ACCIDENT

Aircraft Type and Registration:	Guimbal Cabri G2, G-CILR	
No & Type of Engines:	1 Lycoming O-360-J2A piston engine	
Year of Manufacture:	2015 (Serial no: 1090)	
Date & Time (UTC):	22 July 2019 at 1730 hrs	
Location:	Wycombe Air Park	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Destroyed	
Commander's Licence:	Private Pilot's Licence (Helicopters)	
Commander's Age:	21 years	
Commander's Flying Experience:	174 hours (of which 110 were on type) Last 90 days - 22 hours Last 28 days - 9 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The helicopter had flown from Dunkeswell, Devon, to Wycombe Air Park, Buckinghamshire. As the pilot was shutting down the helicopter, he noticed smoke emanating from the left side of the rotor mast. He evacuated the helicopter and tried, unsuccessfully, to extinguish the fire with the helicopter's on-board fire extinguisher. The helicopter was destroyed.

Examination of the wreckage identified that the electrical cable connecting the alternator to the starter relay had short circuited against the aluminium baffle that surrounds the engine, probably as a result of the cable clips being incorrectly fitted.

As a result of this investigation the helicopter manufacturer issued a service bulletin to instruct operators to inspect for correct installation of the cable clips and has also completed a redesign of the clips to ensure they cannot be fitted incorrectly.

History of the flight

The helicopter was being flown from Dunkeswell Airfield, Devon, to Wycombe Air Park, Buckinghamshire. Prior to the flight, the helicopter had last flown on 17 June 2019 with no reported issues.

The pilot conducted the pre-flight checks and found the helicopter to be in a satisfactory condition. The fuel level was below the minimum to hover-taxi to the pumps, so the pilot

used a jerry can to uplift 20 litres of fuel before initiating the start procedure. When he attempted to start the engine the starter motor would not turn. The pilot thought that the battery may be low on charge due to the elapsed time since the helicopter's last flight so he charged it using a dedicated 12V DC charger. After charging the battery for approximately 2.5 hours the engine was successfully started. The pilot let the engine to idle for approximately 15 minutes, to further charge the battery, before he hover-taxied to the fuel pumps. Whilst waiting for the battery to charge the pilot contacted Wycombe tower to ask permission to land at the airfield outside of normal operational hours, which was granted.

Once the helicopter was fuelled, the pilot completed inter-flight[1] checks, started the engine and departed Dunkeswell at 1600 without issue. During the flight the pilot made specific note of the ammeter indication to confirm that the alternator was charging the battery. He noticed nothing unusual during the flight.

The pilot made a blind radio call on the Wycombe frequency before the helicopter entered the ATZ to the north of the airfield. After crossing Runway 06/24 the helicopter landed on helicopter pad 10. After landing the pilot commenced the normal shutdown procedure. He bought the engine to idle, disengaged the clutch, waited 10 seconds and then shut the engine down. As he did so he noticed a static noise being received on the radio. He also noticed that the ammeter was at its full negative deflection for approximately 2 seconds before stabilising at around 1/3 negative deflection. In addition the Exhaust Gas Temperature (EGT), which would normally read '- - -'[2] shortly after shutdown, indicated approximately 350°C and the carburettor temperature reading was steadily increasing from 30°C to above 50°C. The pilot applied the rotor brake and shortly before the rotor had stopped the he observed smoke rising over the left side of the helicopter. He left the helicopter and saw flames coming from within the cowling around the left side of the main rotor mast. He went back to the helicopter and pulled the emergency fuel shut-off and switched off all electrical switches before retrieving the on-board fire extinguisher. He expended its contents, half into the mast cowling and half onto the underside of the engine, but this had no effect. He then retrieved a personal bag from the cockpit before retreating to a safe distance.

A witness called the emergency services and a local fire and rescue appliance arrived approximately ten minutes later. The fire was extinguished but by this time the helicopter had been destroyed. There were no injuries.

Footnote

[1] Inter-flight checks are defined in the Guimbal Cabri Flight Manual as those to be conducted between flights after completion of the Daily or Pre-flight inspection.

[2] When the EGT is below its normal operating range and operating below the temperature sensing capability of the thermocouples the EGT reading on the display reads '---'.

Accident site

The helicopter was located at helicopter landing pad 10 at Wycombe Air Park. The entire helicopter, except the tail boom had been consumed by fire (Figure 1).

Figure 1

G-CILR prior to being moved

The engine remained attached to its support frame. The battery had been destroyed, however the electrical cables that had been connected to the battery were present. The insulation on the cables had been consumed by fire. The cable connecting the alternator output to the starter relay in the battery compartment was found to be in two pieces. Where it had broken the cable material had fused together, creating a globule of re-solidified molten material (Figure 2). Both ends of the broken cable was removed from the wreckage and taken to the AAIB for further assessment. A section of the helicopter's power generation and distribution circuit diagram can be found in Figure 3.

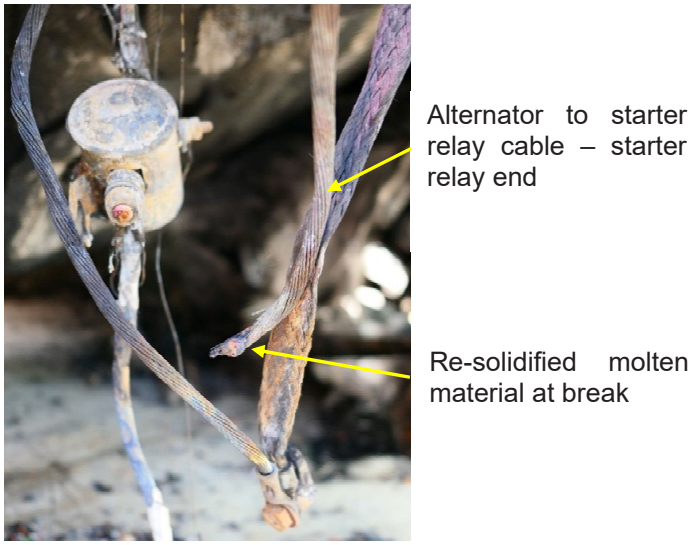

Figure 2

Helicopter cables within the wreckage

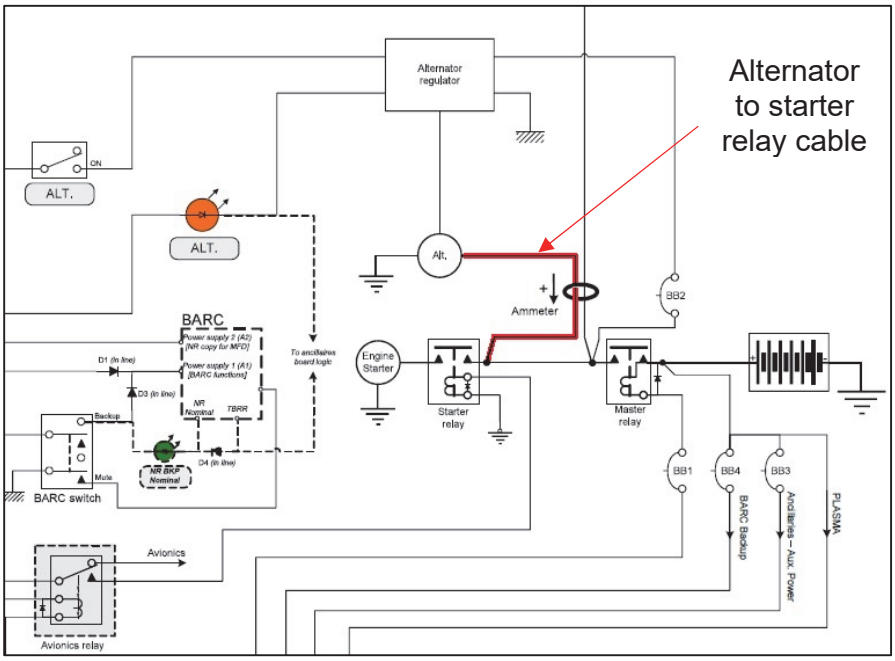

Figure 3

Section of Power Generation and Distribution diagram for Guimbal Cabri G2

Recorded information

A closed-circuit television camera captured the landing and subsequent fire. The first noticeable smoke coming from the rotor mast was observed approximately 244 seconds after the aircraft landed. At this time the rotor blades were slowing and the tail mounted strobe light was flashing, indicating that the master switch was ON.

Aircraft information

The Guimbal Cabri G2 is a light two-seat helicopter primarily used to train private pilots and for aerial photography and observation. It is the first helicopter to be primarily certified to EASA CS27 and then to achieve FAA FAR-27 certification for helicopters with a maximum takeoff weight of less than 3,175 kg (7,000 lbs).

The airframe is composed of three sections; main fuselage, engine section, and tail boom. The main fuselage is a carbon-fibre reinforced monocoque, constructed in five parts. In the cabin there are two side-by-side seats, with the pilot occupying the right position. The main fuselage also includes a central structure, baggage compartment and fuel tank. The engine section is isolated from the cabin by a firewall with the engine supported on a tubular steel frame. The composite tail boom incorporates a Fenestron tail rotor, vertical fin and a horizontal stabilizer.

The engine is mounted to the rear of the passenger compartment and drives a pulley at the front of the engine. A belt transmits the drive from the engine pulley to the main input drive of the rotor system via a pulley and freewheel coupling. A clutch mechanism is used to engage the drive from the engine to the rotor system. This is achieved by pivoting the

engine about its rear mounts; an actuator lowers front of the engine which tensions the belt, allowing drive to be transmitted to the rotor system. When the clutch is disengaged, the actuator retracts, lifting the output pulley and disengages the drive. The engine output pulley moves approximately 15 mm when the clutch actuator moves from engaged to disengaged.

An aluminium baffle is mounted to the front of the engine to aid cooling around the engine. The starter and alternator cables, which run from the battery compartment, on the left of the aircraft behind the firewall, to the engine mounted starter and alternator, pass through the baffle and are held in place by two cotton impregnated phenolic clips either side of the baffle. (Figures 4 and 5)

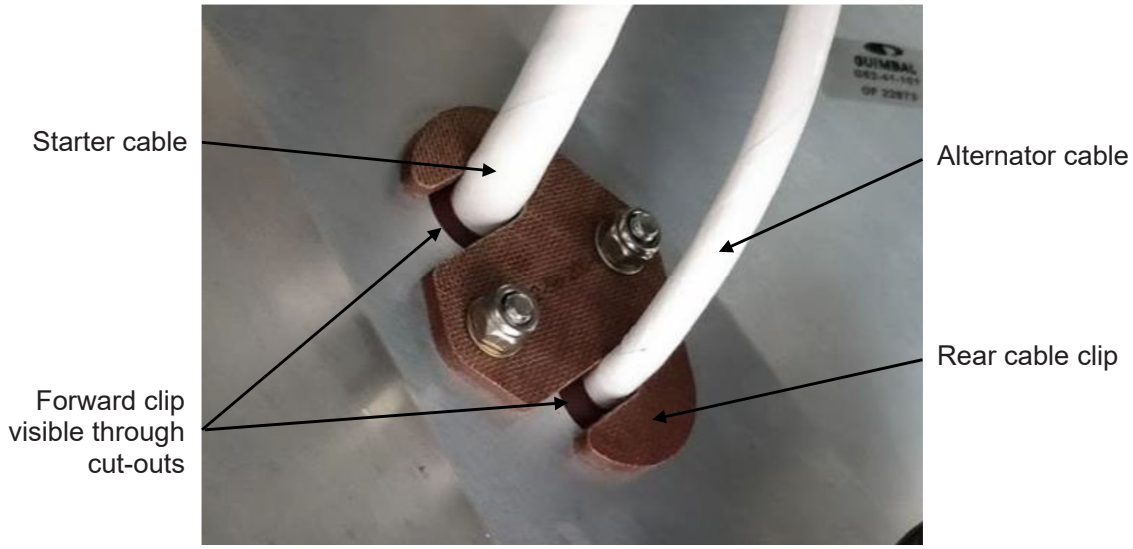

Figure 4

Starter and alternator cables passing through engine baffle (viewed from rear)

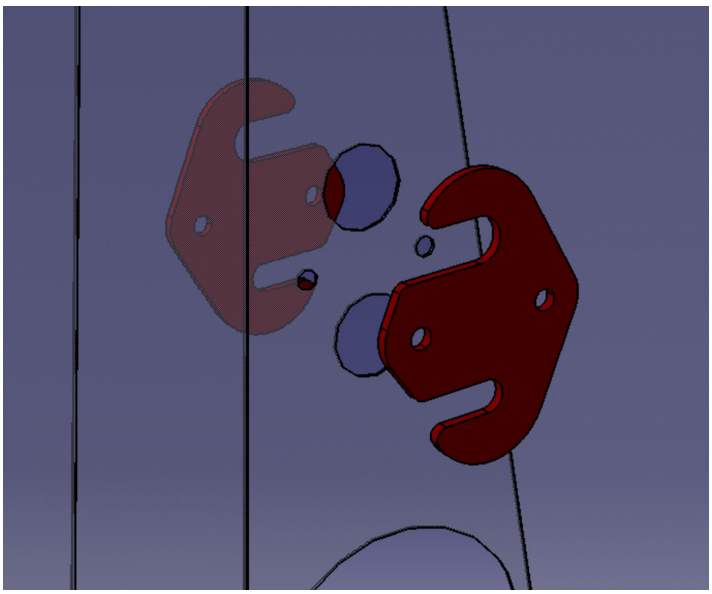

Figure 5

Exploded view of correct installation of cable clips

The clips are designed to hold the cables centrally within the pre-drilled holes in the baffle. The clips themselves are identical and should be fitted in opposition to each other, so they retain the cables between the bottom of each cut out.

A cooling fan, with a carbon fibre housing, is mounted in front of the engine baffle (Figure 6).

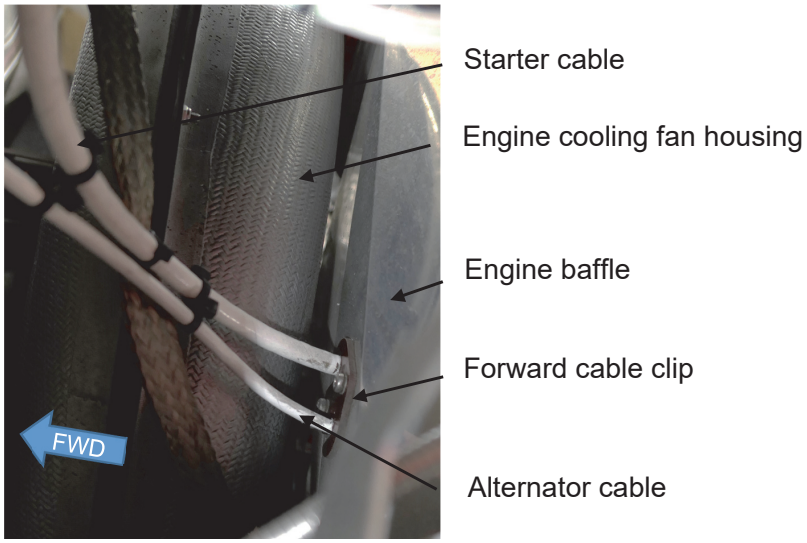

Figure 6

Starter and alternator cables passing through front of engine baffle (view from below)

G-CILR held a valid Airworthiness Review Certificate and was up to date with its required regular inspections. A review of its technical documentation found that the engine had been removed on 18 December 2018, 102.5 hours prior to the event, and that the 'engine cooler baffle' had been repaired on 21 March 2019, 47.6 hours prior to the event. As part of the engine removal the starter and alternator cables and clips would have been removed and replaced. Records were not available to determine whether the cables and clips were removed during the baffle repair.

Cable examination

Laboratory analysis of the cable removed from the aircraft found that the re-solidified molten material (Figure 7) was predominantly copper and nickel, the material of the cable itself. The cause of the fusing was as a result of extreme localised heating associated with electrical arcing. There were no traces of any other metallic elements within the re-solidified molten material to identify the component that the cable had arced against.

Measurement of the cable fragments against a cable of the same part number from another Guimbal Cabri G2 identified that the location of the break was coincident with the location that the wire passed through the aluminium baffle. The baffle on G-CILR had been destroyed in the fire and therefore could not be examined as part of the investigation.

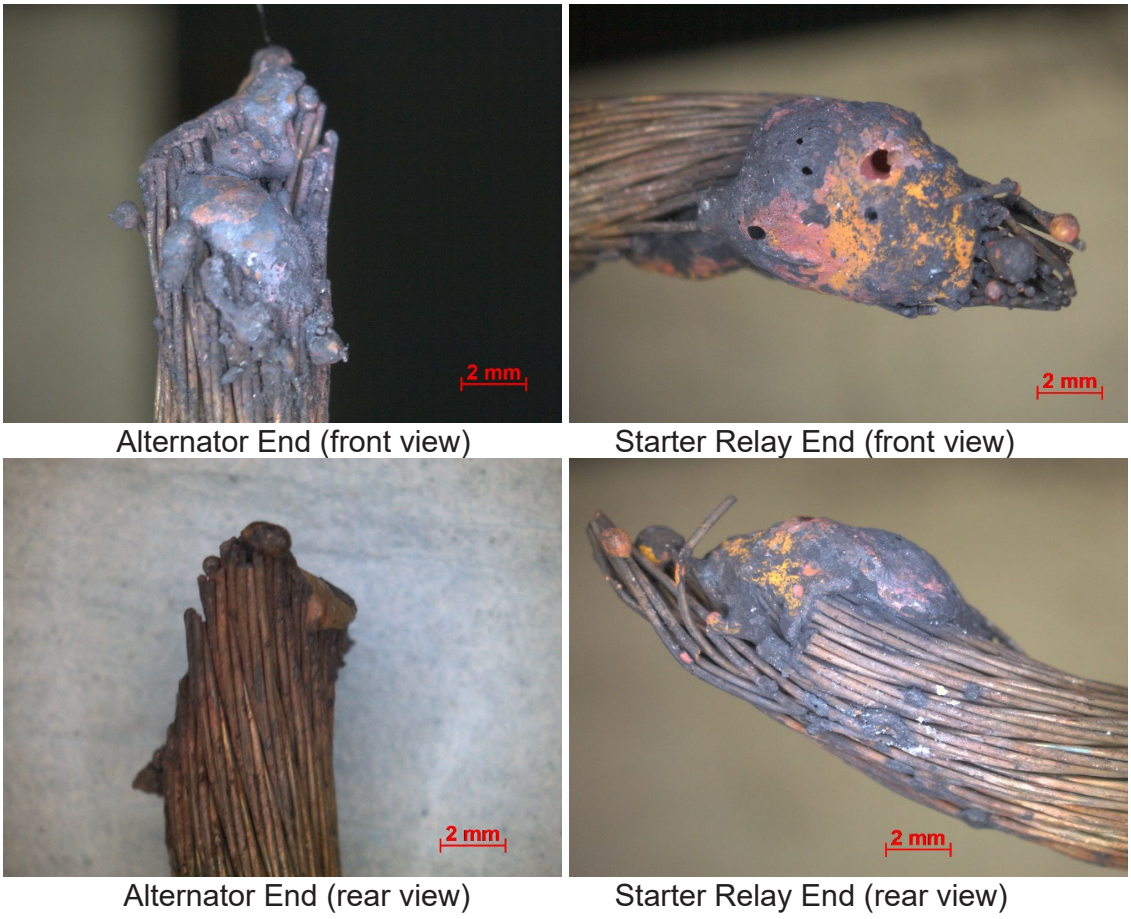

Figure 7

Alternator cable break location

The starter cable, which ran above the alternator cable as it passed through the baffle, was still present and showed no evidence of arcing. The cotton impregnated phenolic clips that supported the cables as they pass through the baffle were not recovered. It is considered likely that they were destroyed in the fire.

Analysis

The laboratory analysis of the failed alternator to starter relay cable confirmed that localised heating of the cable was associated with arcing. The location of the failure along the length of the cable was coincident with where it passed through the aluminium baffle; therefore, the baffle is most likely to have been the component that the cable arced against. The arcing will have heated the aluminium baffle material and generated sparks. This would have been sufficient to ignite the cotton impregnated phenolic clips and then the carbon fibre fan housing forward of the engine baffle. Once the fan housing had ignited the fire would have propagated quickly.

To allow the core of the cable to contact the aluminium baffle, the cable must have been able to move against the baffle. This could have been due to the clipping either failing, being installed incorrectly or not being present at all. Once the cable had contacted the

baffle material, the cable insulation would have to have been breached to allow an electrical circuit to be made. The ammeter reading observed by the pilot during the flight was positive, suggesting that the cable had not short circuited at this time. Only when the aircraft had landed did the ammeter read negatively suggesting that, in this case, the short circuit occurred whilst on the ground.

The clips that should have been fitted to the cable in the location of the baffle were not recovered from the accident site and, if fitted, were likely to have been consumed in the fire. It is therefore not possible to determine how they were fitted, or if they were fitted at all.

An assessment of the clip design identified that it was possible to fit the clips in the same orientation, rather than in opposition, resulting in the cable not being retained as intended. In this situation the cable has sufficient freedom of movement to contact the unprotected edge of the pre-drilled hole in the baffle.

The subject cable uses a polymer tape insulation wound around the wire bundle. The insulation was consumed during the fire but was probably cut or worn away by contact with the edge of the hole.

During the shutdown procedure the clutch is disengaged, pivoting the engine around its rear mounts. As it pivots, the baffle moves upward approximately 15 mm. With the cable being attached at its forward end to the starter relay, mounted in the battery compartment, and at its rearward end, the alternator, when the clutch is engaged or disengaged, there is relative movement that will flex the cable. The intent of the design is to allow the flex to be accommodated between the starter relay terminal and the cable clips mounted on the engine baffle. Without the clips holding the cable, engagement or disengagement of the clutch will have allowed relative movement between the cable and baffle. This relative movement would have been sufficient, over time, to wear through the insulation.

It is likely that during clutch engagement or disengagement the cable was able to move through the baffle hole, as it was unrestrained by the clips. As the clutch was disengaged the baffle would move upward and away from the battery compartment, tensioning the cable. It is likely that this relative movement allowed the cable to contact the hole edge, damaging the insulation and initiating the short circuit. In this instance the issue manifested itself on the ground, however in different circumstance, it may have occurred whilst the clutch was engaged and the helicopter was in the air.

It is not possible to determine whether the low battery charge prior to the accident flight was associated with the short circuit event, however it is considered unlikely to have been linked.

These findings were highlighted to the helicopter manufacturer and as a result it has taken the following safety action:

A Service Bulletin was issued by the helicopter manufacturer to inspect the clips to ensure correct installation.

The helicopter manufacturer has completed a redesign of the clipping system to ensure the cable clipping cannot be installed incorrectly. The new design of clip is being fitted to new production helicopters and will be available via service bulletin from the manufacturer.

Conclusion

The helicopter caught fire shortly after landing because the heat generated from a short circuit in the engine compartment ignited a nearby carbon fibre structure. The short circuit was made between the cable that connected the output of the alternator to the starter relay and the aluminium air baffle through which the cable passed. It is likely that the cable clips that should have held the cable as it passed though the baffle were either not present or, most likely, incorrectly fitted. The upward movement of the engine as a result of the clutch disengagement was sufficient to allow the unsecured cable to contact the unprepared edge of the aluminium baffle, allowing the insultation to be cut and initiate the short circuit.

Report published: 19 March 2020.