Grumman American GA-7 Cougar, G-FLII, 16 April 2000

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Aircraft Type and Registration:	Grumman American GA-7 Cougar, G-FLII
No & Type of Engines:	2 Lycoming O-320-D1D piston engines
Year of Manufacture:	1977
Date & Time (UTC):	16 April 2000 at 0930 hrs
Location:	Elstree Aerodrome, Hertfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 - Passengers - 1
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Damage to right landing gear, right wing tip and flap, cabin door entry step. Right propeller tips damaged
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	660 hours (of which 278 were on type) Last 90 days - 75 hours Last 28 days - 32 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent enquiries and interviews by the AAIB

History of the flight

The aircraft was being operated as a 'Flying Eye' with a reporter broadcasting traffic conditions for a radio station. The reporter had flown frequently in this role and in this aircraft. The flying detail had been completed and the aircraft had returned to land on Runway 26, which has a landing distance available of 656 metres and a width of 30 metres. The wind was calm and the runway surface was dry.

The pilot reported that he had checked that the three landing gear 'down-and-locked' lights had been illuminated on two occasions before the landing. After a normal landing, the aircraft decelerated and rolled to the end of the runway from where it was necessary to backtrack in order to return to the parking area. Because the runway was relatively narrow, when the aircraft had slowed to about 5 kt the pilot turned the aircraft to the right before starting a left turn around onto the reciprocal direction, applying power to the right engine to assist the turn.

However, the aircraft had completed only about 120 degrees of this left turn when the right main landing gear leg suddenly collapsed and the right propeller struck the runway surface. The pilot

stated that he had immediately closed both throttles and remembered looking down at the landing gear selector lever and confirming that it was in the 'DOWN' detent; he also said that he may have pointed to the selector lever. He then retarded both mixture levers and the engines stopped. After a short pause he selected the Master Switch to OFF and both occupants then vacated the aircraft. The pilot and passenger had been wearing lap and diagonal upper torso restraints and escaped without injury.

The passenger had a different recollection of the sequence of events and reported that the right main landing gear had collapsed within a few seconds of the aircraft touching down, after she had seen the pilot's right arm move forward and heard the sound of the 'undercarriage motor' begin. She saw the pilot move his hand onto the landing gear lever and noticed the gear unsafe light illuminate; she also heard a horn sounding 'like the stall warner'. The passenger had previously completed some 10 hours instruction on a private pilot's licence (PPL) course. The pilot had stated in his Aircraft Accident Report Form that the 'amber gear warning light illuminated as the gear collapsed'. However, when interviewed later in an attempt to resolve the apparently differing recollections of his passenger, he could not remember seeing the amber 'gear unsafe' warning light, nor hearing a warning horn.

The landing had, however, been observed by the Flight Information Safety Officer (FISO) who confirmed that the right landing gear had collapsed at the'08' end of the runway as the aircraft had turned to backtrack, confirming the pilot's account of the time of the right landing gear collapse. The FISO also confirmed that there were no related marks on the runway to indicate that the right landing gear leg had collapsed at an earlier stage of the landing.

Initial inspection

The aircraft was subsequently inspected by the maintenance organisation and a surveyor from the owner's insurance company. The right wing tip had contacted the runway as a result of the landing gear collapse and had sustained damage, as had the right flap, indicating that the flaps had been extended at the time of the gear collapse. The right propeller had contacted the runway while under power, with forward bending of the blade tips and associated evidence of rotational scoring. A failed landing gear actuator rod end 'eye' was found during inspection of the right landing gear. The position of this eye end in the landing gear linkage is shown in the accompanying diagram. This failed eye end fitting was forwarded to the AAIB for examination.

Metallurgical examination

Metallurgical examination of the failed eye end found that it had fractured due to overload. Significant elongation and ductile distortion of the eye end had occurred due to excessive tension forces in the rod before the eye end had fractured, with 'necking' of the material cross-section adjacent to the failure. There was no evidence of any pre-existing defect in the eye end material. Hardness test carried out on the eye end steel material gave results of 188 to 198 Hardness Vickers (HV), equivalent to a tensile strength of 492 Newtons/square mm (38 tonf/square inch).

Landing gear system

The Cougar is equipped with a retractable tricycle landing gear. It is retracted or extended hydraulically by means of a single hydraulic actuator on each landing gear leg. Hydraulic pressure is supplied to each actuator by a hydraulic power pack driven by a DC electric motor. Each hydraulic actuator is attached to its actuator arm via a rod eye end fitted with a spherical bearing.

The landing gear is held in the UP position by hydraulic system pressure. A pressure switch senses the pressure build-up as the landing gear reaches the fully UP position and switches off the power pack. The normal operating pressure of the hydraulic system is 1,500 psi and if the pressure falls below 1,000 psi, the power pack operates automatically to restore the normal operating pressure. Each landing gear is held in the DOWN position by a spring loaded overcentre drag brace. The hydraulic actuators lock internally with the landing gear DOWN, holding the drag brace struts in the overcentre position.

The landing gear selector lever is located in the lower left centre area of the instrument panel, with the three green 'down and locked' landing gear lights adjacent. When all three landing gear legs are down and locked these three green lights are illuminated. A warning system is provided to prevent landing gear retraction when the aircraft is on the ground. If the landing gear selector lever is inadvertently moved to the UP position whilst the aircraft is on the ground, a warning horn sounds and an amber (unsafe) warning light illuminates. However, inadvertent retraction of the landing gear on the ground is prevented by a 'squat' microswitch fitted to the left landing gear leg. If this switch is unmade, ie the weight of the aircraft is on the leg, accidental selection of the landing gear selector to the UP position will not result in gear retraction. The operation of the squat switch was checked by the maintenance organisation after the accident and found satisfactory. (Although not fitted to this aircraft, later aircraft are also fitted with an additional red light, which alerts the pilot to select the landing gear DOWN when the throttles are retarded to idle).

Previous incident

This aircraft had been involved in a previous heavy landing, with the same pilot and reporter passenger, on the 9 February 2000. During the landing roll, the pilot had experienced some difficulty with directional control but the aircraft had been brought safely to a halt and had then been taxied slowly back to the parking area. That incident had resulted in damage to the right main landing gear leg torque link, which had been replaced.

Discussion

It was apparent that the eye end had failed due to excessive tensile load. In order for the eye end to have been subjected to excessive tensile forces, the right landing gear would normally have had to have come out of downlock, allowing the leg to collapse in the retract direction under aircraft weight.

The pilot reported that he had checked the 3 green lights for landing gear 'down-and-locked' on two occasions before landing and the aircraft had then landed satisfactorily, indicating that at that stage the right landing gear leg, and the other two gear legs, had been satisfactorily in downlock.

It therefore appeared that at some point between the landing and when the right landing gear leg had collapsed during the left turn at the end of the runway, the landing gear had come out of downlock. In his original report form, the pilot had stated that the gear unsafe amber warning light had illuminated as the right landing gear leg had collapsed. The passenger also reported seeing the pilot's right arm move forward as she wrote her notes and then heard 'electrical noises not unlike the undercarriage motor' just before the landing gear collapsed. In addition, she recalled hearing a warning horn and saw the pilot then quickly reach for the landing gear selector lever, which she then thought he had moved to the down position. The pilot, however, stated in interview that after the right gear leg had collapsed, he had closed both throttles and looked at the landing gear selector lever, and may have pointed to the lever, which was in the DOWN position. He could not

remember the light or horn. However, the electric motor which drives the hydraulic power pack should not have been able to function at this point since the aircraft was on the ground and the left squat switch, which was later found to function satisfactorily, should have been compressed.

The occurrence of the right gear leg collapse just as the aircraft was conducting the 180° left turn at the end of the runway raised the possibility that during this turn the left landing gear may have become sufficiently offloaded momentarily to allow its squat switch to 'make'. If this had occurred and had allowed the hydraulic power pack electric motor to run, for some reason, hydraulic pressure could have been applied to the retract side of the landing gear actuators, moving the landing gear legs out of downlock. With its share of aircraft weight on the unlocked right leg, the loads as the aircraft turned left would have acted to collapse the right landing gear against the hydraulic actuator and so apply a tensile load to the rod end; such a sequence could have induced the observed failure of the eye end. However, the maintenance organisation did not identify any defect which could have inadvertently applied electric power to the electric motor, or caused the selector system to change from the 'DOWN' state to 'UP'. In addition, after repairs were made to the aircraft following this accident, the landing gear system subsequently operated satisfactorily.

An alternative explanation for the collapse of the right gear was therefore considered. During the heavy landing incident which occurred on the 9 February, it is possible that the right eye end had been subjected to tensile forces sufficient to induce some yielding plastic deformation of the steel material, but these forces may not have been quite sufficient to cause a tensile failure of the eye end on that occasion. This eye end may have therefore have been weakened previously during that heavy landing incident and may then have suffered final tensile failure before the right gear leg collapsed in this accident. It is possible that the eye end could have failed finally in tension during the landing gear extension before the landing, and that the drag brace strut nevertheless did achieve the (spring assisted) overcentre downlocked position as a result of the resultant free-fall of the right leg. This would have meant that this leg was able to withstand the touchdown loads and subsequent deceleration on the runway without the assistance of the internal downlock in the right hydraulic actuator. If this sequence had occurred, the outwards sideloads on this right gear leg as the aircraft performed its turn around to the left at the end of the runway could then have overcome the overcentre status of the right drag brace and allowed this leg to collapse. If this had occurred, however, there would have been no warning horn (as stated by the pilot) and no operation of the landing gear motor. It is possible, in the context of this sequence of events, that the passenger may have heard both electric fuel boost pumps operating after the pilot had shut down both engines, since the sound of these pumps would normally be masked by engine noise.

However, in view of the differing recollections of the events in the cockpit, and the possibility that the failed eye end may have been weakened during the previous landing incident, it was difficult to attribute this accident to one definitive sequence of events.