Agusta A109E, G-JRSL

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Aircraft Type and Registration:	Agusta A109E, G-JRSL
No & Type of Engines:	2 Pratt & Whitney 206C turboshaft engines
Year of Manufacture:	1998
Date & Time (UTC):	14 January 2000 at 1655 hrs
Location:	Wheelgate Farm, near Romney Marsh, Kent
Type of Flight:	Private
Persons on Board:	Crew -1 - Passengers - 2
Injuries:	Crew -1 (Minor) - Passengers - 1 (Minor)
Nature of Damage:	Substantial to fuselage and rotors
Commander's Licence:	Airline Transport Pilot's Licence (Helicopters)
Commander's Age:	37 years
Commander's Flying Experience:	5,000 hours (of which 150 were on type) Last 90 days - 200 hours Last 28 days - 20 hours
Information Source:	AAIB Field Investigation

Synopsis

This report should be read in conjunction with that on Agusta 109E, G-TVAA which also appears in this bulletin. Two identical types of helicopter suffered a loss of control as a result of the fracture of swash plate scissors link attachment bolt. This was because, in both cases, a very short time before the accidents occurred, the swash plate scissors link had been incorrectly assembled and installed. In this accident one of the consequences was a total loss of electrical power, possibly due to the headset of the left hand pilot moving the battery and generators switches (all three switches could be activated through a gang bar) to 'OFF'. This report contains recommendations that address the possibility of inadvertent operation of the switches and the consequences of a total loss of electrical power. The report on G-TVAA addresses the design and maintenance aspects of the rotating scissors link component, which is applicable to both accidents.

History of the flight

The helicopter was in transit from Hayes, Middlesex to Lydd, Kent at 1,700 feet in good VMC at night. The weather at Lydd Airport at the time of the accident was, surface wind 340°/10 kt, visibility 10 km, sky clear, OAT +2°C and dew point +1°C. The aircraft commander, who was a qualified A109E instructor, was occupying the front left seat with an experienced private helicopter pilot in the front right hand seat. One passenger was seated in the rear left passenger cabin.

The auto stabilisation, auto trim, altitude and heading hold, were all selected 'ON' and both pilots had their hands and feet clear of the controls. With the helicopter in the cruise at approximately 148 kt IAS both pilots heard a muffled bang from above and behind them. The helicopter became almost uncontrollable and, coincident with this, there was a sudden loss of electrical power. All the Electronic Flight Instrument System (EFIS) screens switched off and all lighting and electrical systems ceased to operate. The rear passenger described what he thought was a violent impact as if they had collided with another aircraft followed by the sensation of the helicopter becoming inverted, leaving his seat but restrained by his seat belt and banging his head on the helicopter roof.

The helicopter immediately rolled left and pitched nose up. The commander had considerable difficulty in controlling the helicopter and, believing that both engines had stopped, established the helicopter in autorotation. The left roll continued, probably past the vertical, and the helicopter entered a steep diving turn with very high main rotor RPM being audible. The commander's application of right and aft cyclic pitch brought the helicopter under control. Orientation in this attitude was not possible due to the lack of internal and external visual references. The commander continued to turn to the right, regaining some external references and levelling the helicopter at approximately 300 feet agl. Some ground definition was possible and the landing gear was successfully lowered in preparation for what the commander and front passenger believed would be an 'engine off' landing. Using a constant attitude technique, at approximately 40 kt ground speed, the commander raised the collective pitch lever to cushion the touchdown, but it appeared to have no effect. The likely reason for this is described later in this report. In the flare the tail rotor struck the ground, and at some stage in the ground impact sequence, detached. The helicopter was thrown forward onto the nose landing gear, which collapsed; it yawed to the left and the right main landing gear collapsed inwards and it rolled onto its right side. The main rotor blades, pitch change links together with many other components in the rotor head area, including the scissors link that drives the rotating swash plate, were either broken or dislodged.

The pilot and front seat passenger made their exit through the broken right upper cockpit window and the rear seat passenger, who was uninjured, climbed out of the left passenger door. There was no fire and the emergency services responded quickly despite the remoteness of the accident site.

Engineering investigation

Personnel from the UK distributor for the helicopter type, who were also responsible for the maintenance of G-JRSL, travelled quickly to the scene of the accident. They found that the helicopter was lying on its side in a badly damaged state. The nose and right main undercarriage units had collapsed and main and tail rotor blades had also separated during the impact and rollover. Extensive damage was present in the rotor head area. It was noted that both generator switches and the battery switch were all set to the 'OFF' position.

Following recovery to its maintenance base, specialists from the manufacturer and the maintenance organisation inspected the helicopter's transmission, drive and control system. Given the initial reports of a double engine failure followed by total electrical failure, and from visual inspection of the fractured bolt it was considered that the scissors link bolt had failed when the main rotor blades

struck the ground. The manufacturer also carried out a comprehensive set of functional tests of the total electrical system. These tests were carried out in accordance with the standard procedures used to confirm the electrical system integrity of newly manufactured A109E helicopter. With the exception of a few items, which related to areas where obvious accident damage was present, all tests were passed satisfactorily. Both generators and their associated control units were removed and rig tested by the helicopter manufacturers. They were found to function within their specifications.

The drive shafts between the engines and the main rotor gearbox were found to have failed. They were removed and subjected to examination by their manufacturers. It was established that failure of the couplings had occurred as a result of geometric displacement of the gearbox relative to the engines. Movement of the gearbox during the ground impact was thought to have caused this displacement. Relative rotary motion was present at the couplings at the time of failure.

Both engines were transported to their manufacturer where the fuel control units were removed and forwarded to their own manufacturer. The engines were subjected to a strip examination; no defects were found. The fuel control units were rig tested and it was confirmed that all functions were operating correctly. The engine Electrically Erasable Programmable Read Only Memory (EEPROM) system was interrogated shortly after the accident. No fault messages were present and it was confirmed that the only significant data recorded were gas generator RPM of 67.7% and 68.8% respectively. The circumstances under which such parameters are noted are those where the main rotor RPM falls outside the range 20% to 127%, or the rotor RPM signal is lost.

Similar occurrence to another A109E (G-TVAA)

On 17 June 2000 another Agusta A109E [G-TVAA] crashed as a result of control difficulties arising from failure of the scissors link attachment bolt. This accident is reported on elsewhere in this Bulletin. Investigation of this accident prompted a re-examination of the scissors link assembly fitted to G-JRSL. It was found to have been assembled and installed in a manner which was not in accordance with the Maintenance Manual and original build drawings (ie back to front). The attachment bolt had failed in a similar manner to that noted on G-TVAA. Furthermore, it was noted from the technical records of G-JRSL that the linkage had been removed and replaced, as part of a combined Annual/100 hour inspection approximately 45 minutes flying time prior to the accident. In the case of G-TVAA the technical log showed that on 16 June 2000, ie the day before the accident and 3 hours and 10 minutes flying time earlier, the lower scissors link had been replaced.

Discussion

The pilots reported hearing a bang from the gearbox area followed by a near loss of control of the helicopter. At some stage there was a sudden loss of all electrical power. If the electrical system was entirely undamaged during the accident impact, any pre-impact technical defect of that system was most unlikely to have occurred without leaving significant evidence. Such evidence would be readily found during the comprehensive set of functional tests of the total electrical system carried out by the manufacturer, which were in accordance with the standard procedures used to confirm the electrical system integrity of newly manufactured A109E helicopters. No such evidence was found. Furthermore, the helicopter occupants and the emergency services reported that no-one had moved the battery, generator switches or the gang-bar at any time after the impact.

Examination of the engines and the fuel-control units revealed no evidence of failure or malfunction. The nature of the EEPROM system operation meant that the gas generator parameters

recorded could readily have been those sampled at either of two points in the accident. These points where either, (1) when the rotor RPM rose to a very high figure as a result of aerodynamic forces during the extreme manoeuvre, or (2) as the RPM decayed when the main blades struck the ground.

In order to protect the power turbine from overspeed damage during unloaded operation, the fuel flow is reduced, followed by the gas generator RPM. The speed with which fuel flow and gas generator RPM then increases after loss of rotor RPM and/or application of collective pitch lever movement depends on the time history of rotor RPM and collective pitch lever movement. Since it cannot be established conclusively whether the EEPROM data sampled at Point 1 or Point 2 the significance of the gas generator RPM data cannot be determined. The absence of any fault signals on the EEPROM systems indicates that no malfunctions occurred in the electronic engine control system.

Conclusion

The similarities between the noise heard and the dropping sensation experienced by the occupants of G-JRSL and G-TVAA would suggest that the scissors link attachment bolt probably failed during flight.

The subsequent sudden reduction in main rotor blade pitch would have caused the violent upward movement from his seat described by the rear passenger in G-JRSL. The pilot in the front left seat described his posture immediately prior to the failure as being crouched over the controls with his feet clear of the tail rotor control pedals and his hands on his lap. The effect of suddenly sitting upright to place his hands and feet on the controls combined with being thrown upwards out of his seat against the restraint harness could have permitted the top of his headset to contact the battery and generator gang bar. Whilst trials in a similar helicopter demonstrated it was possible for the this to occur, it was difficult to operate the gang bar without dislodging the pilot's head set which means that he would have been aware of what had happened.

With the stabilising effect of the auto-pilot and trim system having been lost due to the loss of electrical power, the yaw induced to the left caused the helicopter to roll very rapidly in that direction. Although this could also have occurred as a result of the altered phase lag if the scissors link had become detached at this stage. With no attitude reference either from the EFIS or external visual cues, the pilot made an instinctive movement of the cyclic pitch control to stop the turn to the left. Yet again the detached scissors would have produced an unusual and out of phase response in both cyclic and collective pitch control demands. The exact flight path could not be determined, but given the circumstances the pilot found himself in, any contact between his headset and the gang bar may not have been noticed by him and was certainly not recalled.

The increase in rotor RPM caused by the reduction in main rotor pitch angle combined with the disc loading due to the roll and nose up pitching moment caused both engines to reduce power. By this stage with no engine instruments to refer to the pilot reasonably concluded that there had been a double engine failure and did his best to position his helicopter for a forced landing. Having successfully lowered the landing gear and reduced speed, the pilot attempted to check the rate of descent and cushion the landing by raising the collective pitch control. This had little effect, probably as a result of the failed scissors link, and the helicopter struck the ground heavily as previously described.

Following a detailed investigation of the helicopter and its systems, no technical reason for the total electrical power loss was identified. During the course of the investigation it was considered that a

potential hazard existed involving the location and design of the helicopter battery and generator switches. Their location at the front left of the overhead panel and the presence of an emergency cut-off gang bar operating on single action switches render them vulnerable to inadvertent off selection. There was no evidence to show that the gang bar had been operated in flight, but the switches were all found in the OFF position after the accident. When the battery master was switched on all systems operated normally. The only post accident action carried out by the commander was to place both engine power levers to the off position. Neither pilot recalled switching off the battery or generator switches.

Safety recommendations

The following Safety recommendations were made on 27 January 2000:

Recommendation 2000-9

The CAA should alert all operators of Augsta 109 series helicopters to the possibility of total electrical power loss resulting from inadvertent de-selection of the battery and generator switches, either through direct contact with the switches or by means of the existing 'gang bar' which is positioned near the battery master and generator switches.

CAA Response:

The Authority accepts this recommendation. The Authority published a letter to all UK owners/operators of Agusta A109 Series Series helicopters (No 2002, reference 9/97/CtAw/11) on 28 January highlighting the possibility of total electrical power loss resulting from inadvertent de-selection of the battery and generator switches, either through direct contact with the switches or by means of the existing 'gang bar' which is positioned near the battery master and generator switches.

Recommendation 2000-10

The CAA should determine whether there is any requirement for a 'gang bar' to be fitted and, if not, whether at least the battery master switch should be controlled by a gated or guarded switch.

CAA Response:

The Authority accepts this recommendation. The Authority will carry out a detailed evaluation to determine whether there is any requirement for a 'gang bar' to be fitted and, if not, whether at least the battery master switch should be controlled by a gated or guarded switch. If any issues are identified, these will be taken up with the manufacturer and the original certifying authority by 30 April 2000.

Recommendation 2000-11

The CAA should alert operators of IFR capable helicopters to the possibility of encountering handling difficulties in high-speed cruise, which may result from unexpected failure or de-selection of auto stabilisation systems. These include the effects of yaw being induced when lowering the collective pitch lever to reduce speed with the possibility of a rapid roll couple.

CAA Response:

The Authority accepts this recommendation. The loss of the auto stabilisation system alone, without loss of all electrical power and consequent loss of all flight instruments, should not cause handling difficulties of the type encountered in this accident. Notwithstanding this, the Authority will provide information to operators of IFR capable helicopters to alert them to the possibility of encountering handling difficulties in high speed cruise, which may result from unexpected failure or de-selection of auto stabilisation systems. The effects of yaw being induced when lowering the collective pitch lever to reduce speed with the possibility of a rapid roll couple will also be included. A suitable means to promulgate this information will be identified and the information issued by 31 May 2000.