INCIDENT

Aircraft Type and Registration:	Reims Cessna F406 Caravan II, G-FIND
No & Type of Engines:	2 Pratt & Whitney Canada PT6A-112 turboprop engines
Year of Manufacture:	1989
Date & Time (UTC):	6 September 2007 at 1237 hrs
Location:	Coventry
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	43 Years
Commander's Flying Experience:	11,000 hours (of which 250 were on type) Last 90 days - 270 hours Last 28 days - 90 hours
Information Source:	AAIB Field Investigation

Synopsis

During a routine asymmetric training flight, a control restriction was encountered. An inadvertent selection of the autopilot is suspected although it has not been possible to evaluate fully the autopilot controller. A defect in the autopilot indicating system contributed to the incident.

History of the flight

G-FIND was being used for a crew training detail with two experienced training captains conducting both left and right seat Operators Proficiency Checks (OPC) on each other. On the incident flight the pilot in the right seat was pilot flying (PF) and was being checked by the pilot in the left who was the aircraft commander.

The incident occurred while the aircraft was at 1,000 ft agl on a simulated asymmetric circuit to Runway 05 at Coventry. The left engine was at zero thrust simulating a feathered condition and the right engine was at 600-700 lbs torque, giving a speed of 140 KIAS.

The PF flew a left-hand orbit for spacing from traffic near the end of the down wind leg. Shortly after G-FIND rolled out of this orbit, the PF noticed an uncommanded roll to the right and corrected with left aileron assuming that it was due to turbulence. The PF required excessive force on the control wheel to maintain control with limited control wheel deflection available. He estimated he had 20° left deflection of the control yoke and could not turn the yoke any further. He restored the simulated

failed engine and handed the commander control to confirm the problem and check it was not related to one set of the dual controls. The commander confirmed that in his estimation 20°-30° deflection to the left was the maximum aileron control available and then returned control to the PF. The PF declared a MAYDAY with G-FIND now rolling slowly to the right and turning towards the final approach track. The commander visibly checked the airframe for any asymmetric flap or other abnormal panels but all appeared normal.

The PF decided to return to the airfield and allowed the right turn to continue by reducing the amount of opposite roll force he was applying. G-FIND was placed in a descending right turn from the down wind leg towards final approach to Runway 05. The shortened route on to finals placed G-FIND behind two light training aircraft which were considerably slower than G-FIND. As the PF was attempting to roll out of the turn the commander called Coventry tower to request that the aircraft ahead be sent around and if possible to turn to the south away from G-FIND. One of the aircraft did so immediately however the other did not respond and G-FIND overtook it at a distance of approximately two wingspans.

The PF on G-FIND continued to require extreme physical force to control the aircraft. During the turn onto finals he attempted to use rudder to assist with directional control but it seemed to be jammed in the neutral position. During the latter stages of the turn onto finals the pitch force also became excessive. The PF elected to land with approach flap rather than change configuration and potentially degrade the situation.

At approximately 300 ft agl the crew felt G-FIND lurch and regained partial control in pitch and roll or though the rudder pedals still appeared to be jammed. The PF noticed the pitch trim had run away to full nose-up trim. G-FIND was landed successfully on Runway 05 approximately 90 seconds after the first control problem began. During the landing rollout the PF handed control to the commander again for an assessment of the controls. The commander found the rudder pedal movement restricted with no more than one inch of travel available in either direction.

The crew taxied G-FIND to its normal parking position using differential power and brakes. After shutdown they noticed the electric trim switch assembly on the PF's side had broken loose from the control yoke.

Commander's comment

During the pre-flight full and free control check carried out by the PF, the trim wheel for the pitch trim had moved. The commander had assumed that the PF had moved the trim switch either deliberately or accidentally and so had not mentioned it at the time. He recalled that during the incident the PF asked him to look around for anything unusual but the commander stated that he did not check the autopilot mode annunciations located above his artificial horizon.

The commander also stated that during the incident, the PF had pressed the autopilot disengage switch on the right control yoke.

PF comment

The PF stated that during the pre-flight checks he had not actioned the trim switch either accidentally or deliberately. He is also certain that he did not press the autopilot disengage switch during the incident as he did not think the autopilot was engaged. He recalled asking the commander to look for any anomalies and intended for this to include the mode annunciations over the artificial horizon. He could not recall any incident where he may have knocked the autopilot engage switch.

Aircraft examination

The AAIB examination began on the morning following the incident. When the aircraft was first viewed, most of the central floor panels had been removed.

Despite the close grouping of cables and springs in the forward part of the aircraft, all control functions were found to be unobstructed and no foreign objects were found anywhere in the region of the total under-floor control run length which could have lead to mutual interference.

The aircraft was jacked and the landing-gear retracted. Control and autopilot functional checks were carried out but no control jamming or restriction was detected. On selection of yaw damper it was noted that rudder-free travel became very limited and no visual indication of yaw-damp engagement was evident. It was noted that the illumination bulb of the yaw damp selector button was not operating and the autopilot mode indicator was operating in dim or night mode, regardless of ambient light levels.

With auto-pilot selected, the aileron servo responded to a position signal from the unpowered instrument gyro system and drove the roll control to full travel. Attempts to resist this movement using the pilot's control column revealed unexpectedly high forces.

The aircraft engines were subsequently run, supplying vacuum power to the gyros. The aircraft was taxied and manoeuvred on the ground with various autopilot modes selected. No unexpected control inputs occurred. During the ground tests it was noted that the left knee of the pilot in the right seat is very close to the autopilot activation switch. This would be especially so in asymmetric flight with the left engine at idle.

MOR reports on previous Rheims Cessna 406 aircraft incidents were studied and a number of flying control issues were noted, three of which remained unresolved. A fourth event, to aircraft G-SFPB involved an uncommanded autopilot engagement which could not be overcome by operation of the right control column switch although disconnection was achieved via the commander's switch. When subsequently engaged, the autopilot failed to function correctly and created a number of strong and inappropriate control effects. A series of further control problems occurred culminating in the commander finding it necessary to keep his autopilot disconnect button permanently depressed to ensure the autopilot remained inactive.

Subsequent testing and examination of G-SFPB revealed wiring damage and arcing between adjacent cables associated with the autopilot where a cable loom passed through a hole in the shaft on which the control spectacle was mounted. Movement of the column had caused chaffing of the cables against the sides of the hole. Once the affected cable region was repaired, no further associated problems were reported.

Examination of the corresponding area of G-FIND revealed that, unlike the situation on G-SFPB, the relevant cables were not routed within the shaft and thus did not exit via a corresponding hole. Instead a long, very flexible pre-coiled cable was routed externally from the centre/underside of the control wheel to the instrument panel. Checks of electrical insulation and continuity on the autopilot associated cable looms through the aircraft (G-FIND) were nonetheless carried out. No faults were found.

The power supplies to pitch and roll servos, together with those to the yaw damper and to the pitch trim actuator were disconnected and the aircraft was

test-flown in purely manual mode. A reproduction of the circumstances of the incident flight (ie use of asymmetric power) was also carried out at a safe height. No control problems were encountered. The aircraft was returned to service, with all electrical actuators and the pitch trim servo disconnected, operating in purely MANUAL mode. No further control problems have been reported.

Component examination

The autopilot control unit was determined to have been manufactured in the USA to a design developed over 20 years ago and is no longer in production. Technical support for it is limited to repair stations who routinely replace a significant number of components without normally diagnosing the reasons for technical failure. The expertise for such critical diagnosis no longer appears to exist**.** A full and comprehensive defect investigation on the unit could not therefore be carried out.

Aircraft controls

The aircraft type has conventional cable operated flying controls and trimmers. It is also equipped with electric pitch trim and an autopilot operating in pitch and roll axes, incorporating a yaw damper. Autopilot servos driving elevator and aileron circuits are electrically powered and incorporate break-out clutches enabling pilot input to override the automatic control system. The pitch trim actuator is situated in the rear fuselage and responds to both the control column mounted electric trim switch and to pitch trim demands sensed by the autopilot.

The autopilot modes are controlled by illuminated push-buttons situated on a control panel mounted on the aft face of the control console on the aircraft centreline. This console is located below the power, propeller and condition levers. The sources for pitch roll and heading information are the gyros of the P1 attitude and heading indicators. These gyros are powered by engine driven vacuum pumps. The status and mode of operation of the autopilot and yaw-damper functions are shown by an illuminated mode indicator positioned on the instrument panel, above the attitude indicator, directly in front of the P1 position. The mode indicator has a light sensitive system automatically giving BRIGHT (day) indication and DIM (night) indication.

All flying control and trim cables as well as cables for the three control functions for each engine are routed beneath the cabin floor along the central trough of approximately one foot square cross-section situated between the longitudinal webs carrying the inboard seat rails. The area between those webs, extending from the instrument panel to the wing centre section, thus contains 24 closely grouped cables. The rudder and aileron control cables on the type are flexibly connected by bias springs also situated in this area. There is also close positioning between cables where they pass vertically upwards just forward of the pilot's seats in the region of the engine control console.

Autopilot engagement

The autopilot fitted to G-FIND is engaged by a push switch located below the power levers between the pilots. It is one of a cluster of 12 auto-flight related switches. During the AAIB's initial inspection of G-FIND it was noticed that this switch requires only a very light pressure to activate. The light on this panel associated with the autopilot engage switch had failed.

Discussion

The initial event of which the PF was aware was an uncommanded roll which he thought was due to atmospheric turbulence. When the roll continued, he realised there was a control problem. To respond to this

and level the wings, it was necessary to apply roll control input sufficient to both arrest an established rate of roll as well as achieving a roll rate in the reverse direction. This would have required significant roll control forces to produce the required control surface deflections acting against aerodynamic loads.

Tests on the aircraft demonstrated that high forces were required to 'break-out' the autopilot servo clutches and to overcome and reverse the control system roll deflections when inadvertent autopilot engagement took place with a steering demand present.

If inadvertent autopilot operation had occurred on the occasion of the initial control problem, the pilots would have needed to move the controls against the sum of the mechanical (autopilot servo) and aerodynamic (aileron) forces. This would have required a large total force. The effective non-functionality of the mode indicator (ie its operation in DIM during strong daylight conditions), coupled with the positioning of the autopilot control panel low down outside the scan of either pilot, would have removed the obvious cue that the autopilot system was operating and applying inputs to the flying controls.

Forceful movement of the pilot's control column to return the aircraft to a wings-level attitude would have been difficult to carry out without causing some degree of deflection in the fore and aft direction, applying inadvertent pitch control input. If the autopilot was functioning whilst this was occurring, the controller would have acted in the same way as when it detected an out-of-trim condition whilst operating in its normal mode. Thus the trim actuator would have operated, causing the pitch trim wheel to rotate.

Rudder pedal operation by the crew would not necessarily have taken place early in the sequence of events but later on, particularly as the power was restored to a symmetrical condition, some rudder pedal movement would be expected. Had the autopilot been engaged at the time, the yaw damper would have been in operation. Tests showed that a high degree of rudder restriction was produced when yaw damper was in use. The pedal movement restriction reported by the crew would have been even greater on the ground at low taxiing speeds when the pedal forces required to achieve nosewheel steering were additional to any forces from the yaw damper, if it was engaged.

Most of the effects of inadvertent autopilot engagement described above broadly reflect the pilots recollections of the event. In view of the lack of any evidence of control problem, defect or restriction found during a detailed examination of the flying control system and the continued satisfactory operation of the aircraft in purely MANUAL mode, the basic controls of the aircraft appear not to be at fault. It is therefore likely that the autopilot was operating when this control problem occurred.

The lack of any facility to evaluate all the variables of the electronic functions of the autopilot controller prevents the elimination of the possibility of an intermittent fault on that unit. Equally the possibility of crew members accidently achieving autopilot engagement by inadvertently applying pressure to button/s or dropping charts, note-pads or other loose cockpit equipment in such a way as to inadvertently strike buttons on the controller, cannot be ruled out. Either way, the absence of an effective crew warning of autopilot status and the absence of any subsequent evidence of control system defect in the aircraft increases the likelihood of this being an accidental and undiagnosed autopilot engagement.

Subsequent actions

The operating company have contracted an appropriately approved design organisation to develop an autopilot system modification which introduces a new disconnect facility. This is planned to involve a prominent switch and warning light, adjacent to the mode indicator and thus in the normal scan of the pilot occupying the left seat. The switch will enable a pilot to isolate all three servos and the trim actuator from their power supplies, enabling the aircraft to be returned easily to purely manual flight should inadvertent operation of the autopilot system occur.

In addition, the training organisation associated with the aircraft operator has reviewed procedures to raise awareness amongst flight crews of the possibility of accidental autopilot engagement and the importance of considering this possibility if control problems are encountered.