ACCIDENT

Aircraft Type and Registration:	Cessna 208B Caravan, G-BZAH
No & Type of Engines:	1 Pratt & Whitney Canada PT6A-114A turboprop
Category:	1.2
Year of Manufacture:	2000
Date & Time (UTC):	4 November 2004 at 1600 hrs
Location:	Netheravon Airfield, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - One Passengers - One
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to lower forward fuselage structure and nose landing gear spring fairing
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	10,600 hours (of which 627 were on type) Last 90 days - 91 hours Last 28 days - 35 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was returned to dispersal after its pilot heard two loud bangs from the area of the nose landing gear whilst taxiing to depart. The rear support of the nose landing gear spring had come away from its fuselage mounting point because one attachment bolt had failed due to bending fatigue and the other three had pulled from their self locking anchor nuts. Long-term fretting between the bolts and the rear support casting was evident and elongation of the bolt holes in the fuselage structure had occurred in a forwards direction, indicating that the nose gear spring had moved forward, possibly whilst the aircraft was being towed over a surface irregularity. Four safety recommendations were made which addressed nose gear maintenance inspections and the control of towing loads.

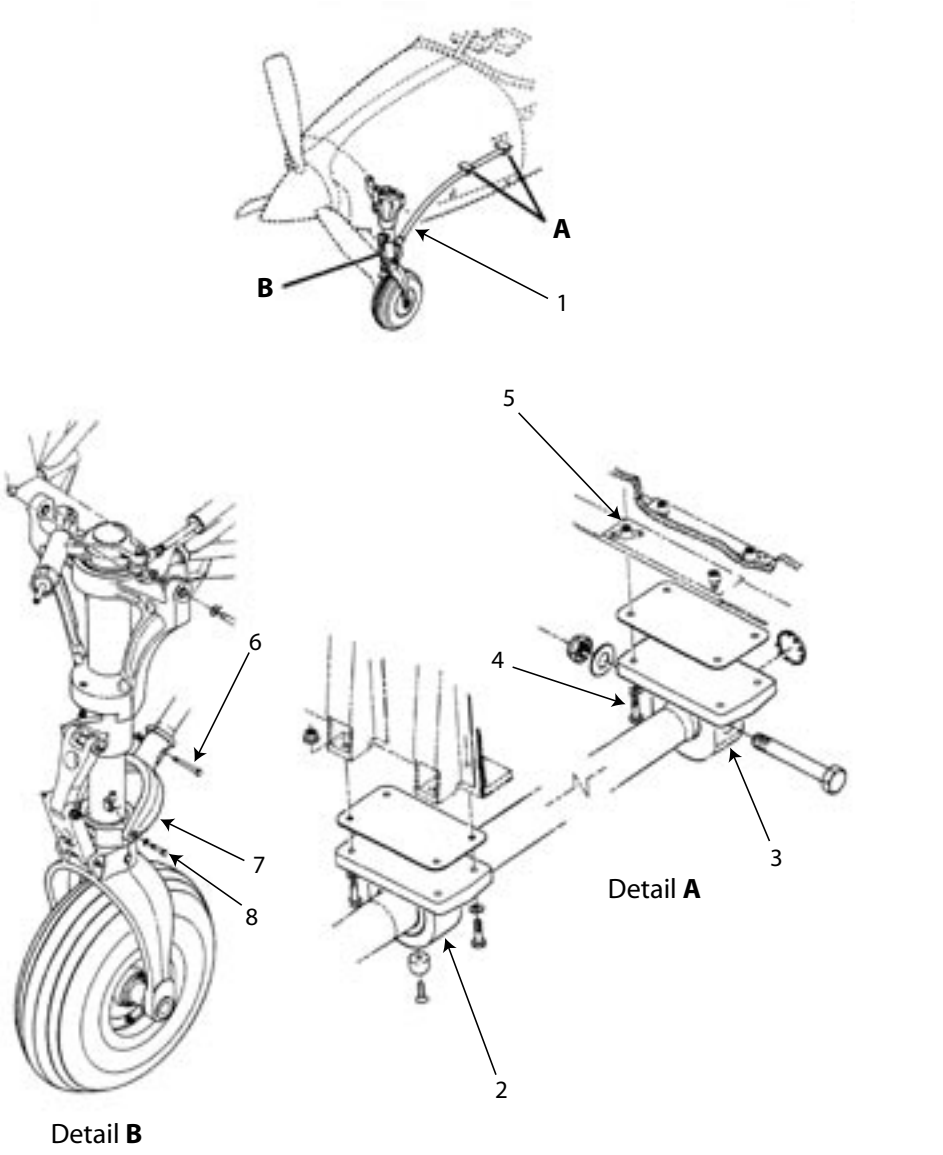
History of the accident

The aircraft was being taxied from the dispersal to the holding point in preparation for departure for a local flight when the pilot heard two loud bangs from the area of the nose wheel. The pilot contacted ATC on the radio and requested them to look for damage or anything abnormal. ATC reported that a 'panel' appeared to be loose so the pilot returned the aircraft to dispersal and shut down the engine.

Examination by the operator's aircraft engineer found that the rear support of the nose landing gear (NLG) spring had come away from its rear fuselage mounting point and had dislodged the composite fairing that was fitted immediately below the spring and its supports.

Engineering Examination

The NLG spring (Figure 1, item 1) is attached to the fuselage by a forward support (Figure 1, item 2) and a rear support (Figure 1, item 3). Each of these spring supports are secured to the fuselage structure by four attachment bolts that are tightened to 50 foot-pounds torque. The four rear support attachment bolts (Figure 1, item 4) are assembled into self-locking anchor nuts (Figure 1, item 5) mounted within the fuselage structure. One of these four attachment bolts had failed leaving the threaded portion located within the anchor nut. The unthreaded shank section of the bolt was never recovered. The other three attachment bolts were found lying loose within the composite fairing fitted below the forward and rear spring supports.

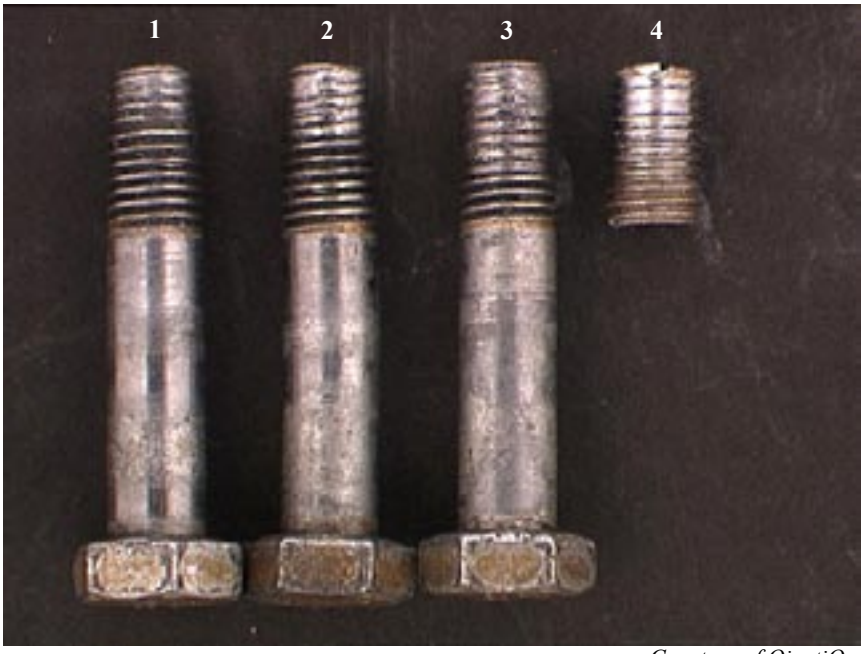


Adapted from a manufacturer's drawing

Figure 1

Diagram of the nose landing gear

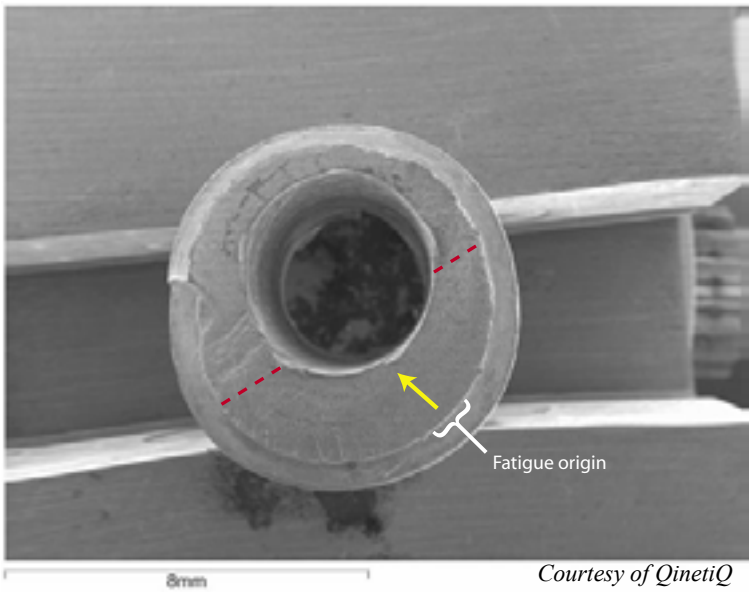
The three attachment bolts and the remaining section of the fourth bolt, together with the sections of fuselage structure with the mounted self-locking anchor nuts, were submitted for metallurgical examination. This examination showed that bolt No 4 bolt failed due to bending fatigue and the remaining three were pulled from the anchor nuts causing the bolt threads to strip (Figures 2 & 3). The fatigue crack in bolt No 4 had initiated at multiple origins in the thread root and propagated across approximately half the bolt's diameter prior to a final overload failure. The multiple origins of the fatigue were at one side of the bolt indicating that it was due to bending fatigue. As the orientation of the bolt in the structure was not known, it is not possible to determine the direction of the loading that was responsible for the fatigue in relation to the fore/aft axis of the aircraft. In addition to the fatigue crack observed in bolt No 4, fatigue cracks were also observed in the thread roots of bolt No 1.



Courtesy of QinetiQ

Figure 2 (left)

The four rear support retaining bolts (Figure 1, item 4)
(Note: The numbering of bolts has no relationship to the positions that they were fitted in the rear support; this was not known)



Courtesy of QinetiQ

Figure 3 (right)

Fracture surface of etaining bolt No 4 (fatigue limit highlighted by the red dashed line and direction of growth indicated by yellow arrow)

All four retaining bolts had differing amounts of thread stripping. Four threads were stripped from bolt No 1, five from bolt No 2, eight from bolt No 3 and four from bolt No 4. After re-assembling the rear spring support to the fuselage structure, it was apparent that engagement by the attachment bolts with the anchor nuts should reach at least the eighth thread of the bolt and that four threads would protrude beyond the nut. This showed that at the time of thread stripping, only bolt No 3 was fully engaged in its anchor nut. Either four or five threads were stripped from bolts Nos 1, 2 and 4, indicating that these bolts were not fully engaged in their anchor nuts.

Attachment bolts Nos 1, 2 and 3 showed very good evidence of long-term fretting on the unthreaded shanks and slight bending in the area where the threaded sections abutted the unthreaded sections. All four bolt holes in the rear spring support casting showed very good evidence of long-term fretting between the casting and the shank section of the attachment bolts. It was not possible to determine the period over which this fretting had occurred.

Measurements and material hardness checks were carried out on all four of the attachment bolts which showed that they met their specification. The four self-locking anchor nuts were examined and found to be both serviceable and of the type specified by the aircraft manufacturer.

The examination of the holes in the fuselage structure where the anchor nuts were mounted showed good evidence of elongation (Figure 4). The majority of this elongation had occurred in a forward direction, indicating that the NLG had moved forward relative to the aircraft's fore/aft axis.

Examination of the lower surface of the NLG rear spring support casting (Figure 1, item 3) showed paint loss and polishing of the metal (Figure 5). This polishing was in a fore/aft direction. Examination of the inside surface of the composite fairing, which was mounted directly below this support, showed similar rubbing and polishing that had been caused by contact with the lower surface of the support.

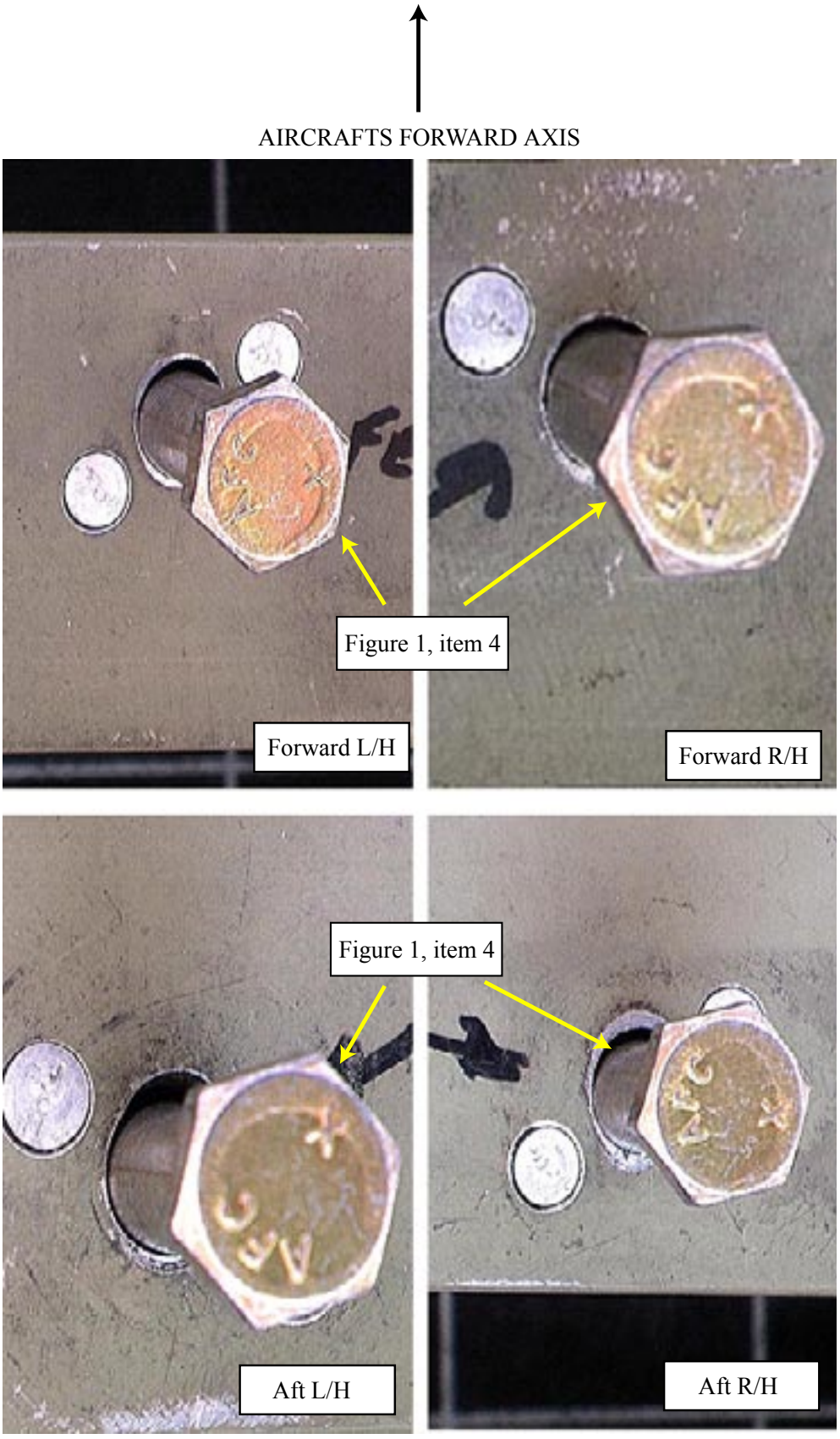
The two bolts (Figure 1, item 6) that attached the forward end of the NLG spring to the fork casting (Figure 1, item 7) where visually examined. They showed good evidence that they had been placed under large shear loads in one direction over a significant period of time. The orientation of these bolts was not known and therefore it was not possible to determine if these shear loads were in the aircraft's fore or aft axis.

The two bolts (Figure 1, item 8) that attached the fork casting to the bottom end of the NLG leg were visually examined. They showed no evidence of excessive or unusual wear markings. It was later established that the operator had replaced these bolts shortly before the accident.

Maintenance history

The aircraft had been regularly maintained by the operator's aircraft engineer in accordance with the manufacturer's schedule. The engineer had been responsible for the aircraft's maintenance from the time it was delivered as new from the manufacturer until the date of the accident. One of the manufacturer's maintenance requirements is to:

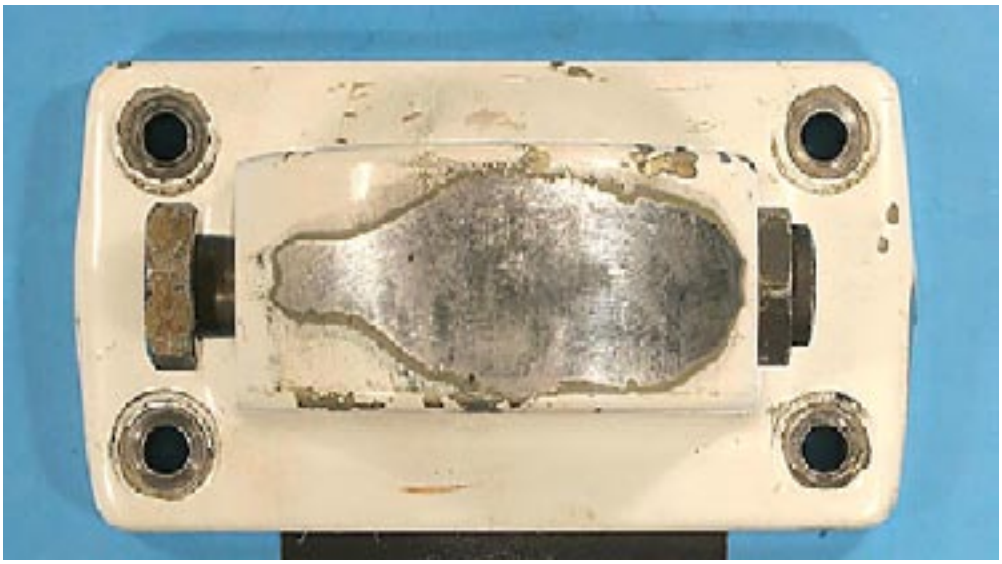
> *'Inspect forward and aft drag link spring supports for condition, loose or worn bushings, loose or missing jack point on forward support and security of attachment of both supports'.*



Courtesy of QinetiQ

Figure 4

Elongation of the rear support retaining bolt holes in the aircraft's structre



Courtesy of QinetiQ

Figure 5

Polishing effect on the bottom of the nose landing gear spring rear support

This inspection was required to be carried out every 200 airframe hours; it had last been performed by the engineer approximately 106 hours (375 flights) prior to the accident.

Early in the service life of the aircraft, the operator had encountered a problem whereby the bush that is fitted between the NLG spring and the forward spring support casting, migrated out of the casting and along the spring. This problem was eventually resolved by 'polishing' the circumference of the spring and bonding the bush into the casting. It was not possible to establish if this rectification involved removal of the rear spring support.

Aircraft operations

The aircraft was primarily used for sport parachuting from a grass airfield. At the time of the accident the aircraft had flown 7,071 flights and 2,527 hours. When not in use it was kept and maintained in a hangar that is situated downhill from the airfield and aircraft dispersal areas, which necessitated the use of a powered aircraft tug to ground handle the aircraft. The aircraft dispersal and refuelling areas are concrete hard standings on the edge of the grass airfield. In a few areas there are significant steps between the grass surface and the concrete.

Ground tug equipment

The aircraft operator used a Hydrau Tug 400 powered tug (Figure 6) to ground handle the aircraft from the dispersals to the hangar and vice versa. The tug functioned by hydraulic fluid under pressure powering two drive wheels and a lift and tilt mechanism and was handled and manoeuvred by an operator who walked with the unit. The tug was connected to the aircraft by manoeuvring it towards the NLG wheel, positioning the wheel onto the tug's platform, raising and tilting the platform towards the tug and attaching a webbed strap around the lower portion of the NLG leg. There was no 'weak link' or safety strap in the attachment between the tug and the aircraft.

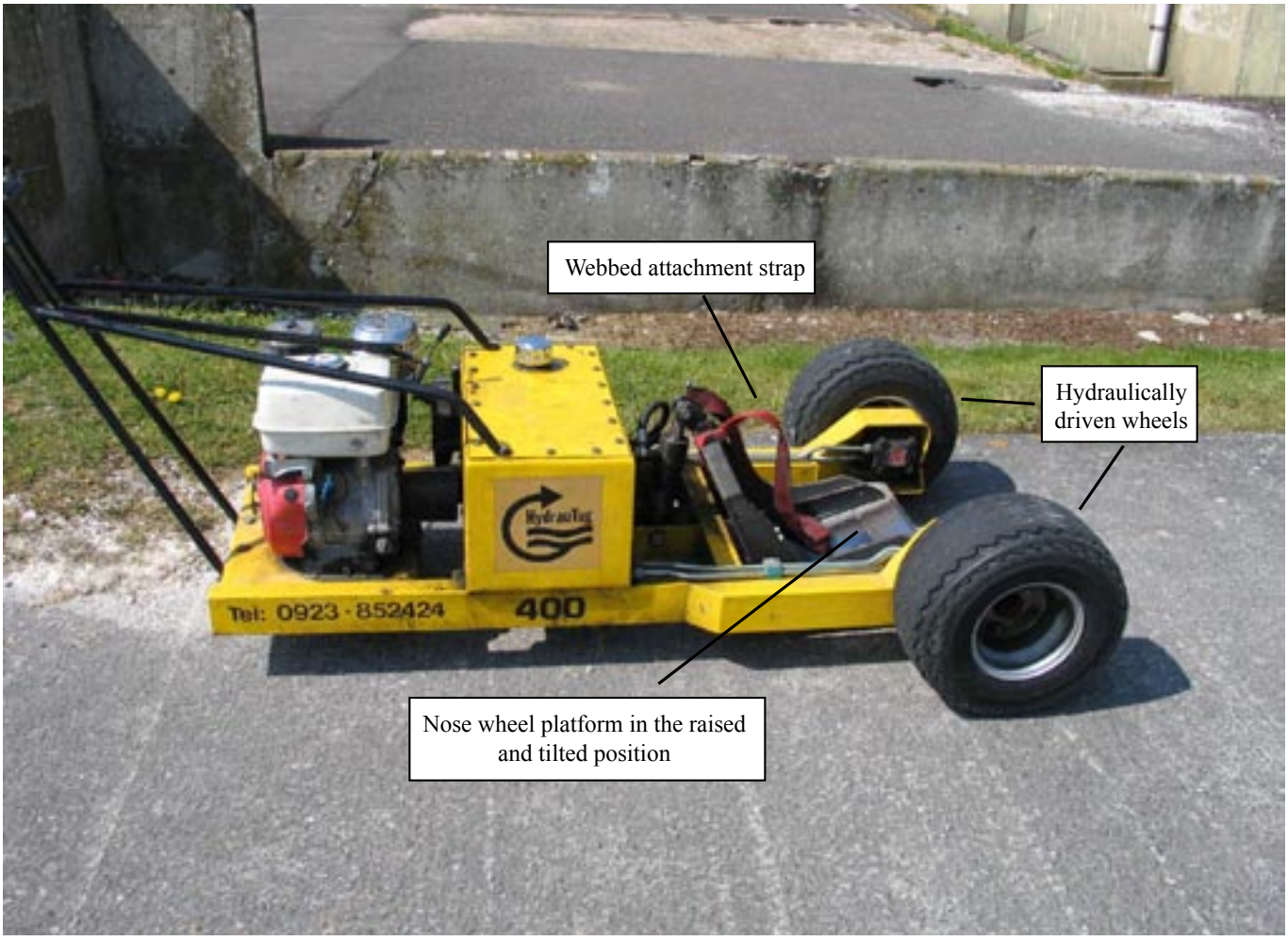


Figure 6

The Hyrau Tug 400

The tug is rated for aircraft weighing up to 25,000 lbs, but in reality could tow aircraft of higher weights on level, hard surfaces.

During a visit to the operator's base by the AAIB investigator it was found to be very easy for an inexperienced tug operator to introduce quite a severe 'snatch' when initiating movement of the tug.

Nose landing gear towing limitations

G-BZAH had an MTWA of 8,750 lb (3,969 kg). There are no towing force limitations stated in the aircraft's Operating Handbook or Maintenance Manuals.

Discussion

Examination of the four bolts that attach the NLG rear spring support to the fuselage has shown that one bolt failed due to fatigue and the remaining three were pulled from their anchor nuts causing the bolt threads to strip. The fatigue crack initiated at multiple origins in the end thread at one side of the bolt indicating that it was due to bending fatigue. In addition to the fatigue crack observed on fractured bolt No 4, fatigue cracks were also observed in the thread roots of bolt No 1. A likely scenario for the initiation of the fatigue cracks observed in two of the bolts (Nos 1 and 4) is that they were caused by movement in

the NLG rear spring support due to loose fasteners. This scenario is supported by the evidence of fretting, which indicates 'chattering', between the attachment bolts and the rear spring support casting. The fatigue crack in bolt No 4 was sufficiently large that during a high load event, the bolt fractured, increasing the load on the remaining three bolts. This increased loading on the three bolts caused, over a period of time, the threads to strip and the NLG to fail. The differing number of threads that had been stripped on the attachment bolts indicated that they had not been correctly fitted sometime in the past or that they had loosened in service. No evidence could be found to indicate how these bolts could have loosened in service. It is possible that the loose rear spring support could have been the cause of the forward spring support bushing migrating out of its casting, implying that rear spring support had been loose for some considerable time.

The examination of the elongated holes in the fuselage structure showed that the majority of the elongation occurred in a forward direction, indicating that the NLG spring had moved forward rather than aft as would be expected for the loading experienced during taxing, takeoff and landing.

From the geometry of the NLG it can be seen that towing the aircraft by the nose wheel increases the forward load on the NLG rear spring support. A sudden start, jerk or attempt to start towing with the parking brake on or wheel chocks in place could substantially increase the forward loads on the rear support attachment bolts. Therefore, any of these reasons could be the cause of the forward hole elongation seen in the fuselage structure.

Safety Recommendations

With an MTWA of almost four tonnes, the Cessna 208B is too heavy to be manoeuvred on a slope by hand but there are no towing limits published in Aircraft Operating and Maintenance manuals. Without adequate information on and the observance of suitable towing limits, it is possible for an aircraft to be damaged during ground operations and for this damage to pass undetected during routine maintenance. Therefore, the following safety recommendations were made:

Safety Recommendation 2005-102

It is recommended that the Federal Aviation Administration of the USA requires the Cessna Aircraft Company to augment the current routine maintenance procedure for the nose landing gear forward and aft drag link spring supports of the Cessna 208 Caravan aircraft models with a requirement to torque check the attachment bolts.

Safety Recommendation 2005-103

It is recommended that the Federal Aviation Administration of the USA requires the Cessna Aircraft Company to advise maintainers of Cessna 208 Caravan aircraft to replace the nose landing gear rear spring support attachment bolts if these bolts are found to be loose when torque checked during routine inspection.

Safety Recommendation 2005-104

It is recommended that the Federal Aviation Administration of the USA requires the Cessna Aircraft Company to establish the maximum towing loads that can be applied to the nose landing gear wheels of Cessna 208 aircraft and to publish suitable towing load limits in the Aircraft Operating and Maintenance Manuals.

Safety Recommendation 2005-105

It is recommended that the UK Civil Aviation Authority should ensure that all UK aircraft and airport operators utilising powered aircraft towing equipment define and implement towing procedures that ensure the aircraft manufacturer's published towing load limits are not exceeded.