Cessna 421C, N6315X

AAIB Bulletin No: 1/2002	**Ref: EW/G2001/07/26**	**Category: 1.2**
Aircraft Type and Registration:	Cessna 421C, N6315X	
No & Type of Engines:	2 Continental GTSIO 520-N piston engines	
Year of Manufacture:	1980	
Date & Time (UTC):	24 July 2001 at 1435 hrs	
Location:	Oxford Airport	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to right propeller, engine, wing lower skin and flap	
Commander's Licence:	Airline Transport Pilots Licence (Frozen)	
Commander's Age:	25 years	
Commander's Flying Experience:	730 hours (of which 5 were on type)	
	Last 90 days - 70 hours	
	Last 28 days - 3 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Introduction

In January 1998 this aircraft had been involved in an overrun incident at Denham Aerodrome in which the right engine and propeller, wing, flap, aileron, tailplane and right landing gear strut had all been damaged (ref: AAIB Bulletin 5/98). Subsequent repair of the aircraft had been carried out by a company at Kidlington Airport and had involved replacement of the right wing and a strip examination of the right main landing gear (MLG) hydraulic actuator/sidestay unit. Following satisfactory functional checks of the aircraft systems, including operation of the landing gear, the aircraft had undergone power and taxi checks prior to its first test flight following these repairs.

During these checks, all three landing gear lights had operated satisfactorily and indicated 'green' with the gear down and locked.

History of the flight

After a normal take off, with an observer on board, the landing gear was retracted. However, as the aircraft climbed through 600 feet agl, the airspeed indication began to reduce to zero. The pilot also noticed that there was no indication on the vertical speed indicator and the altitude indication remained at 600 feet, despite the fact that the aircraft was still climbing. The pilot continued in a right turn and requested a priority landing.

The landing gear was lowered during the downwind checks, but only the nose and left landing gear green lights indicated; the right main landing gear red light illuminated. With reference to the Flight Manual, the pilot tried all of the related emergency procedures for lowering the landing gear including yawing the aircraft, applying positive 'g' and operating the landing gear 'blow down' system. However, these actions were not successful and after recycling the landing gear several times the aircraft was twice flown past the control tower for visual inspection. The pilot was informed by the controller that all three landing gears appeared to be fully down.

With the red light still illuminated for the right landing gear the pilot made an approach to land on Runway 20, with the Airport Fire Service in attendance. The aircraft touched down gently on both main wheels and the pilot then immediately shut off the fuel, closed down the engines and feathered both propellers. However, during the final part of the roll out the right main landing gear leg slowly retracted, damaging the right propeller and right wing as they contacted the runway, and causing the aircraft to veer off the right side of the runway onto the grass. No injuries were sustained and there was no fire. The pilot shut down all systems before he and the observer evacuated the cabin.

Initial examination of the aircraft indicated that the right MLG locking actuator, which also performs the function of a sidestay for the leg, appeared to have failed to lock into the down position. These actuators contain an internal mechanical locking device which is designed to lock the actuators in their extended positions.

Previous strip inspection of the right main landing gear actuator

The particular actuator fitted to the right MLG of this aircraft was the same unit which had been fitted at the time of the aircraft's previous accident in 1998. Because the eye end bearing had sheared off this actuator at that time, the company which had carried out the required repairs on the aircraft at Kidlington Airport had decided to completely strip the right actuator in order to assess its condition and check the straightness of the ram. However, having strip-inspected the actuator components and determined that they all appeared satisfactory, the actuator was reassembled in accordance with the relevant Cessna Component Maintenance Manual. It was then function tested on a test rig and subsequently installed on the aircraft. Satisfactory landing gear retraction tests were then performed.

Landing gear tests after this accident

Following this accident, the aircraft was placed on jacks and the landing gear system was operated, with AAIB participation. During several operating cycles of the landing gear system, it was observed that all three landing gears would consistently lock down, with three green lights

illuminated. However, with no hydraulic power applied to the system, the right MLG actuator consistently failed to lock down when pulled into position by hand and the right landing gear cockpit indication remained at red. The left MLG, however, could be consistently and positively pulled into the locked position by hand.

Actuator description

The MLG hydraulic actuator was of conventional design with a ram/piston operating inside a hydraulic cylinder. Fitted inside the head of the cylinder was a locking mechanism, which was designed to lock the ram in the extended (gear down) position. Hydraulic pressure was not required for the lock to engage, this function being accomplished by an internal spring. Hydraulic pressure was required, however, to disengage the lock. A diagram of the locking mechanism, drawn with the ram at mid stroke and the lock disengaged, is shown in Figure 1a, and with the ram extended and the lock engaged in Figure 1b.

The lock function is achieved at the ram extended position by four bronze locking segments engaging in a groove machined into the ram. To ensure positive engagement, a chamfered sleeve is moved by spring pressure against the segments to push them by a cam action into the groove. Further movement of the sleeve allows it to cover the outer diameter of the segments, thereby ensuring a positive lock.

To disengage the lock, hydraulic pressure applied to the small area (retract) side of the piston also acts upon the sleeve and forces it back against the spring, thereby allowing the segments to move away from the ram. To ensure a positive outward movement, chamfers are present on the mating faces of the four segments and the ram groove, which drive the segments outward as the ram begins to move. Axial movement of the sleeve causes a second chamfered section around its outer diameter to operate the 'downlock' indication switch.

Examination of the right MLG actuator

Following the landing gear cycling tests after this accident, the right MLG actuator was removed and functioned using a hydraulic test rig. This verified that under hydraulic pressure the actuator would apparently lock in the extended position, but not when pulled into the same position by hand. When the unit was subsequently stripped for examination, no failed or defective components were apparent, although wear could be seen on the 'non chamfered' edges of the locking segments and on the chamfered face of the groove in the ram. However, a 'sliver' of the backing ring some 20 mm long, identified as * in Figure 1a, was discovered free within the locking mechanism area. Consideration was given to the possibility that this sliver might have become trapped between the sleeve and the housings, thereby restricting its movement, but close examination of the sliver and components showed this not to have been the case.

During strip of the actuator, three of the segments were found in their correct orientation, but one locking segment fell from the assembly and thus the orientation of its chamfer was not positively established. Within the component maintenance manual was an instruction which stated:

> *'Note: When installing segment in the actuator, ensure that chamfer of each segment is facing away from retaining washer' (identified ** in Figure 1a)*

When the maintenance personnel who had been involved with the previous re-assembly of this actuator after the earlier accident in 1998 were asked about their re-fitment of the segments, they responded that they thought that all of these segments had been installed in their correct orientation.

Microscopic examination revealed the presence of metal transfer ('pick-up') from the bronze locking segments onto the chamfered face of the locking groove and locally onto the ram surface. There was also evidence of wear between the segments and the chamfered face of the groove. A similar actuator, removed from service for reasons not associated with landing gear operation problems, was strip-examined in order to make a comparative assessment of the locking mechanism. This mechanism was found to be correctly assembled and there was little evidence of wear and no evidence of pick-up between the locking segments and the ram, or locking groove.

In order to conduct further testing, the actuator from N6315X was re-assembled. During re-assembly, the ease with which a segment could be inserted the 'wrong way round' became apparent, and appeared due to the difficulty in visually detecting the chamfer when a segment was covered in a film of oil. After ensuring correct fitment, the actuator was extended by hand and a positive lock was established. The actuator, with the indication switch both fitted and removed, was then hydraulically functioned several times with no abnormalities apparent. During this testing, full movement of the locking sleeve was observed through the switch mounting hole.

In order to explore the operation of the locking mechanism further, the actuator was re-assembled but with one segment deliberately inserted the 'wrong way round'. Operation of the actuator on the rig demonstrated that a lock in the extended position could still be achieved, but the sleeve only moved partially towards the locked position. This scenario is illustrated in Figure 1c. As may be seen, any restriction to the movement of the sleeve by (for example) one segment, would not allow the remaining segments to fully engage with the locking groove. Although a lock may be achieved under service loading with vibration etc, it was considered that a positive lock would not be assured and that the degree of 'locking' was unlikely to be repeatable. Similarly, the operation of the indication switch would depend on its rigging (ie depth of engagement) and the actual travel of the sleeve.

It was considered possible that the observed bronze pick-up on the ram might have resulted from the significantly increased contact pressures that would have resulted from a segment edge contacting the groove chamfered surface, rather than the segment chamfer.