviation, Bedford revealed no evidence of pre-crash mechanical defect and in fact the general condition of this engine was good.

In conclusion therefore, it has to be stated that the cause of the starboard engine stoppage during overshoot cannot be determined, though the possibility that it was due to overfuelling for whatever reason cannot be discounted.

3. Conclusions

(a) *Findings*

(i) The aircraft had been maintained in accordance with an approved maintenance schedule and its documentation was in order. The weight and centre of gravity were within limits.

(ii) The aircraft's Certificate of Airworthiness was valid and its renewal was not conditional on the completion of a test flight notwithstanding the stipulation made by the local CAA surveyor concerned.

(iii) The pilot was properly licensed and adequately experienced to conduct the flight though he had not been nominated formally by the CAA as being acceptable to the Authority to make such a flight.

(iv) The flight test was not conducted strictly in accordance with the CAA schedule nor were the results of the tests made properly recorded.

(v) There was no prescribed procedure to be followed in the event of engine failure during overshoot (go around), though the procedure to be followed in the event of an engine failure after take-off virtually covered the overshoot case with the exception of flaps. Had the pilot taken this action and also raised the flaps, the accident would, in all probability, have been averted.

(vi) The pilot's belief that the aircraft would not climb away at all on the port engine alone after the starboard engine had cut was not wholly justified, though it is possible that the port engine was to some extent down on power.

(vii) The reason for the malfunction of the starboard engine both during the stall test and later during the overshoot could not be determined.

(viii) The instructions contained in BCARs relating to the requirements for the flight testing of aircraft following C of A renewal are contradictory.

(b) *Cause*

The accident was caused by the pilot failing to feather the propeller and raise the flaps after the starboard engine had cut during an overshoot manoeuvre. A contributory factor is considered to have been the absence of any prescribed procedure in the Flight Manual to meet this eventuality.

4. Safety Recommendations

It is recommended that:

4.1 In the case of the Cessna 421B and any other multi-engine aircraft, where this is not already done, comprehensive drills for the go-around manoeuvre and suitable background material to emphasise the principles and priorities of asymmetric flight be included in the Flight Manual.

4.2 The procedures and requirements contained in BCARs relating to the flight testing of aircraft following C of A renewal be clarified and be made more explicit.

P J BARDON
Inspector of Accidents

Accidents Investigation Branch
Department of Trade

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