AAIB
Air Accidents Investigation Branch

AAIB Bulletin 10/2019

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(ALL TIMES IN THIS BULLETIN ARE UTC)

AAIB Field Investigation Reports

A Field Investigation is an independent investigation in which AAIB investigators collect, record and analyse evidence.

The process may include, attending the scene of the accident or serious incident; interviewing witnesses; reviewing documents, procedures and practices; examining aircraft wreckage or components; and analysing recorded data.

The investigation, which can take a number of months to complete, will conclude with a published report.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 737-4Q8, G-JMCR	
No & Type of Engines:	2 CFM56-3C1 turbofan engines	
Year of Manufacture:	1992 (Serial no: 25372)	
Date & Time (UTC):	12 October 2018 at 0155 hrs	
Location:	En-route to East Midlands Airport	
Type of Flight:	Commercial Air Transport (Cargo)	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	None reported	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	50 years	
Commander's Flying Experience:	8,418 hours (of which 6,314 were on type) Last 90 days - 112 hours Last 28 days - 46 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft was operating a night flight to East Midlands Airport, with the left engine generator disconnected, and had just commenced its descent when the crew faced an unusual array of electrical failures on the flight deck. Despite the loss and degradation of a number of systems, the aircraft landed safely at East Midlands.

The electrical failures were caused by the right engine Generator Control Unit (GCU) which had been incorrectly secured in its mounting tray and had disconnected in flight. The investigation also uncovered a number of contributory factors including: the management of defects and Acceptable Deferred Defects (ADD), recording of maintenance, and a number of weaknesses in the operator's Safety Management System with regards to managing risk.

Five Safety Recommendations are made to the operator regarding its safety management system and one to the Civil Aviation Authority.

History of the flight

The crew reported for work at Leipzig Halle Airport, Germany, on the evening of 11 October 2018. They were rostered to operate a three-sector day from Leipzig to Amsterdam Schiphol Airport, then to East Midlands Airport and finally to Aberdeen Airport.

On arrival at the aircraft, the crew met with the pilots who had flown the aircraft into Leipzig and briefly discussed that the aircraft was operating with an ADD for an inoperative Gen 1. The aircraft was permitted to operate under Minimum Equipment List (MEL) 24-1b providing the APU, and its generator, were run during the flight. In this condition the No 1 electrical system was powered by the APU generator and the No 2 system by the engine-driven generator on the right engine (Gen 2).

At 2243 hrs, the aircraft departed from Leipzig and the flight was without incident until the landing at Amsterdam when the co-pilot's flight instruments, which are powered by the No 2 electrical system, intermittently blanked and several electrical warning lights on the overhead panel illuminated intermittently. The crew were unable to determine the cause of the problem and concluded that Gen 2 had failed, leaving the APU generator providing the only electrical power to the AC busses. They attempted to select the APU generator to provide power to the No 2 electrical system, but it would not connect. The aircraft was taxied to the parking stand and shut down.

The crew were aware that the MEL did not allow the aircraft to dispatch with only a single generator functioning and, therefore, the crew contacted the operator's Line Maintenance Control (LMC) who arranged for an engineer in Amsterdam to attend the aircraft. After around 30 minutes, the engineer arrived at the aircraft and was briefed by the commander. He was seen to open the cowlings on the right engine in order to examine Gen 2; he also checked the relevant circuit breakers and Panel M238 on the sidewall of the cockpit. The engineer informed the crew that he had reset a circuit breaker and was confident that this was the cause of the problem but would require the right engine to be run in order to ensure that the engine generator was working correctly. The engine run was performed satisfactorily and the generator on the right engine and the No 2 electrical system worked normally. The engineer cleared the entry in the aircraft technical log and as part of their pre-flight preparation the crew discussed the actions they might take in the event they lost the remaining engine generator. The aircraft departed Amsterdam with the original ADD for an inoperative Gen 1.

The flight was without incident until the aircraft was approximately 60 nm from East Midlands, with the co-pilot as PF, when during the descent the autopilot disconnected, the co-pilot's screens lost power and his flight instruments failed. The commander took control and disconnected the autothrottle as he was flying the aircraft manually. Numerous lights on the overhead panel and system annunciation panels illuminated and flashed, and multiple aural warnings were generated by the Terrain Avoiding Warning System (TAWS). As both crew members were visual with the runway, the commander instructed the co-pilot to make a PAN call and ask for vectors straight onto the ILS at East Midlands. During the next 20 minutes, and until the aircraft landed, the flight instruments on the co-pilot's side came on and off numerous times.

The commander manually flew an ILS approach onto Runway 27. The aircraft controls, flaps and gear worked normally although the distracting flashing warning lights and aural callouts continued throughout the approach. On landing, numerous aircraft systems failed including the autobrakes (although manual braking remained available), half the exterior lights and the commander's speed indications on his electronic attitude display indicator. On reaching the stand, the crew were unable to connect the electrical ground power to the aircraft system. While the flaps were retracted, the flap indication showed them still deployed. No electrical power was available to the cargo door, cargo bay and multiple items on the flight deck.

The crew briefed the ground engineers and completed the technical log before continuing to Aberdeen on a replacement aircraft. The engineers later discovered that the GCU for Gen 2, which is located in the flight deck behind the right pilot seat, was not correctly fitted in its housing.

Recorded information

The aircraft's flight data recorder (FDR) and cockpit voice recorder (CVR) were removed from the aircraft and downloaded at the AAIB where their recorded information was analysed. The duration of the CVR was 30 minutes and the recording started about 5 minutes before the descent into East Midlands. The FDR recorded just over 52 hours of data; however, there were no parameters associated with the aircraft's electrical system that were of use to the investigation.

Airfield information

East Midlands has a 2,863 m long runway and was long enough for G-JMCR to stop with a complete brake failure using the other available retardation devices.

Meteorology

The weather for the route from Amsterdam to East Midlands was relatively clear with little cloud forecast during the night, although the weather was expected to deteriorate markedly during the day. The weather observations at East Midlands during the event reported a clear night with scattered or broken cloud at 1,300 ft aal.

Organisational information

The operator was part of a parent organisation that operated out of the UK and Sweden with the UK group operating a fleet of Boeing 737 aircraft. The Air Operators Certificate (AOC) and EASA Part M[1] for the Boeing 737 was held in the UK. In the 18 months prior to the incident, the UK fleet increased from 11 to 17 aircraft and by the beginning of June 2019 had increased to 21 aircraft with a corresponding increase in staff. During this period the operator's main operating base moved from Coventry Airport to East Midlands. The administration of the AOC and its Part M responsibilities also moved from Coventry Airport, to a nearby business park.

The operator has an extensive European network with engineering support provided by fixed base contracts supported by EASA Part 145[2] organisations. When aircraft are required to operate to other non-standard locations, the aircraft is supported with either on-board engineers or short-term temporary line support contracts with Part 145 organisations.

Footnote

[1] Commission Regulation (EU) No 1321/2014 of 26 November 2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks Annex I Part M.

[2] Commission Regulation (EU) No 1321/2014 of 26 November 2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks Annex II Part 145.

All line maintenance defects, rectification action and certification are recorded on the appropriate Sector Record Page (SRP) in the aircraft technical log and controlled by LMC which is also located at East Midlands. The operator uses a Flight Status Reporting system (FSR) that allows defects and daily aircraft status information to be recorded by line maintenance engineers through an on-line portal. This replicates the information on the SRP and provides troubleshooting feedback and a messaging system that provides the LMC engineers with immediate and relevant information. Flight crew have access to the FSR when operating down route through a tablet device.

A group audit carried out in May 2018 identified issues with the level of competence of the staff in LMC, which resulted in the establishment of an LMC Manager post who took over the management functions from the Operations Manager and placed LMC under the Part M organisation. The LMC procedures were also revised and additional staff training was planned. This process was ongoing at the time of the event. It was also decided to create the post of Defect Controller to manage the ADD and MEL entries; this individual reported directly to the Maintenance Manager. A contractor was initially employed in this post from 18 June 2018 while a suitable candidate was recruited; however, the contractor had to leave on 24 September 2018 and the position was vacant when the incident occurred.

Of the 15 engineers who worked in LMC, two were employed on each shift, with an additional person providing logistical support. Oversight was exercised by the Operations Shift Supervisor (Figure 1). During the normal working week, a conference call involving representatives from the LMC and the Part M organisations in the UK and Sweden took place at 0600 hrs each morning to review what had happened overnight. In January 2019, following this event, the operator introduced an additional conference call at 0815 hrs that included representatives up to the Accountable Manager from the operation, technical and business areas of the company. However, neither of these conference calls takes place at the weekends or public holidays.

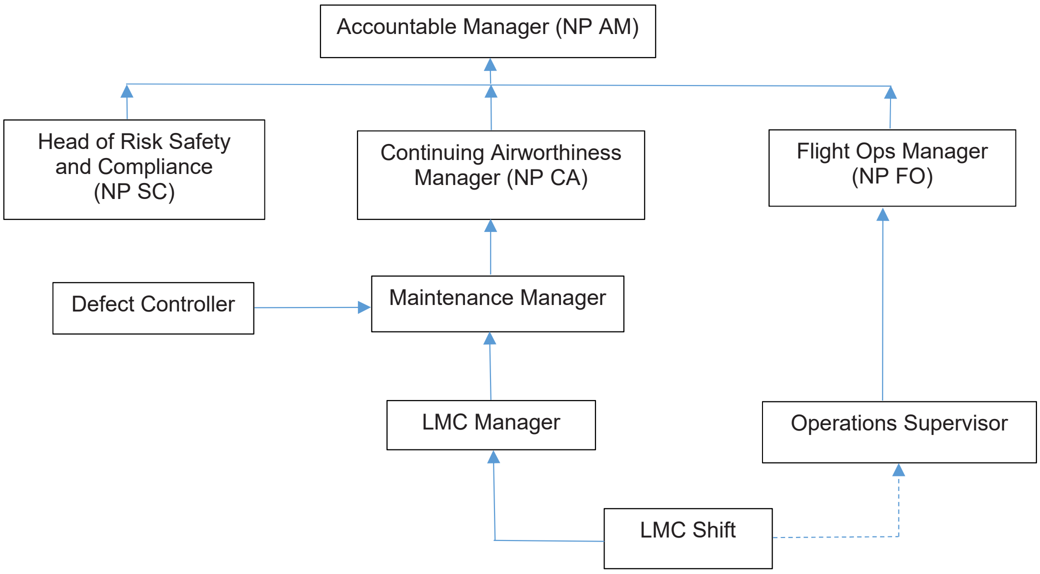

Figure 1

Organisational diagram

Aircraft information

G-JMCR is a Boeing 737-400 freighter aircraft. Its Certificate of Airworthiness was issued on 4 August 2014 and the Airworthiness Review Certificate was valid until 4 August 2019.

The last significant scheduled maintenance was a 'C' check that was completed on 8 March 2018 at a Part 145 organisation based at Norwich Airport. No problems were experienced with the electrical power system and none of the GCUs were recorded as having been disturbed during the maintenance.

Systems description

General

In the B737-400, AC electrical power is provided by one generator fitted to each engine through a Constant Speed Drive Unit (CSDU) and one generator connected to the APU. The normal configuration inflight is for each of the engine-driven generators to power one of two 115V AC generator busses (Gen Bus 1 or 2). If one generator is inoperative, the APU generator may be used to power the inoperative generator's bus. In the air, the APU generator can only power one of the generator busses, whereas on the ground it can power both. One generator (engine-driven or APU) can provide sufficient power for all essential flight systems. A schematic of the electrical power system is at Figure 2.

AC power supply

The AC power supply consists of two systems identified as 1 and 2 with system 1 powering the flight instruments on the left side of the flight deck and system 2 the right side. Each generator is connected to a Gen Bus (1 or 2) and a Transfer Bus (1 or 2). The Transfer Busses normally receive their power from their respective Gen Bus and have an associated Transfer Relay which automatically selects the opposite Gen Bus as a power source if its Gen Bus loses power. At the same time the protective automatic load-shedding circuit turns off all power to the aircraft galleys to ensure that the remaining generator is not overloaded.

The GCU monitors itself for correct voltage, frequency, ground faults in the generator or excessive current draw from any generator. If any malfunction develops, the GCU will detect the fault and disconnect the generator from its generator bus.

Generator malfunction lights

Panel M238, which is located in the entrance to the cockpit, contains four white generator malfunction lights for each generator: High Voltage (HV), Low Voltage (LV), Feeder Fault (FF) and Manual Trip (MT). These warning lights are controlled by double-coil relays inside each of the GCUs and once energised will be latched in the TRIP position by a permanent magnetic latch. The HV, LV and FF malfunctioning lights can be reset by pressing the ERASE button located on Panel M238.

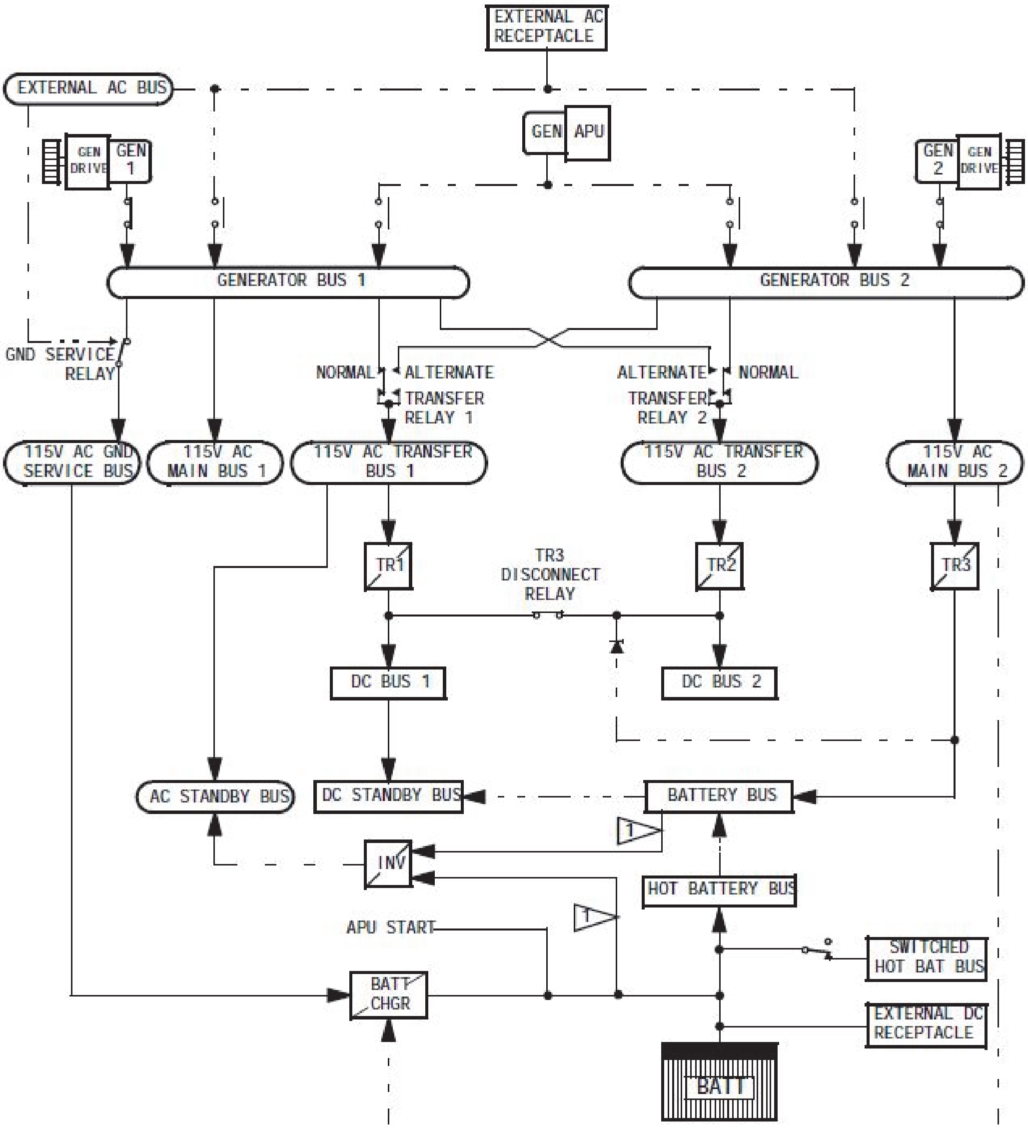

Figure 2

Schematic of electrical power system

Generator Control Unit

Each generator is controlled by its own GCU located in panel P6 located behind the right pilot seat. The effect of GCU 2 becoming disconnected in flight, which is described in Appendix 1, would be the loss of the following busses:

- 115V AC Main Bus 2
- 115V AC Transfer Bus 2
- 115V AC Electronic Bus 2
- 28V DC Bus 2
- 28V DC Electronic Bus 2

Racking of Generator Control Unit

The GCUs are mounted in the electrical equipment rack and are fitted by sliding the unit rearwards into the tray with the handle lever in the open position and ensuring that the guide pins at the back of the tray engage in the frame (Figure 3). Once the unit has been pushed in far enough, the hook at the bottom of the handle lever will engage with the fork assembly that is attached to the shelf. The handle lever is then moved into the locking detent securing the box in the tray. The Aircraft Maintenance Manual[3] (AMM) provides further instructions to ensure that the handle and fork assembly have been correctly adjusted.

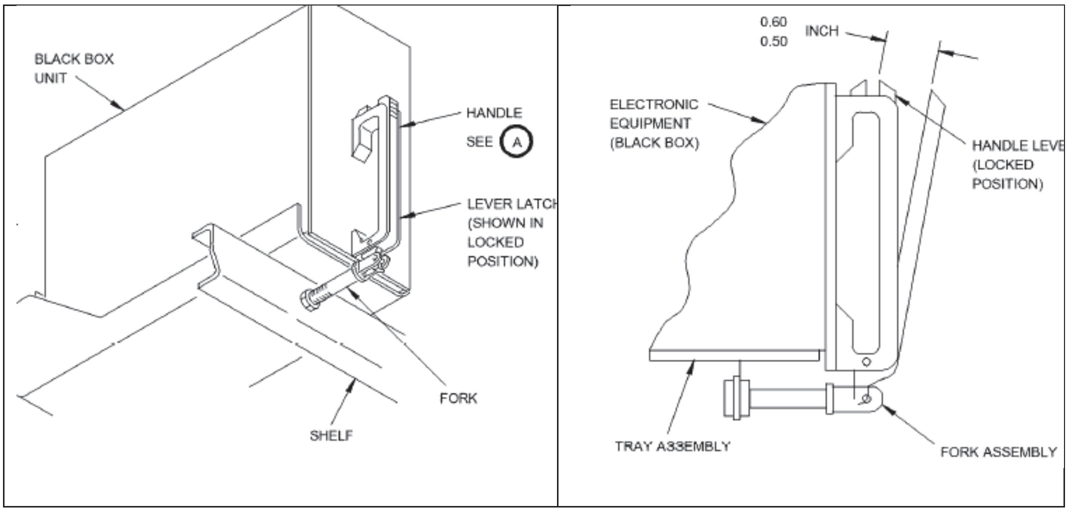

Figure 3

Racking of Generator Control Unit

Minimum Equipment List (MEL)

Purpose of the Minimum Equipment List

The EASA Acceptable Means of Compliance[4] (AMC) provides the following guidance on the purpose of the MEL:

> *'PURPOSE OF THE MEL*
>
> *The MEL is an alleviating document having the purpose to identify the minimum equipment and conditions to operate safely an aircraft having inoperative equipment. Its purpose is not, however, to encourage the operation of aircraft with inoperative equipment. It is undesirable for aircraft to be dispatched with inoperative equipment and such operations are permitted only as a result of careful analysis of each item to ensure that the acceptable level of safety, as intended in the applicable airworthiness and operational requirements is maintained. The continued operation of an aircraft in this condition should be minimised.'*

Footnote

[3] AMM, Task 20-10-07-422-011, Rack Mounted E/E Box – Installation.

[4] EASA Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Annex III Organisation requirements for air operations [Part-ORO] of Commission Regulation (EU) 965/2012 on air operations. Consolidated version including Issue 2, Amendment 12, December 2017.

MEL for Boeing 737-300/400

The EASA has not issued a Master Minimum Equipment List (MMEL) for the Boeing 737-300/400, instead the operator used a MEL, approved by the CAA, which was based on the FAA Boeing 737 MMEL[5]. For an inoperative engine generator, the MMEL specified that for dispatch the aircraft required one engine generator and the APU generator, which must operate normally and be used throughout the flight.

The following statements were made in the Operation Manual regarding the use of the MEL:

- *'It is the intention that the MEL may be used to permit operations with inoperative items for a period of time until rectifications can be accomplished. These rectifications should, however, be accomplished at the earliest opportunity.*
- *It is emphasised that the existence of MEL conditions and limitations in no way absolve the Commander from ensuring that an aircraft is safe for flight, and the decision of the Commander regarding acceptance of the aircraft is final.*
- *The aircraft may depart on the flight or series of flights for the purpose of returning directly to a base where the repairs or replacements can be made/* [sic] *the aircraft may continue the flight or series of flights but shall not depart an airport where repairs or replacements can be made. This statement is intended to allow the aircraft to be flown using the most direct route, to the nearest maintenance base where arrangements for repairs or replacements can be made.*
- *Once the aircraft lands at the maintenance base, the aircraft shall not be dispatched until the defect has been rectified.'*

Rectification Interval Extension

Where a deferred defect cannot be cleared within the MEL time limits, the operator's procedures allow a one-time Rectification Interval Extension (RIE). The Operation Manual sets out the procedures for authorising an RIE and states that it should only be used in *'exceptional circumstances.'* The RIE must be approved by one of the three managers specified in the Operation Manual and must only be approved when *'…it was not reasonably practical for the repairs to be made. "Reasonably practical" means the availability of spares, time and personal.'*

Footnote

[5] Boeing 737 Master Minimum Equipment List, Revision 60, Date 02/09/2018.

On 11 October 2018 an RIE was approved for the extension of MEL 24-1b on G-JMCR for Gen 1. The reason for the extension was given as:

> *'Extensive wiring checks and component replacements have been carried out to isolate the fault on generator 1 system which is tripping TRU 1 CB when selected. The fault finding so far has not managed to isolate the root cause, further trouble shooting required'*

The ADD had originally been approved when the aircraft was on scheduled maintenance at East Midlands between 5 to 8 October 2018. The aircraft then returned to the operator's main operating base at East Midlands on three further occasions before the RIE was approved when the aircraft was in Oslo. During this period, the aircraft landed at a number of other bases where troubleshooting and rectification was started but could not be completed before the aircraft was dispatched.

Aircraft examination

Following the event on 12 October 2018, an investigation into the cause of the electrical failures was carried out by the operator's maintenance staff at East Midlands who identified a fault in the left engine electrical generating system and the incorrect racking of GCU 2.

Left engine electrical generation system

The fault in the left engine electrical generation system was traced to an open phase on one of the three power feeder cables that run from Gen 1 to its generator circuit breaker. The cause of the open phase was a burnt pin on connecter C at the wing / pylon disconnect (Figure 4 and 5). The operator reported that there was no evidence of arcing between the pin and either the adjacent pins or the body of the connector; both the socket and pin appeared to be formed correctly at the crimp. Due to the extensive damage to the pin, it was not possible to establish the cause of the damage.

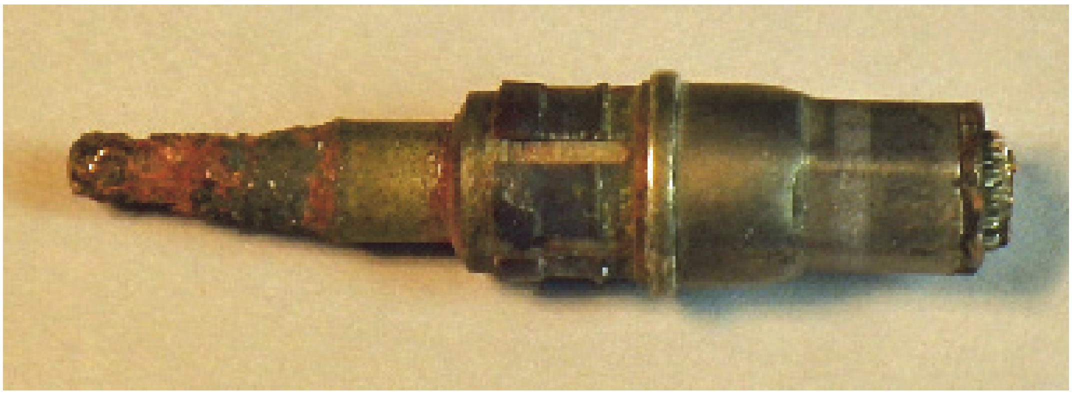

Figure 4

Burnt pin from connector C

Figure 5

Burnt pin receptacle at connector C

Comments by the aircraft manufacturer

The aircraft manufacturer advised that previous occurrences of burnt pins had usually been caused by the connector having not been correctly torqued, or because the wire spacer was missing, which created excessive load on the connector pins. When incorrectly torqued, vibration can cause the connector shell to move in relation to the receptacle connector shell. Relative motion between the connector shells would allow similar motion between the pin and socket contacts. This promotes wear and fretting corrosion that degrades the pin to socket contact interface, resulting in increased resistance and a rise in temperature. The aircraft manufacturer issued a Service Letter[6] to operators with suggested actions to ensure the best possible connection of these pins and connectors. This was a known problem.

Generator Control Unit 2

After the incident flight, GCU 2 was found to be protruding from the equipment shelf by approximately 3 cm. This would have been sufficient for the contacts at the rear of the electrical unit to disengaged with the contacts in the shelf (Figure 6). The handle lever, which was in the locked position, was found to be serviceable and the locking hook and fork intact. There was no visible damage to the electrical shelf, tray or its connectors. The electrical unit was re-racked and the right engine electrical generating system was tested and found to be serviceable.

Footnote

[6] Boeing Service Letter 737-SL-24-173-A, ATA:2400-60, 1 November 2004.

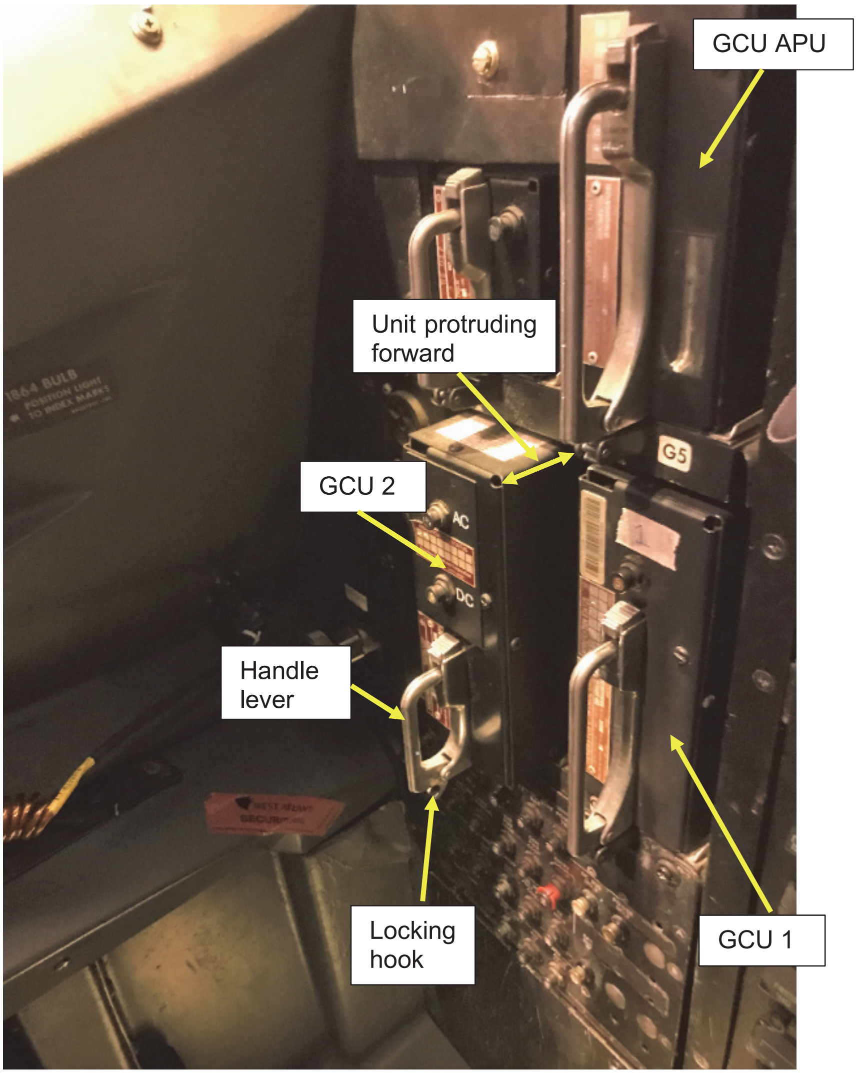

Figure 6

GCU 2 protruding forward

Comments by the aircraft manufacturer

The aircraft manufacturer advised that there had been no reports during the previous four years of electrical units having been incorrectly racked. There was also no model-wide or Boeing 737 fleet trend of units separating from the racks during flight.

Review of SRP, work sheets and Tech Log entries

As part of the investigation a time line was compiled from the entries in the company's SRP, FSR entries and the aircraft technical log. The time line revealed:

- On three occasions between 1 and 9 October 2018, GCU 2 had been transposed with either GCU 1 or the APU GCU without any documentation having been raised.

- There had been ongoing electrical problems during the 12 days prior to the incident flight when an electrical fault appeared to transfer from the APU generator system to the No 1 electrical system.
- A number of engineers during this period had recorded that the aircraft needed sufficient downtime to fully investigate the electrical faults.
- On 1 October 2018 the aircraft was allowed to operate in accordance with MEL 24-2a[7] as there was '*insufficient time'* to investigate multiple electrical failures on the ground when the APU generator was on-line.
- On 5 October 2018, an ADD in accordance with MEL 24-1b was raised for '*GEN 1 tripping TRU 1*', while the aircraft was at the operators main engineering base at East Midlands without the engineers having determined the cause of the fault.
- On 11 October 2018, an RIE was authorised to extend the ADD for Gen 1 without the engineers having identified the cause of the electrical failures.
- On six occasions during the 12 days preceding the incident flight it appears that fault finding was either stopped or not started as there was insufficient time during the turnaround to carry out the work.
- During these 12 days the aircraft frequently passed through locations where there were sufficient maintenance resources to identify the cause of the electrical faults and clear the ADD.

Recording maintenance

The requirement for the recording of maintenance carried out on aircraft is detailed in Regulation (EU) No 1321/2014[8]. Subpart C, AMC M.A 306(a) states:

> *'AMC M.A.306(a) Aircraft technical log system*
>
> *For CAT operations, commercial specialised operations and commercial ATO operations, the aircraft technical log is a system for recording defects and malfunctions during the aircraft operation and for recording details of all maintenance carried out on an aircraft between scheduled base maintenance visits.'*

Crew experience

Both flight crew members were experienced on the aircraft type and were familiar with operating with a single inoperative engine-driven generator in accordance with the MEL. The commander had recently joined the company from another operator and was on his first week of flying having completed the company-required flight training and operational checks.

Footnote

[7] MEL 24-2a allows the aircraft to operate with the APU generator system inoperative.

[8] COMMISSION REGULATION (EU) No 1321/2014 of 26 November 2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks.

Operational procedures

Available checklists

The Boeing 737-400 uses a Quick Reference Handbook (QRH) for abnormal and emergency situations, which includes a section on aircraft electrics. None of the checklists in the QRH matched the flight deck indications directly, with the closest match being the '*Loss of all Engine Driven Generators*'. The crew did not consider this checklist as they did not believe they had lost all engine generators. Using this checklist would have involved the crew reading through the first part without completing any actions as it did not apply to their situation as the APU was already running. Eventually it would have instructed them to connect the APU generator to AC Bus 2 to power the part of the electrical system that most needed the electrical power from the APU. However, it is unclear if this would have been effective, given the inability to connect the APU onto the No 1 AC Bus at Amsterdam, and with the fault having been caused by the disconnection of GCU 2. There was no other checklist that would have provided any assistance to the crew.

Additional abnormal and emergency procedures

The operator recognises that crews can be faced with complex and challenging problems when operating an aircraft. The use of a strategy to manage the resources available to the crew and to assist them in dealing with a problem is recommended in the company Operation Manual. The strategy recommended in the manual is the decision-making tool DODAR. This mnemonic is a circular tool in that the last action is to review the actions and decisions the crew have made, thereby encouraging them to continually reassess whether their course of action is still the most valid. The letters of DODAR correspond to:

D – Diagnose (what is the problem)
O – Options (hold, divert, immediate landing etc)
D – Decide (which option)
A – Act/Assign (carry out selected option and assign tasks)
R – Review (can involve the addition of new information, and/or the ongoing result(s) of selected options)

The Operations Manual provides more information on each step of the DODAR mnemonic. Before departing on the incident flight the crew discussed what actions they might take in the event of the loss of the working engine generator. However, during this event the crew did not carry out a DODAR or use any other tool to assess the situation.

Recent maintenance

In the twelve days leading up to this serious incident there had been a number of electrical power faults on the aircraft which had resulted in engineering activity taking place at several locations across Europe. Table 1 summarises the information recorded in the aircraft technical log.

Date	Location	Entry in Tech Log	Action taken
1/10/18	Belfast	TRU[9]1/2/3 failed on ground, multiple electrical failures.	Fault traced to APU generator. ADD and MEL raised.
2/10/18	Cologne	TRU 1 CB 'popped' during approach. Reset and failed again. Other electrical systems also failed.	Test found satis. Suspect due to electrical failure. Fault traced to suspect transfer Relay 1 (R3); relay replaced.
5/10/18	East Midlands	Clear ADD for APU electrical systems inop.	APU generator replaced. ADD and MEL cleared.
8/10/18		When Gen 1 online TRU 1 tripped.	Number 1 engine generator inop. ADD and MEL raised.
8/10/18	Aberdeen	Maintenance work to clear ADD. Number 1 generator trips TRU 1.	No 1 GCU transposed to APU position. Fault not cleared.
10/10/18	Aberdeen	Maintenance work to clear ADD. Number 1 generator trips TRU 1.	Number 1 generator replaced, fault did not clear. Open phase condition found on feeder cable, unable to isolate fault.
10/10/18	East Midlands	Normal exhaust fan power CB found tripped.	CB reset no further problems.
11/10/18	Oslo	Maintenance work to clear ADD Number 1 generator trips TRU 1.	ADD extended by a further 3 days.
11/10/18	Amsterdam	Generator 2 failed on landing with both bus off and transfer bus off lights flashing. All FO's instruments flashing and blanking.	Found FF (Feeder Fault) tripped. Reset carried out and engine tests carried out satis. Aircraft released for flight.
12/10/18	East Midlands	Serious incident occurred on flight between Amsterdam and East Midlands Airport.	

Table 1

Recent electrical faults and actions recorded in the aircraft technical log

---

Footnote

[9] TRU is a Transformer Rectifier Unit, which converts the AC power provided by the generators to 28V DC power.

Maintenance carried out at Amsterdam

At 0040 hrs, after landing at Amsterdam, the co-pilot contacted LMC at East Midlands while taxiing to the stand. From the LMC telephone recordings the co-pilot can be heard explaining that they had lost Gen 2 after landing. The APU generator was still running and connected, but various warning lights and instruments were “blinking”. At 0054 hrs, the commander then informed LMC that he was parked on the stand and confirmed that both engine generators had failed and the voltages and frequency on the gauges all indicated zero.

At 0120 hrs, LMC contacted an EASA Part 145 organisation at Amsterdam and spoke to the senior engineer on shift and requested assistance. LMC briefed the engineer that the crew had reported that they had lost both Gen 1 and Gen 2. There was already an ADD for Gen 1. The engineer was asked to see if they could “Get the number 2 back and reset the system so that they could get the aircraft back to East Midlands”. The Part 145 organisation responded to the call and recorded the work to be carried out in the billing invoice, which stated *‘Both GEN’S INOP’*. No other documentation between the two organisations was raised.

At 0124 hrs, LMC contacted the commander, informed him that engineers were on their way and asked for a full description of the electrical problems on the aircraft to record on their system (FSR). The commander gave a very detailed brief during which clarification as to what the crew had experienced was sought by LMC. LMC commented that there was a serious electrical problem on the aircraft and they had been unable to identify the root cause. He advised the commander to wait and see what the engineers at Amsterdam found.

A licensed engineer (B1) with a type rating for the Boeing 737-300/400 was tasked to attend the aircraft and as the shift was relatively quiet was accompanied by the senior engineer. On arriving at the aircraft, the engineer noted that the Ground Power Unit (GPU) was connected and the APU was not running. In this configuration the GPU should have powered both Gen Bus 1 and 2. However, the indications showed that only Gen Bus 1 was powered, which was not what the engineer expected to see. Following a brief from the commander, the engineer believed that Gen 2 disconnected from Gen Bus 2 in flight; however, this was not the case. He also noted from his conversation with the commander and from reading the technical log that there was an ADD for Gen 1. However, the technical log entry made by the commander, which said ‘*Gen 2 failed on landing, with both bus off & transfer bus off lights flashing, also all FO’s instruments flashing and blanking*’, confused the engineer who could not understand why both generator busses were OFF when the APU generator would still have been on-line. The engineer was not aware that the GEN 1 OFF Bus light on the Bus switching panel had been removed as part of the MEL and, therefore, could not have illuminated during the flight.

The engineer’s first action was to visually check the position of the ‘AC’ and ‘DC’ circuit breakers on the front of GCU 2. Both circuit breakers appeared to be fully in. He did not touch the GCU and was also not aware of it protruding forward out of the rack. He then checked the fault lights on Panel M238 and found that for Gen 2, the ‘FF’ lamp was illuminated; the lamps for ‘MT’, ‘HV’ and ‘LV’ were all extinguished.

Based on the briefing from the commander and the illuminated lamp 'FF', the engineer followed the trouble shooting chart for '*The feeder fault light on the annunciator panel comes on'*. As part of this action the engineer opened the cowling on the right engine and checked the drive on the CSDU (which had not disconnected) and the feeder cables from the generator to the Differential Protection Current Transfer, which visually appeared to be normal.

Once the cowling had been closed, the commander, at the request of the engineer, started the right engine using the APU generator to power Gen Bus 1. When selected, Gen 2 would not come on-line. The engineer then cleared the 'FF' code on Panel M238 by pressing the ERASE button on the panel. When selected, Gen 2 connected to Gen Bus 2. With Gen Bus 1 powered by the APU, Gen 2 was cycled several times and it connected to Gen Bus 2 every time.

At 0155 hrs, the commander contacted LMC and told them the problem had been fixed and then passed the telephone to the engineer. The engineer told LMC that there had been a "frequency fault" which had been cleared by resetting the circuit breaker. The engineer mentioned that from the technical log there seemed to have been a number of electrical problems on the aircraft and LMC responded that they were going to conduct a further investigation over the weekend. The engineer cleared the entry in the aircraft technical log and the commander accepted the aircraft for flight.

The senior and licensed engineers both said that it was not a particularly busy night and that there was no pressure on them to complete the work and return the aircraft to service. They did not have access to the operator's on-line portal which provided a technical history of the aircraft, but instead relied on the brief from the commander and the limited information in the technical log. The task in clearing the fault, from initial callout to clearing the entry in the technical log, took approximately 35 minutes.

The AAIB investigation could identify no evidence to show that the aircraft would have been grounded when it reached East Midlands for further investigation work on the electrical systems to be carried out. Instead, the same crew had been scheduled, after a short stop at East Midlands, to continue their flight in this aircraft to Aberdeen.

Safety Management System

Requirements

Both ICAO[10] and EASA[11] require operators to have a Safety Management System (SMS) in order to continuously manage the safety risks associated with their activities and responsibilities. The safety risk management system should describe the operating system and have policies and procedures to identify the hazards, and assess and control the risks.

Footnote

[10] ICAO Doc 9859 AN/474, Safety Management Manual (SMM).

[11] Commission Regulation (EU) No 965/2012. as subsequently amended.

Operator's process

The Operator's SMS is detailed in its Management System Manual that integrates the functions of safety and compliance monitoring and management. The following posts are responsible to the Accountable Manager for discharging their SMS responsibilities:

- The Flight Operations Manager is responsible for the overall safety of the Flight Operations.
- The Ground Operations Manager is responsible for the Management of Ground Operations on a day to day basis.
- The Continuing Airworthiness Manager is responsible to the Accountable Manager for Continuing Airworthiness activities.

Analysis

Cause of the electrical failures

The electrical failures that occurred during the landing at Amsterdam and on the subsequent flight to East Midlands were caused by GCU 2 moving forward in its rack far enough to cause the electrical connectors to disconnect. The flickering lights and screens indicate that initially there was a partial connection that was intermittent, but on landing at East Midlands the GCU appears to have moved forward sufficiently for the connector to fully disconnect. This would have resulted in the loss of: Gen 2; Gen Bus 2; Transfer Bus 2; 115V AC Electronic Bus 2; 28V DC Bus 2; and 28V DC Electronic Bus 2. Electrical System 1 would still have been powered by the APU generator through Gen Bus 1.

The Boeing 737-400 is not designed to operate with the GCU disconnected. While there was no record in the aircraft technical log or worksheets for the previous 12 days of GCU 2 having been disturbed, messages on the company's FSR stated that it had been disconnected on three occasions during this period as part of the fault finding to clear the ADD on the left engine generator.

Details of the effects of the GCU disconnection on the aircraft's electrical system are contained in Appendix 1 to this report.

Management structure

Since November 2017 the operator had experienced a number of significant changes. There had been an increase of approximately 30% in the number of aircraft and staff with the operator's main operating base and LMC moving from Coventry Airport to East Midlands Airport. The administration of the AOC and Part M responsibilities also moved from Coventry Airport, to a nearby business park. The operator's own audit recognised the need to change the management structure of LMC and improve the management of defects and the competency of the staff within the LMC. This serious incident occurred during this transition period.

Flight crew performance

At no stage during the event did the flight crew consult the QRH or attempt to analyse the fault. They did not use either the operator's suggested decision-making tool DODAR nor any other tool. Given the good weather conditions, the point in the flight when the failure occurred, and the availability of a long runway at East Midlands, the crew were able land the aircraft safely with few issues. Had the crew performed some kind of analysis and discussed options for a safe landing, it is likely that they would have decided that landing at East Midlands was still the safest option.

If the aircraft had been in cloud, with poor weather conditions on the ground, the crew would have faced a challenging recovery with little automation available and with the co-pilot unable to monitor the flight path of the aircraft. The use of a suitable decision-making tool, such as DODAR, would have aided the crew in analysing the problem and agreeing a suitable solution. It would also have prompted them to consider what systems may have been inoperative, and its effect on the approach and aircraft's landing performance. Although the time available to the crew was only around 15 minutes, this was long enough for such an analysis to be performed without delaying the approach and landing.

Use of the MEL and RIEs

The operator did not appear to use the MEL in the spirit of EASA's Acceptable Means of Compliance or its own procedures. Rather than using the MEL to allow the aircraft to return to its main operating base where the faults could be rectified, it appears to have been used to enable the aircraft to meet operational commitments. Fault finding, and rectification was frequently stopped before the root cause had been identified and on a number of occasions the aircraft was dispatched from a location where the work could have been carried out.

The burnt pins on the feeder cable was a known fault. On 10 October 2018, an engineer correctly identified that there was a FF on Gen 1 and inspected the connector between the engine and pylon but ran out of time to check the connector between the pylon and wing where the burnt pin was located.

The RIE for the defect on Gen 1 should only have been granted in exceptional circumstances. However, while resources were available to identify and fix the fault within the specified time, the RIE was approved to enable the operator to meet operational commitments.

There also seemed to be confusion with operations and engineering staff within the LMC and the Part M organisation as to what constituted a main operating base. It was commonly believed that a number of locations across their operating network that had Part 145 organisations could be considered as a main operating base and that it was acceptable for aircraft to be dispatched from East Midlands with an ADD operating in accordance with the limitations in the MEL. This was, however, contrary to the operator's Operation Manual.

The confusion as to what constituted a main operating base and the routine deviation from the operator's procedures on the use of the MEL and RIE might have partly been due to the operator's policy and procedures not being suitable for its routine operations. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2019-004

It is recommended that West Atlantic UK revises its policy and procedures for approving and clearing Minimum Equipment List entries and Rectification Interval Extensions to ensure that it conforms with the guidance contained within the European Union Aviation Safety Agency Acceptable Means of Compliance.

Management of defects

The operator recognised that the management of defects and rectification across their fleet was challenging due to the nature of their operations. The aircraft were rarely in the same place on consecutive days and there were frequently changes to the flying programme, which made the provision of spares, specialist engineers and equipment difficult. The operator's staff were also conscious of the tight turnaround times that their customers expected and whilst there was no evidence of external pressure having been applied to any individuals, there may have been an element of self pressure to ensure that aircraft were not delayed. Fault finding was frequently stopped part way through and on three separate occasions the GCU were swapped without the aircraft documentation having been completed in accordance with Commission Regulation (EU) No 1321/2014, (continuing airworthiness). The following Safety Recommendation is made:

Safety Recommendation 2019-005

It is recommended that West Atlantic UK ensures that all work undertaken on its aircraft is documented in accordance with the requirements of Regulation (EU) No 1321/2014 (regarding continuing airworthiness).

The management of defects was primarily carried out by staff in the LMC. These individuals may be required to manage a number of issues on separate aircraft during their shift. Their main aim is to ensure that the company meets its operational commitments during their period of duty. The main oversight was undertaken during the 0600 hrs morning conference which involved representatives from LMC and the Part M organisation using the updates provided on the operator's messaging system. Despite numerous entries on FSR highlighting concerns with the electrical system on G-JMCR, and the difficulty in completing the fault finding during the tight turnaround times, there was no evidence of a plan to ensure that the aircraft was given sufficient downtime to rectify the faults and clear the ADD. Instead, the issue drifted on with an RIE approval and a number of engineers at different locations repeating similar fault-finding tasks until eventually the GCU was incorrectly secured and disconnected in flight.

The operator has addressed the situation by establishing the post of Defect Controller who reports through the Part M organisation. However, this individual is not available outside normal office hours or during periods of holiday or sickness. Moreover, the morning conference calls only take place during the normal working week which means that frequently only the operations supervisor and the LMC staff are in a position to undertake a dynamic risk assessment of the ongoing airworthiness of individual aircraft. While these individuals have the authority to prevent an aircraft flying if they believe it is unsafe to do so, it might not be apparent to them that this dynamic oversight is a key part of their job. The following Safety Recommendation is made:

Safety Recommendation 2019-006

It is recommended that West Atlantic UK revises its policy and procedures to ensure effective management of defects, and the undertaking of dynamic risk assessments of the airworthiness of aircraft during all hours of operation.

Communicating with other Part 145 organisations

The electrical fault that occurred during the landing at Amsterdam was unusual. Lights and screens that can only be on or off were flashing which indicated that there was an intermittent fault within the No 2 electrical system that eventually caused the circuit breaker for GCU 2 to trip. The Part 145 engineers did not have access to the operators FSR and would not have known the history of the electrical problems on the aircraft, which LMC described to the commander as serious. While the commander gave a detailed explanation to LMC as to the problems he had experienced, this was not relayed to the engineer who was tasked with rectifying the problem with Gen 2 and resetting the system so that the aircraft could return to East Midlands. No written tasking document, recent history of the aircraft or the concerns from LMC that there was a serious electrical problem on the aircraft were provided to the engineer. The engineer reset the system as requested and reported back to LMC who did not ask him to undertake any further work. The total time from the engineer being tasked to travelling to the aircraft and completing the work was 35 minutes.

In completing the trouble shooting as laid out in the Maintenance Manual, the engineer had satisfactorily completed the task he was given, which was to investigate why the two serviceable generators were inoperative. But the circuit breaker that was found to have tripped could not have caused the intermittent electrical supply to the flight deck instruments. Significantly, no one appeared to address the potential increase in risk to the safe operation of the aircraft should the fault reoccur in flight while operating with one generator already inoperative in accordance with MEL 21-1b.

The commander initially felt uneasy at the fault being cleared but was reassured when the engineer discussed what he had done with LMC: the engineer felt that his conversation with LMC was more to do with when the aircraft could be returned to service. In turn, the LMC was reassured by the commander, who was new to the company, and the engineer that the aircraft was now serviceable. However, the engineer in Amsterdam did not have knowledge of the ongoing electrical problems on the aircraft and none of the three parties discussed the impact of the fault on Gen Bus 2 reoccurring during the next flight. In summary, none of the three individuals involved had the full picture on the condition of the aircraft and a risk assessment was not carried out to determine if the aircraft was in a safe condition to continue flying with one generator inoperative. The following Safety Recommendation is made:

Safety Recommendation 2019-007

It is recommended that West Atlantic UK revises its policy and procedures for the tasking of maintenance activities by Line Maintenance Control and the sharing of relevant aircraft technical history to ensure that maintenance organisations undertaking work have access to all appropriate information.

Safety management system

This investigation identified safety issues across a number of areas that had not been identified or addressed by the Operator's SMS. Therefore, the following Safety Recommendations are made:

Safety Recommendation 2019-008

It is recommended that West Atlantic UK revises its Safety Management System to meet the requirements of the scale and nature of their operation.

Safety Recommendation 2019-009

It is recommended that the Civil Aviation Authority assess West Atlantic UK's Safety Management System to ensure it meets the requirements of the scale and nature of their operation.

Conclusion

This serious incident was caused by the incorrect racking of GCU 2 which moved forward in flight initially causing an intermittent and then total disconnection of the electrical connector. The aircraft was not designed to operate with the GCU disconnected and the crew were presented with an unusual situation that was not covered in the QRH.

The activities surrounding the management of the faults on G-JMCR during the previous 12 days, and the actions of the crew in handling the emergency, indicates a weakness in the operator's policies and procedures for the management of risk. Engineers were not always given sufficient time to investigate the faults, with the result that fault finding was often repeated and not finished. Work at a number of locations was not recorded as having been carried out in the aircraft documentation. The aircraft was dispatched from its main operation base with an ADD and flew through a number of locations where it could have been cleared, which was contrary to the procedures in the Operation Manual.

Communication between LMC, the commander and the Part 145 organisation at Amsterdam was ineffective in highlighting the underling technical problems on the aircraft. The engineer was unaware of the full history of the faults and the concerns that LMC conveyed to the commander that there was a "serious electrical fault on the aircraft". The engineer was tasked with resetting the generators and spent less than 30 minutes at the aircraft. Despite the ongoing concerns with the electrical systems previously raised by a number of engineers and crews, and the unusual set of failures that occurred during the landing at Amsterdam, LMC did not carry out any form of risk assessment or ensure a deeper investigation was carried out before the aircraft departed Amsterdam. While the commander had the ultimate decision on accepting the aircraft, he was new to the company and may have relied on the advice of the engineers without being aware that the engineer had only been tasked with resetting the generators.

The operator had previously identified that there was a need to restructure LMC, introduce the post of Defect Controller and provide staff with further training to improve their competency.

Safety actions proposed by the operator

As a result of this serious incident, and the findings of the AAIB, the operator has stated that they will take the following safety actions:

- Redefine the criteria of a maintenance base with each aircraft allocated to a specific maintenance base dependent on the route flown.
- All ADDs will be monitored daily and best endeavours made to rectify them within 48 hours. Where this time limit is not achieved an occurrence report will be raised to enable an investigation to be carried out to establish why this was not possible.
- A Safety Report will be raised via the SMS for all RIE applications.
- Monitor in real-time the management of ADD and RIE applications using a number of Performance Indicators over a 12-month rolling period.
- LMC will be informed of all intended deferred defects before actual deferral.
- Prior to deferral of a defect, a risk assessment based on the source of the fault and subsequent impact on the aircraft systems and operational limitations will be carried out by an engineer in consultation with the crew. LMC will provide historical defect information relevant to the unserviceable system in question and knowledge of the aircraft’s historical airworthiness generally.
- An additional status header of ‘Risk Assessment’ has been added to the FSR. A summary of the risk assessment will be documented in the FSR against the deferred defect highlighting significant risks that are associated with the aircraft’s airworthiness status.
- A review of persons authorised to ground a serviceable aircraft without reason and with good reason following a risk assessment has been carried out.

- Procedural deficiencies were identified in the following processes. A compliance review of these areas had been planned for completion by 31 July 2019 with corrective and preventative actions identified implemented by 30 Sept 2019.

    - Risk management of deferred defects.
    - Rectification management of deferred defects.
    - Interface between LMC and remote Part 145 organisations.
    - Standardisation of policy across all departments concerning deferred defect control.

Safety Recommendations

The following Safety Recommendations are made in this report:

Safety Recommendation 2019-004. It is recommended that West Atlantic UK revises its policy and procedures for approving and clearing Minimum Equipment List entries and Rectification Interval Extensions to ensure that it conforms with the guidance contained within the European Union Aviation Safety Agency Acceptable Means of Compliance.

Safety Recommendation 2019-005. It is recommended that West Atlantic UK ensures that all work undertaken on its aircraft is documented in accordance with the requirements of Regulation (EU) No 1321/2014 (regarding continuing airworthiness).

Safety Recommendation 2019-006. It is recommended that West Atlantic UK revises its policy and procedures to ensure effective management of defects, and the undertaking of dynamic risk assessments of the airworthiness of aircraft during all hours of operation.

Safety Recommendation 2019-007. It is recommended that West Atlantic UK revises its policy and procedures for the tasking of maintenance activities by Line Maintenance Control and the sharing of relevant aircraft technical history to ensure that maintenance organisations undertaking work have access to all appropriate information.

Safety Recommendation 2019-008. It is recommended that West Atlantic UK revises its Safety Management System to meet the requirements of the scale and nature of their operation.

Safety Recommendation 2019-009. It is recommended that the Civil Aviation Authority assess West Atlantic UK's Safety Management System to ensure it meets the requirements of the scale and nature of their operation.

APPENDIX 1

Transfer of electrical power

With GCU 2 correctly racked

Each generator Bus provides power to a Transfer Bus through the NORMAL position of the Transfer Relays (R3 /R4). If one generator losses power, and provided the Bus Transfer switch is at AUTO, the remaining generator will automatically power the other generator's Transfer Bus. During the accident flight, Gen Bus 1 was powered by the APU and Gen Bus 2 by the generator on the right (2) engine. This situation is shown at Figure 7.

The loss of power from Gen 2 would normally result in circuit breaker (CB2) opening causing the coil in the Transfer Control Relay R350 to deenergise. This would provide a path for the 28V DC power from the DC Bus through GCU 2 to energise the Alternative coil in Transfer Relay 2. At the same time the Normal coil in Transfer Relay 2 would deenergised and the Bus Off light on the overhead panel would illuminate.

With GCU 2 disconnected

The situation where the electrical connectors at the back of the GCU 2 electrical unit become disconnect in flight is shown at Figure 8. Circuit Breaker 2 (CB2) would have tripped and the loss of control from GCU 2 would have caused generator 2 to stop producing power. The electrical path between the 28V DC supply to Transfer Control Relay (R350) would be broken and the relay would deenergise. The path from Transfer Control Relay (R350) to both the Normal and Alternative coil in Transfer Relay 2 (R4) would also be broken and both relays would deenergise. With no electrical power at Relay 350, the Transfer Bus 2 light in the cockpit would illuminate. Once CB2 had tripped, reconnection of the electrical connecter to GCU 2 would have energised the Alternative coil in Transfer Relay 2 (R4) enabling Transfer Bus 2 to be powered by Gen Bus 1.

Published 5 September 2019.

BULLETIN CORRECTION

In the last paragraph of the Synopsis of this report it was stated that six Safety Recommendations are made to the operator regarding its safety management system and one to the Civil Aviation Authority.

This is incorrect it should have read **five** Safety Recommendations are made to the operator regarding its safety management system and one to the Civil Aviation Authority.

The online version of the report was amended on 10 October 2019.

Appendix 1 cont

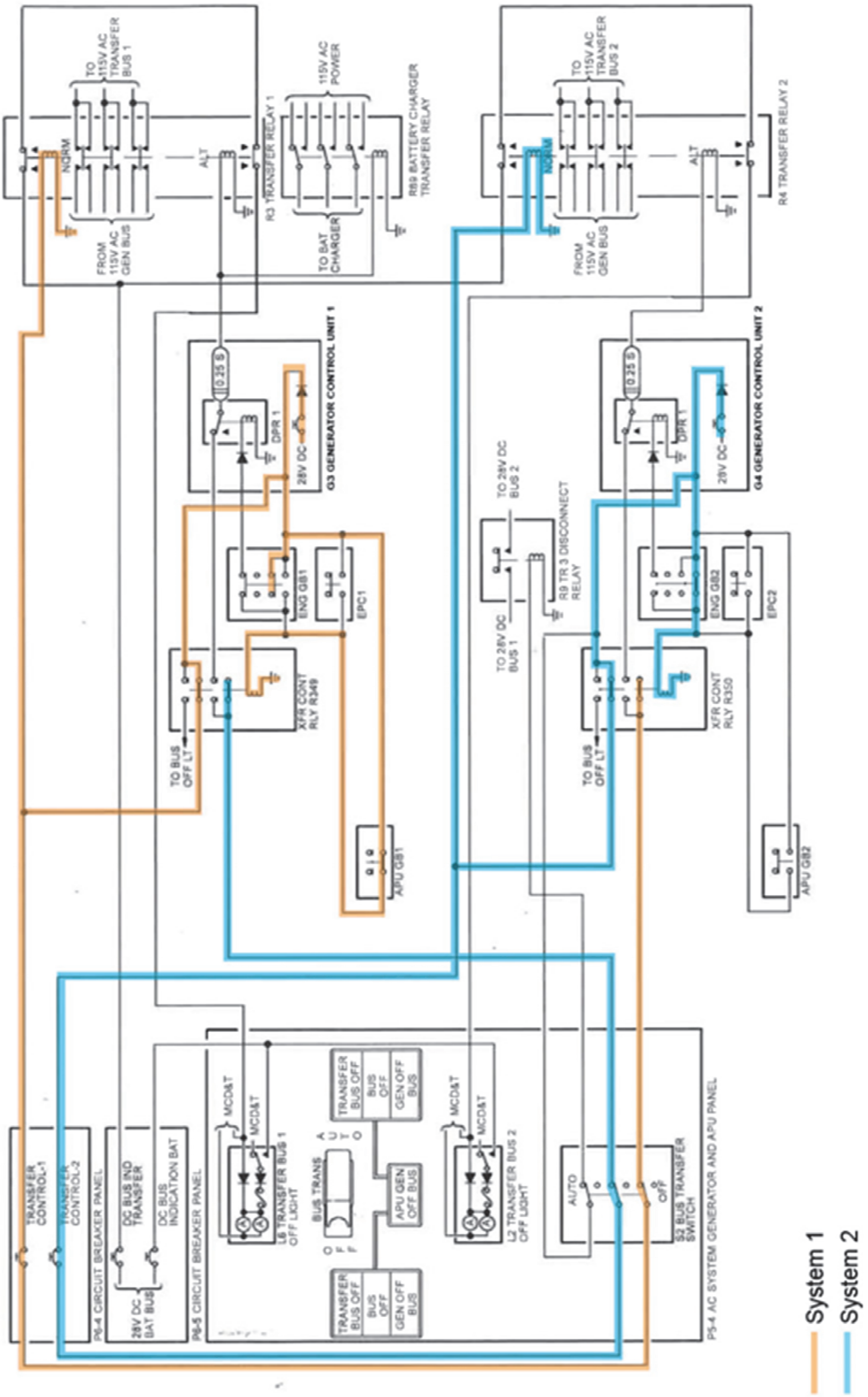

Figure 7

Routing for electrical power at start of flight

Appendix 1 cont

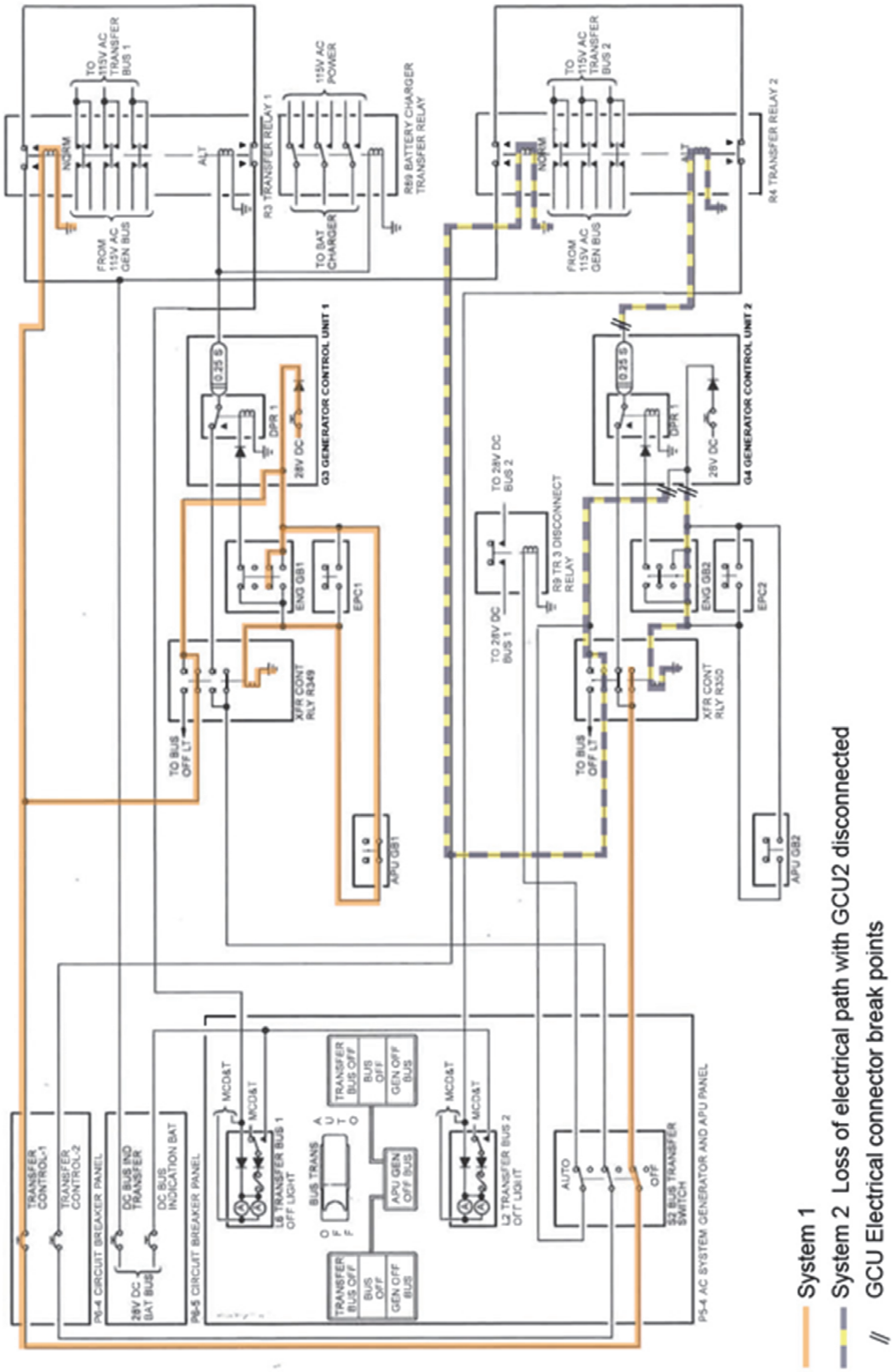

Figure 8

Routing for electrical pwer after disconnection of GCU2

ACCIDENT

Aircraft Type and Registration:	Guimbal Cabri G2, G-PERH	
No & Type of Engines:	1 Lycoming O-360-J2A piston engine	
Year of Manufacture:	2016 (Serial no: 1164)	
Date & Time (UTC):	8 June 2018 at 1433 hrs	
Location:	Goodwood Aerodrome, Sussex	
Type of Flight:	Training	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - 2 (Serious)	Passengers - N/A
Nature of Damage:	Damaged beyond economic repair	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	59 years	
Commander's Flying Experience:	8,920[1] hours (of which 69 were on type) Last 90 days - 30 hours Last 28 days - 7 hours	
Information Source:	AAIB Field Investigation	

Synopsis

While conducting a Simulated Engine Failure from the Hover (SEFH) the helicopter yawed rapidly to the left. Despite the actions of the pilots the helicopter continued to yaw rapidly, and control was not recovered. The helicopter was seen to climb while spinning before descending rapidly and contacting the ground, sustaining severe damage. Both occupants suffered serious injuries.

The manufacturer has subsequently issued service letter SL 19-001, *Throttle management during simulated engine failure*, and SL 19-002, *Controllability in yaw at low rotor speed*.

History of the flight

On the day of the accident the commander and a student pilot were conducting a PPL(H) skills test; they were in the helicopter's left and right seats respectively.

The helicopter departed Goodwood Aerodrome at about 1300 hrs for a navigation exercise and then returned to the aerodrome to complete the remaining exercises, which included an SEFH. The SEFH was completed to a satisfactory standard, but

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Footnote

[1] The commander's total flying hours are a combination of fixed and rotary wing hours, with 4,420 rotary wing hours.

the commander noted that the helicopter yawed slightly to the right[2]. At the time the weather was fine with the wind from about 050° at 5 kt.

Once all the required exercises had been completed the commander asked the student whether there was anything else he would like to do. He asked if he could attempt another SEFH, as he felt he was able to fly the manoeuvre to a better standard; the commander agreed.

The student commented that during the subsequent SEFH, he recognised the helicopter starting to yaw to the right and applied left pedal to counteract this, after which the aircraft began to descend gently. His intention was to raise the collective to cushion the landing at about 1.5 ft agl. However, the helicopter started to rapidly yaw left. He applied full right pedal before handing control to the commander, who was already on the controls with full right pedal applied. The commander believes she moved the cyclic forward slightly to try to keep the helicopter level, but she could not remember what collective inputs she may have made. Witnesses in the control tower saw the helicopter spin and climb to about 40 ft agl, before descending and contacting the ground.

Once the helicopter had come to rest the commander secured it. The airfield's emergency response vehicles quickly arrived on the scene. They were followed shortly thereafter by local authority ambulances. Both pilots were seriously injured and, after being extracted from the helicopter, were taken to hospital by road.

Pilots' comments

Student pilot

The student pilot stated that the first SEFH landing felt “a bit firm” to him and he felt he could do better, so he took the opportunity to repeat the manoeuvre.

On the accident SEFH, after the helicopter start to yaw rapidly to the left, he also felt it climb. He felt that the application of the right pedal did cause the rate of left yaw to slow down. He tried to keep the helicopter steady with the cyclic but did not recall handing control to the commander. He reported that the forces involved were so violent that he was forced sideways to his right.

He added that he is “reactive” to the yaw during engine-off exercises and waits for the yaw to commence before applying the appropriate pedal to counteract it.

Footnote

[2] The Cabri G2's main rotor blades rotate in a clockwise direction when viewed from above. The torque effect is a tendency of the main rotor to yaw the fuselage in the opposite direction from the rotor. The tail rotor provides thrust to counteract this. After an engine failure the torque effect is reduced, resulting in a tendency for the helicopter to yaw in the direction of the main rotor blades, to the right in a Cabri G2. Hence some left pedal is required after the failure.

Commander

The commander stated that for a SEFH, once the student had established the helicopter in a stable hover, at approximately 7 feet agl, she announces "engine failure in 3, 2, 1, GO". On "GO" she closes the throttle ensuring it goes through the detent[3].

The commander stated the student had been a bit slow in applying the left pedal on the first SEFH. She believes that on the accident SEFH, she had not fully closed the throttle before the helicopter started to yaw to the left and thinks the student may have anticipated the left pedal and applied it before she said "GO" and the throttle was closed.

Instructor's comments

The student's instructor, who had flown the six instructional flights with him prior to the accident, commented that the student was very conscientious and always well prepared. He added that he could, at times, "over-analyse" some of his performances and be excessively critical on himself despite the skills demonstrated being generally of an acceptable standard.

Helicopter's Flight Manual

Section 4 of the Cabri G2's Flight Manual, *Normal Procedures,* states:

> '***Training***
>
> *…*
>
> ***Power failure in hover in ground effect practice***
>
> 1. *Roll-off throttle frankly[4] until on its stop,*
> 2. *Counteract yaw motion by applying left pedal,*
> 3. *Increase collective as ground approaches, to smooth landing,*
> 4. *Push collective down once landed.*
>
> ***Note 1****: If the helicopter is light, it may bounce after a first touchdown.*
>
> ***Note 2****: The Cabri G2 has no natural tendency to depart in roll or pitch after failure. No systematic corrective cyclic action is needed.*
> *A slight forward motion at impact is recommended for better control.*
>
> ***Note 3****: For a forgiving practice, respect a maximum of 5 feet height.*
>
> *…*'

Footnote

[3] See *Helicopter information* for a description of the Cabri G2's throttle.

[4] The manufacturer commented that 'frankly' means that the throttle should be closed in one motion and without hesitation.

Accident site

The accident site occurred in the Helicopter Training Area at Goodwood Aerodrome. The helicopter came to rest upright with the right side of the fuselage in contact with the ground and pointing in a north-east direction. The landing gear had penetrated the fuselage on the left side and the right passenger door had broken and become detached. The fenestron tail rotor had detached from the tail boom and there was evidence that two of the main rotor blades had struck the ground (Figure 1). Both landing skids had dug into the ground with no evidence of movement after contact.

Figure 1

G-PERH at the accident site

Helicopter 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 landing gear is composed of two tubular bows with skids. It is attached to the fuselage by soft elastomeric mounts, to avoid potential ground resonance problems. The landing gear is designed to withstand vertical landing loads combined with smaller longitudinal and lateral loads.

Seats

The seats have been designed to reduce the forces on the passengers in the event of an impact and are capable of absorbing loads up to 19 g forward and up to 30 g vertical, which corresponds to a free fall rate of about 10 m/sec (2,000 ft/min). The seats comprise a composite shell with minimal cushioning added for comfort. The seat shell is attached to the bulkhead by two seat rails, which allow it to move vertically and is restrained by an energy absorbing strut (Figure 2).

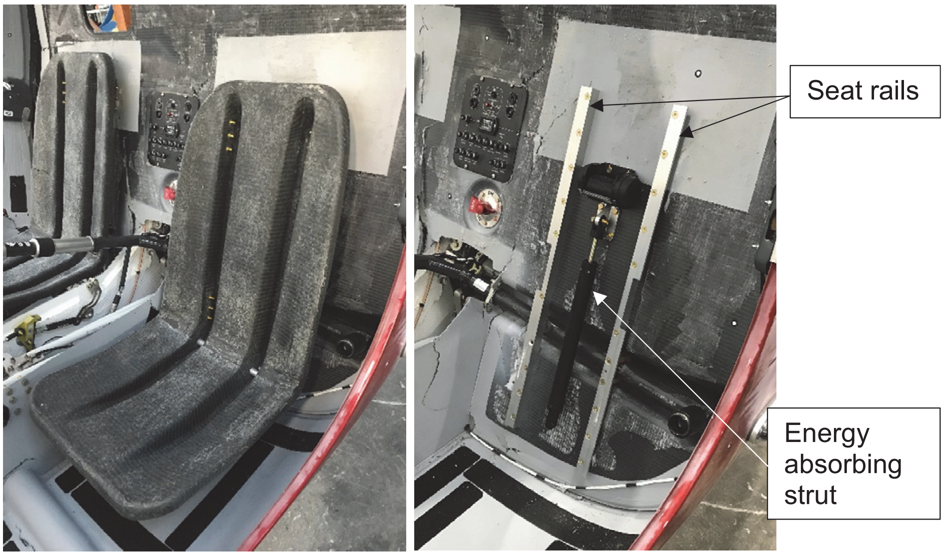


Figure 2

Left seat composite shell and seat rails with energy absorbing strut

Engine and controllers

The helicopter is powered by a four-cylinder, air-cooled Lycoming O-360-J2A engine. It is installed aft of the main gearbox, with its crankshaft facing forward and is supported on elastomeric vibration mounts.

To reduce pilot workload the helicopter is equipped with an electronic engine governor to maintain the engine at the nominal speed regardless of power demand. The governor regulates the engine speed to 2,650 rpm using data from an engine speed pickup, rotor speed pickup and the throttle position. If the engine speed is commanded to below 2,000 rpm (such as for shutdown) the engine governor disengages but will re-engage and accelerate the engine to the nominal running speed once the speed is above 2,000 rpm.

The engine throttle control is on the collective lever and is operated by a conventional twist-grip (Figure 3). The twist grip rotates a shaft which, through a system of cams and levers, operates the engine throttle cable. At the extreme clockwise rotation of the twist grip, a detent gives the pilot a physical indication that the throttle has fully closed. A motor, controlled by the governor, is connected to the twist grip shaft and there is a friction coupling which allows the pilot to overcome the governor if required. A switch on the end of the collective activates or deactivates the engine governor.

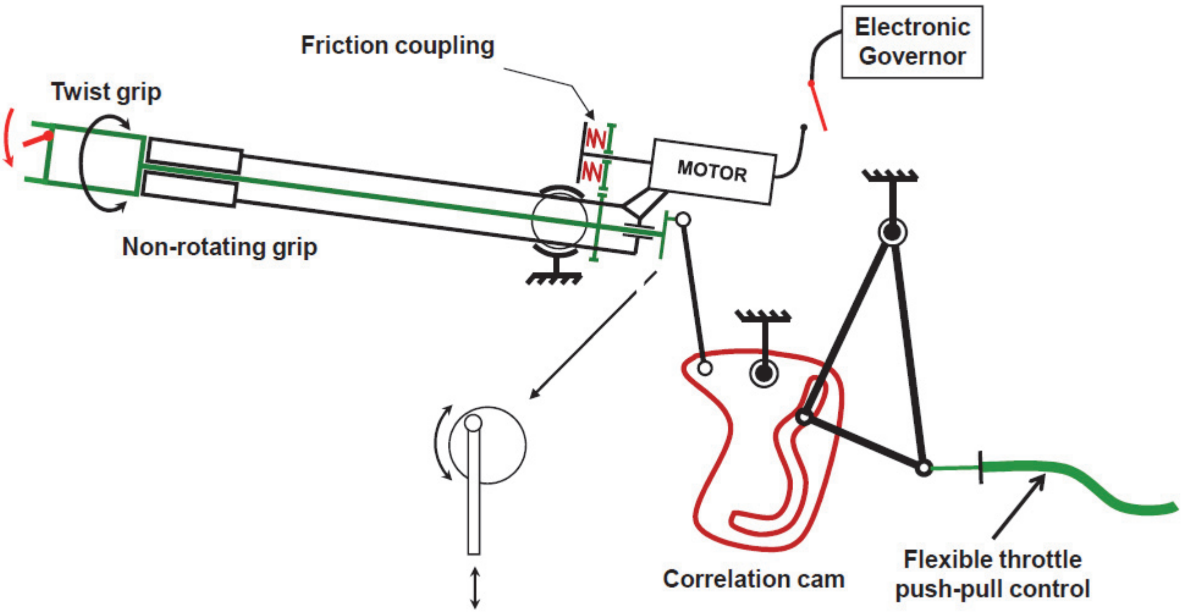


Figure 3

Engine throttle control system

Correlation cam

The output of the throttle shaft from the collective lever is connected by a linkage to a correlation cam so that when the collective is raised the throttle will increase the engine power. The cam profile is designed to aid the function of the engine governor and to minimise the pilot work should the governor fail. When the collective lever is raised with the throttle twist grip fully closed, the cam profile is designed to have no effect on the engine throttle.

Tail rotor effectiveness

The manufacturer commented that the main rotor can produce lift in a hover at rotor speeds well below its authorised speed range of 515 to 540 rpm and even below 450 rpm[5]. However, in such a situation, the Fenestron thrust will not be sufficient to maintain effective yaw control and even with full right pedal, the helicopter will start spinning uncontrollably to the left. In addition, if such a loss of control in yaw occurs, raising the collective will lower the rotor speed even more and will aggravate the situation by increasing the spin rate to the left.

Footnote

[5] 450 rpm is the minimum authorised rotor speed in autorotation.

Helicopter examination

Airframe

The airframe was subjected to a visual examination at the AAIB facilities to assess the damage sustained during the impact. The monocoque structure was largely intact with evidence of crushing on the aft right underside. All access panels were in place except for the luggage door and right passenger door, which was broken in two pieces. There was evidence on the underside of penetration from the landing gear bows at both mounting locations. The front landing gear bow had caused minor damage to the central console in the cabin and the aft bow had penetrated the luggage bay and the fuel tank volume. The flexible fuel tank liner had deformed around the bow without perforation and no fuel had leaked. The Fenestron had detached from the tail boom and there was impact damage to the tips of two main rotor blades.

Following the visual examination, the helicopter was digitised using a '3D' structured light scanning system to quantify the structural deformation. All exterior surfaces were scanned, as well as the landing skids, engine bay and cabin interior. The results of the scan were then compared with the original design data obtained from the helicopter manufacturer (Figure 4).

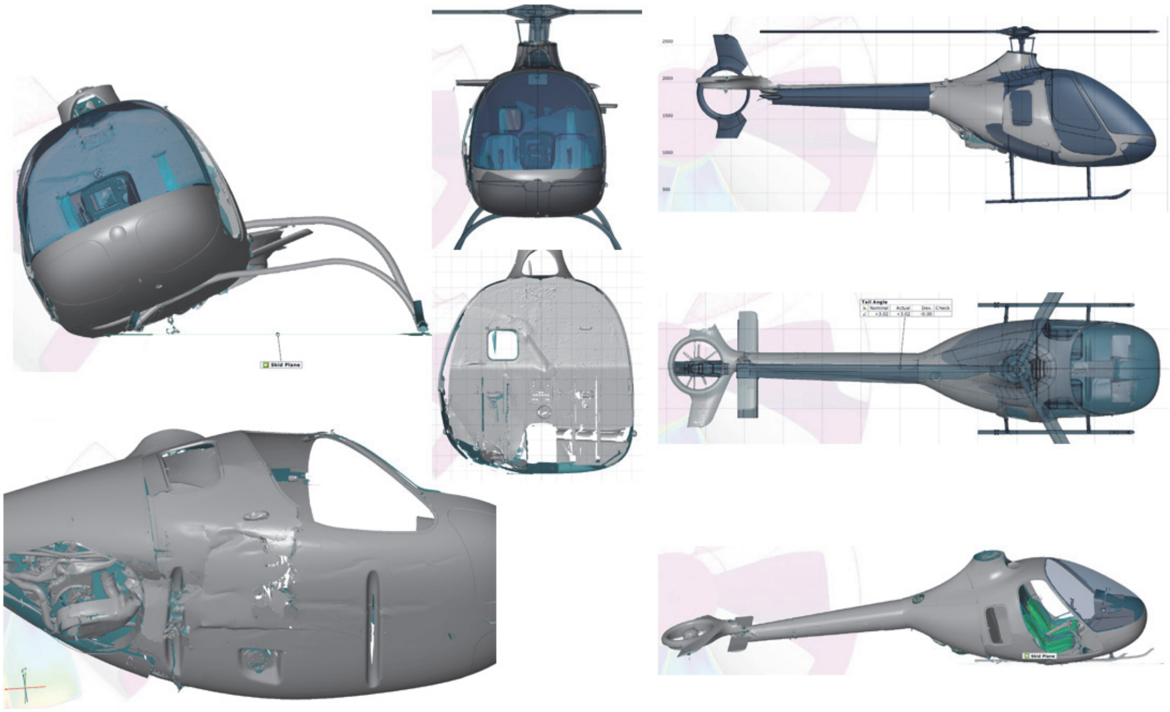


Figure 4

Digital analysis of G-PERH

The results of the scanning showed that the tail boom of the helicopter was misaligned by approximately 3° to the left of nominal and bent slightly upwards. The cabin bulkhead showed evidence of multiple damage locations of crushing, cracking and delamination.

Seats and attachments

The position of the seats was recorded with the cushions removed to enable accurate measurements to be taken from the composite shell (Table 1). Once the seat shells were removed, the length of the energy absorbing struts was measured:

Strut	Nominal Length	Measured Length	Extension
Left	302 +/- 0.5 mm	351.6 mm	49.6 mm
Right		304.5 mm	2.5 mm

Table 1

Seat position and energy absorbing strut extension

The right seat shell was examined, and several damage locations were identified. The left seat was undamaged.

The lower end of the right seat, outboard track was bent inwards and forwards by approximately 20° and the lower end of the inboard track showed minor deformation. The bend was located at the lower attachment to the seat and a witness mark was evident on the seat shell from the track. The deformation of the right seat tracks was coincident with the crushing deformation of the lower section of the monocoque and cabin bulkhead.

Landing gear

The landing gear assembly was intact and removed from the helicopter at the accident site. There was evidence of bending of the tubes and local buckling at the joints. It was noted that the landing skids fitted to the accident helicopter were of a later modification standard which was introduced to prevent the bow tubes from failing, which had occurred in previous accidents. The geometry of the landing gear assembly was measured using the 3D structured light system and it was found that the right skid was straight, in accordance with the design, whereas the left skid was curved. The aft end of the left skid was bent upwards by approximately 5 mm and was forward of the right skid by more than 350 mm. The profile of the two bows between the skids showed evidence of the right skid being bent outwards whereas the left side showed no such deformation.

Engine bay

The engine bay was covered by three composite access panels and the Lycoming engine was supported by a steel tubular frame attached to the monocoque. The frame also supported some ancillary equipment and the Fenestron drive shaft. Visual examination and digital analysis of the frame identified several members were bent and the right lower monocoque attachment point was deformed in the impact. The friction lining of the Fenestron drive braking system was damaged due to misalignment of the drive shaft and it was noted that the main drive belt was not correctly aligned on the upper pulley.

Survivability

There are four requirements to survive a crash:

1. Maintain a liveable volume for the occupant throughout the crash sequence.
2. Restrain the occupant.
3. Keep the crash loads experienced by each occupant within human tolerance.
4. Provide time to escape. Primarily, this is time to escape a post-crash fire.

The manufacturer actively markets the safety features of the Cabri G2 helicopter and its compliance to survivability requirements of EASA CS-27 and FAA FAR-27. The carbon fibre monocoque provides a rigid structure for the protection of the occupants. In this accident the liveable cabin volume was not compromised, and the seat belts restrained the occupants. However, lateral movement of the right seat occupant during the impact sequence most probably resulted in the right passenger door being broken. It is not thought any injuries were sustained from this.

The lack of post-crash fire meant that there was no immediate urgency to evacuate the helicopter and the first responders were able to remove the occupants in a timely manner, limiting the potential for further injury.

The energy absorbing struts in the seat system are designed to reduce the loads on the occupants in the event of a vertical impact. The manufacturer states that in certification testing the '*occupants would survive a 2000 ft/min impact, equivalent to a 5 m free fall'.* In this accident the left seat strut extended to 116% whereas the right seat strut extended to 101%. However, the injuries sustained by both occupants were similar and so it is judged that the impact energy was absorbed by a different mechanism for the right seat occupant.

Analysis

Loss of control

The first simulated SEFH was completed to a satisfactory standard, but the helicopter yawed slightly right and, in the student's opinion, landed firmly. Given that the student tended to over-analyse some of his performances, could be highly self-critical and generally strived for excellence, it is likely he would aim for a gentler landing in any subsequent SEFH.

Despite the student stating that he was reactive to the yaw in simulated engine failure exercises, it is probable that in this instance he anticipated it by applying left pedal and then started to raise the collective to cushion the landing before the throttle was closed. The forces experienced as the helicopter was yawing rapidly may also have caused him to unintentionally raise the collective. Lifting the collective before the throttle was fully closed would have resulted in the correlator cam increasing the engine speed until, at 2,000 rpm, the engine governor would have re-engaged. These actions would have caused an increase in engine speed resulting in the high rate of yaw and climb, which the student felt. Had the throttle been fully closed the correlator cam profile would have had no effect on the engine speed when the collective was raised.

The application of right pedal not stopping the yaw to the left indicates that the rotor speed had reduced, thus making the Fenestron less effective.

Impact Sequence

Immediately prior to ground impact, the helicopter was rotating with a high rate of left yaw, in a slightly nose-up attitude and rolled to the left. The first impact point was the aft end of the left landing skid and this deformed upwards. The aft bow penetrated the fuel tank volume, but the fuel quantity was such that the liner was able to deform without rupturing. It is likely that at this moment the left seat moved downward on the seat rails, absorbing the vertical energy for the occupant.

As the impact sequence progressed the helicopter pitched forward, and the left skid deformed further as it dug into the soft ground. Due to the yawing motion, the helicopter rolled to the right until the right skid contacted the ground and dug into the ground, deforming the right side of the bow. The helicopter fuselage still had inertia in yaw and consequently it slid around the profile of the landing gear bows until the right aft fuselage contacted the ground. As a result of this lateral motion, the lower part of the Fenestron struck the ground and applied a torsional load at the junction to the tail boom, resulting in failure of the composite structure. The fuselage was now inclined to the right and two of the main rotor blades hit the ground, the impact of the second causing the engine to stop.

As the aft right side of the fuselage contacted the ground, the remaining vertical energy was absorbed by the composite structure crushing and delaminating. This was clearly seen at the lower cabin bulkhead position and caused the right seat rails to deform. From the direction of the deformation it was possible to deduce that the loads were predominantly lateral. This was also demonstrated by the right seat occupants contact with the right door and the damage to the outside of the seat shell.

Survivability

The seats fitted to the Cabri G2 are designed to absorb only vertical energy and, along with seat belts, restrain the occupants in the longitudinal direction. From analysis of the impact sequence it has been shown that the left seat occupant was subjected to vertical loads during the initial impact and the seat stroke was enough to survive the impact. As the accident progressed, due to the high rate of yaw, the loads became lateral in direction and so the energy absorbing seat became less influential for survivability. Further, the deformation of the seat rails did not impede the motion of the right seat as the loading was predominantly lateral. The remaining energy was absorbed by the distortion of the composite structure which kept the loads experienced by the right seat occupant below survivable limits.

Conclusion

The accident was probably initiated by premature application of the left yaw pedal and raising the collective lever, before the throttle was fully closed during a simulated engine failure exercise. This was probably because the student anticipated the right yaw before the commander had said “GO” and the throttle was fully closed.

In this accident, the helicopter maintained a liveable volume for the occupants throughout the accident sequence and the first responders were able to extricate the occupants in a timely manner without risking further injury. The flexible fuel tank liner had not been compromised and there was no post-crash fire. The occupant retention system did not prevent the right seat occupant from contacting and breaking the access door, however he was retained within the cabin. A combination of the energy absorbing seat system and the destruction of the composite fuselage absorbed the vertical and lateral impact energy such that both occupants survived the crash with injuries which were serious but not life-threatening.

Safety actions

As a result of this, and other similar events, the manufacturer published in February 2019 two Service Letters to prevent reoccurrence. They are available on its customer support portal.

SL 19-001 - Throttle management during simulated engine failure.

This service letter provides an explanation of the engine governor / correlator system and the need to ensure the twist grip throttle is fully closed whilst practicing certain manoeuvres. It proves advice to flight instructors on how to position the hand on the throttle grip to enable the throttle to be closed in one movement and therefore ensuring the engine throttle does not open when the collective is raised.

SL 19-002 - Controllability in yaw at low rotor speed.

This service letter proves advice on yaw control when operating with low rotor speeds. It includes a list of scenarios where yaw control could be lost and mitigating actions to prevent loss of control. One scenario is Simulated Engine Failure from the Hover. When operating at low rotor speeds with full or almost full right pedal applied it is recommended not to raise the collective but keep it as low as possible and increase forward airspeed by cyclic input, and not to increase the rotor speed by turning the twist grip.

Published 19 September 2019.

ACCIDENT

Aircraft Type and Registration:	Robinson R22 Beta, G-OODX	
No & Type of Engines:	1 Lycoming O-320-B2C piston engine	
Year of Manufacture:	1987 (Serial no: 720)	
Date & Time (UTC):	1 August 2018 at 1248 hrs	
Location:	Near Naunton Beauchamp, Worcestershire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - 1 (Minor)
Nature of Damage:	Extensive	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	46 years	
Commander's Flying Experience:	220 hours (of which 100 were on type) Last 90 days - 18 hours Last 28 days - 4 hours	
Information Source:	AAIB Field Investigation	

Synopsis

During a flight from Culworth in Northamptonshire to Worcester, drive was lost to the main rotor. The pilot established the helicopter in autorotation but as he flared for landing the tail struck the ground and the helicopter rotated forward before coming to rest. The pilot and passenger were able to exit the helicopter with minor injuries.

The investigation found that both drive belts between the engine and drive shaft had failed but the cause of that failure was not determined.

History of the flight

On the day of the accident the pilot hired the helicopter from Denham Aerodrome and flew to a private site near Bedford. He then flew from Bedford to a private site near Culworth in Northamptonshire. The pilot then planned to fly from Culworth to a private site near Worcester, taking off at 1218 hrs. He reported that the first two flights were uneventful. He recalled seeing the clutch light illuminate for approximately one second on two occasions after leaving Bedford and again on two occasions on the accident flight.

The pilot reported that whilst cruising at 800 ft and 80 kt he heard a sudden bang, the helicopter "aggressively" yawed to the left, he heard the low rpm horn and saw the clutch light illuminate. He initially established the helicopter in autorotation at 60 kt but then reduced the speed to 30 kt to reduce the range and reach a suitable field. During the descent, the pilot pulled the clutch circuit breaker because the clutch light had been illuminated for some time.

He recalled that the low rpm horn was sounding throughout the descent. As the helicopter approached the ground, the pilot flared but this did not sufficiently arrest the descent rate and the tail of the helicopter struck the ground followed by the skids.

Figure 1

G-OODX after the accident (provided by the operator)

The pilot recalled the helicopter rotated forward one or two times before coming to a halt. The pilot and passenger were able to exit the helicopter without serious injury.

Helicopter examination

The AAIB did not attend the accident site. After initial assessment, the AAIB authorised the helicopter operating company to photograph the scene (Figure 1 and 2) and transport the wreckage back to their premises.

They reported that the drive belts were missing when the aircraft was examined initially. An extensive search was carried out using both a camera equipped drone and a search dog but neither belt was located. The aircraft was subsequently examined, at the operator's premises, by the AAIB.

Examination confirmed that the aircraft was extensively damaged. The damage precluded any assessment of the pre-impact alignment of the driving and driven pulley pairs.

Small fragments of a drive belt were recovered from the wreckage and retained for laboratory examination.

Some months later, a walker found a broken belt lying in a nearby field. This was passed to the operator, which identified it as being of the type used in the R22 helicopter type. It was also returned to the AAIB and subjected to laboratory examination.

Figure 2

G-OODX after the accident (provided by the operator)

Pilot's pre-flight checks

The pilot recalled completing a pre-flight check on the helicopter before the first flight of the day and did not detect any defects. He checked the drive belts and both appeared normal.

Weather

The pilot stated that, at the time of the accident, the weather was CAVOK, temperature 20°C, and the surface wind was from approximately 200° at 8 kt.

An aftercast produced by the Met Office confirmed the weather would have been benign, with light south or south-westerly winds, visibility of 10 km or more and no significant cloud below 5,000 ft.

Pilot information

The pilot held a Helicopter Private Pilot's Licence (PPL(H)) with R22 and R44 ratings. His R22 rating was valid until 31 March 2019. He had last flown the R22 in May 2018 whilst completing his night rating.

The pilot also held a fixed wing pilot's licence. The pilot reported he had flown approximately 75 hours fixed wing and 19 hours rotary in 2018.

Recorded information

The pilot was using a navigation app. Copies of the data recorded by the app were provided to the AAIB. The ground track from the accident flight is shown in Figure 3 and 4.

Figure 3

Track recorded by navigation app, showing flight from Culworth

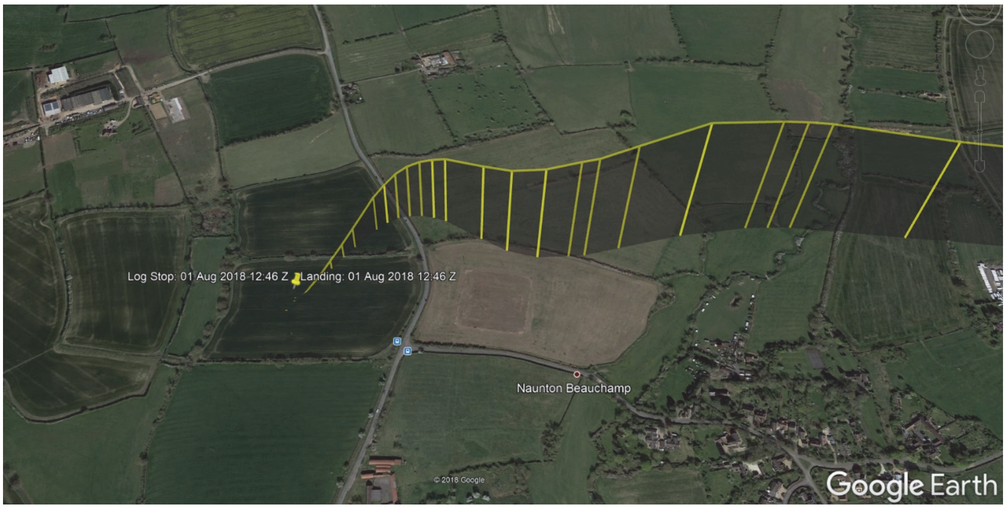


Figure 4

Track recorded by navigation app, showing autorotation

Figure 5 shows the helicopter's groundspeed, altitude, vertical speed and track recorded by the app. As the autorotation was flown into wind the groundspeed shown is approximately 10 kt less than the indicated airspeed seen by the pilot. Figure 5 shows the groundspeed initially stable at 50 kt. Once the descent was established the groundspeed reduced to approximately 30 kt then increased back to 60 kt. At approximately 60 ft above the ground the groundspeed was 60 kt. The groundspeed and rate of descent then reduced as the pilot flared the helicopter.

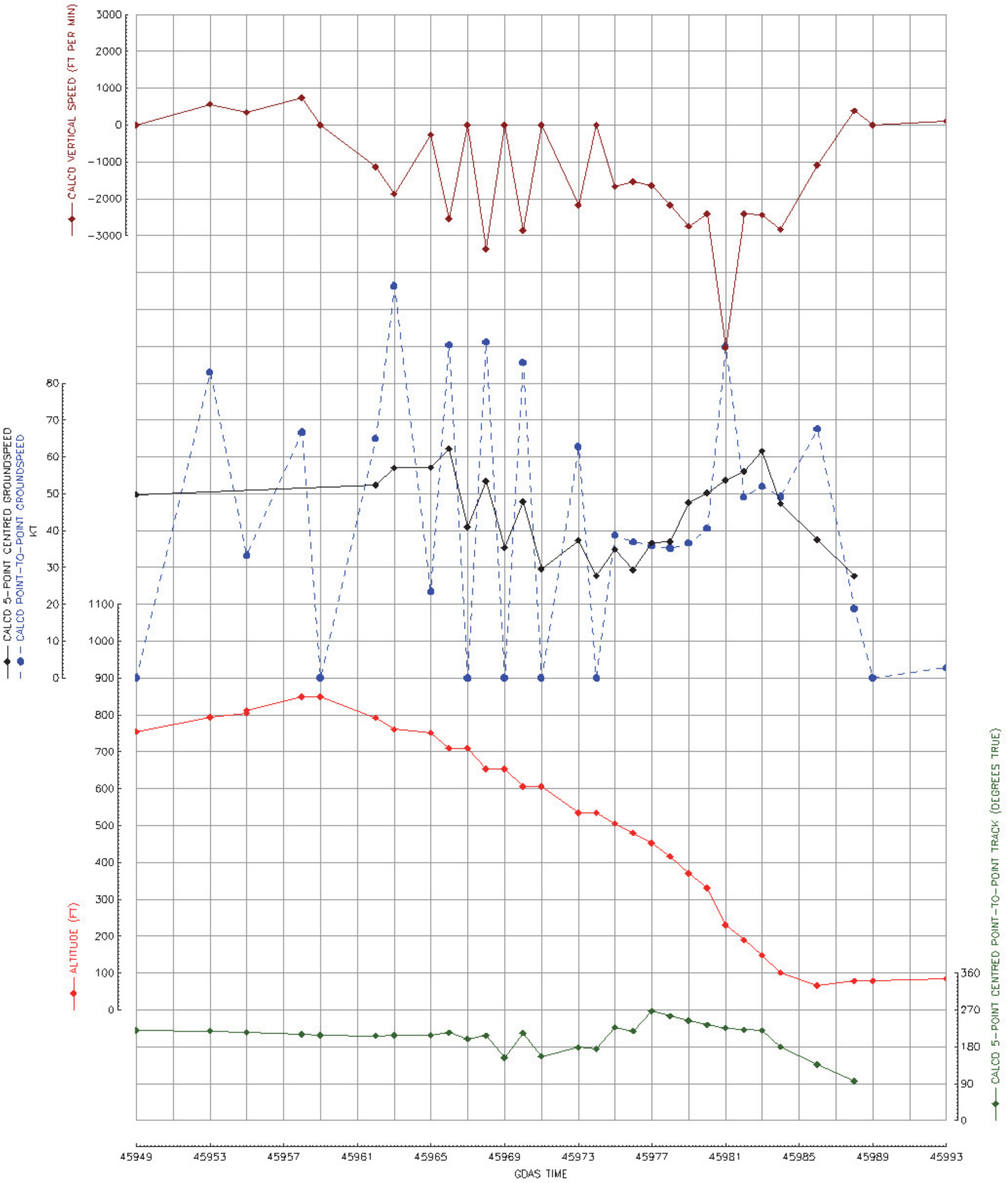


Figure 5

Helicopter Vertical Speed, Groundspeed, Altitude and Track during the autorotation, derived from navigation app

Helicopter information

The R22 utilises a double belt arrangement to transmit drive from the engine to the rotor system (Figure 6). The driven pulleys (or sheaves) are mounted on the tail rotor drive shaft. The shaft can be moved vertically by the functioning of an electrically operated actuator. This allows the tension in the belts to be altered and enables the system to act as a clutch. The engine is started with the belts slack and operation of the actuator gradually tensions them. As this occurs, the rotors begin to turn. The actuator continues to move the shaft/pulley arrangement until the belts are tight and slippage ceases.

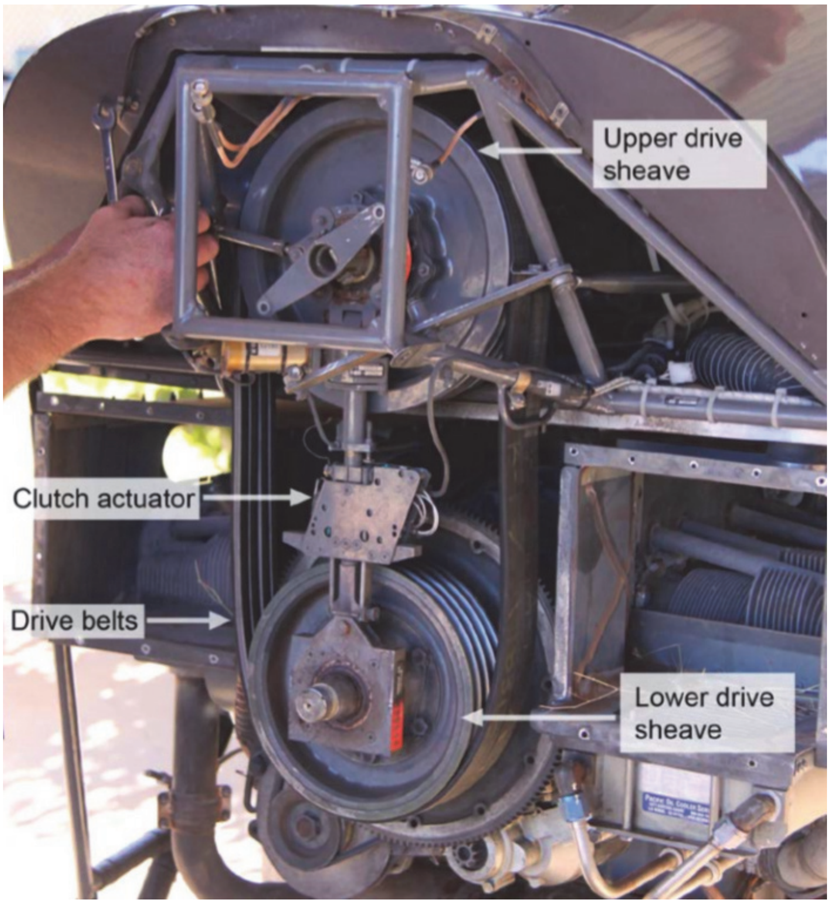


Figure 6

R22 Drive system (from Australian Transport Safety Bureau report AI-2009-038[1])

During normal flight, the belt tension is monitored and the actuator automatically re-tensions the belts if any slackness is detected. A ‘clutch’ light in the cockpit illuminates when the actuator is operating. The R22 pilot’s operating handbook contains the following note:

Footnote

[1] ATSB report ‘Reliability of the Robinson R22 helicopter belt drive system’ - http://www.atsb.gov.au/media/4120236/ai-2009-038_final.pdf [accessed 4 April 2019]

The R22 pilot's operating handbook contains the following note:

> *'Clutch light may come on momentarily during run-up or during flight to retension belts as they warm-up and stretch slightly. This is normal. If, however, the light flickers or comes on in flight and does not go out within 10 seconds pull* CLUTCH *circuit breaker and land as soon as practical.'*

The two belts are identical and each is of a type having inclined side running surfaces and a central v-groove. Each pulley has four running surfaces engaging with the corresponding running surfaces of the belt.

Laboratory examination

The belt found in a field sometime after the accident was examined and found to be complete but fractured (Figure 7). Although some slight wear was identified within the v-groove, there was no evidence that the belt was running other than correctly on both the engine drive pulley and the driven pully on the tail rotor drive shaft. No damage or witness marks were visible on the running surfaces of the belt. There was similarly no evidence that the strength of the belt was significantly reduced. Evidence suggested that the failure was one of simple tensile overload.

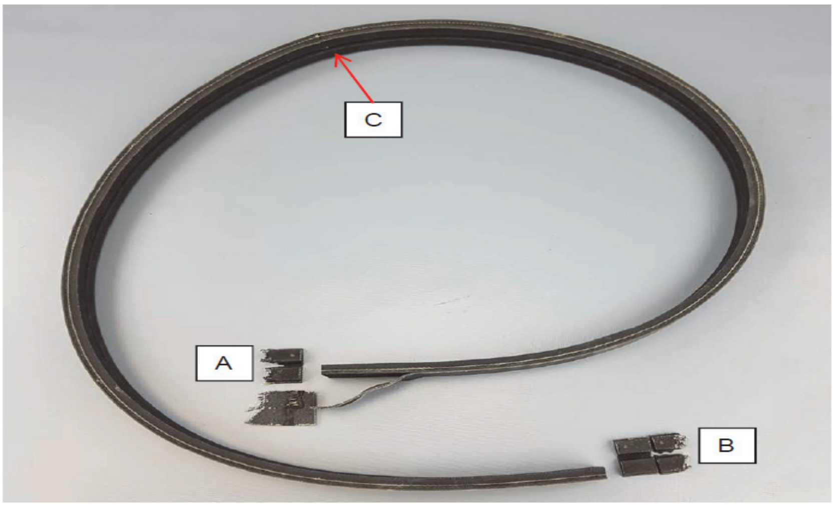


Figure 7

Damaged belt with fractured ends detached for analysis

The fragments of the other belt found with the helicopter wreckage, represented small lengths and in each case were ground away such that all the material defining the side running surfaces and the v-groove was no longer present; only the external tie band and some tensile reinforcing chords, with associated rubber matrix material, remained (Figure 8). This was consistent with the belt having been operated whilst no longer aligned in the pulleys.

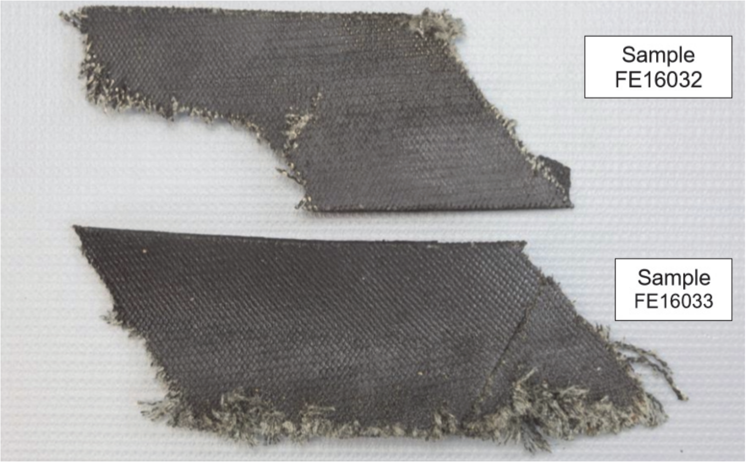


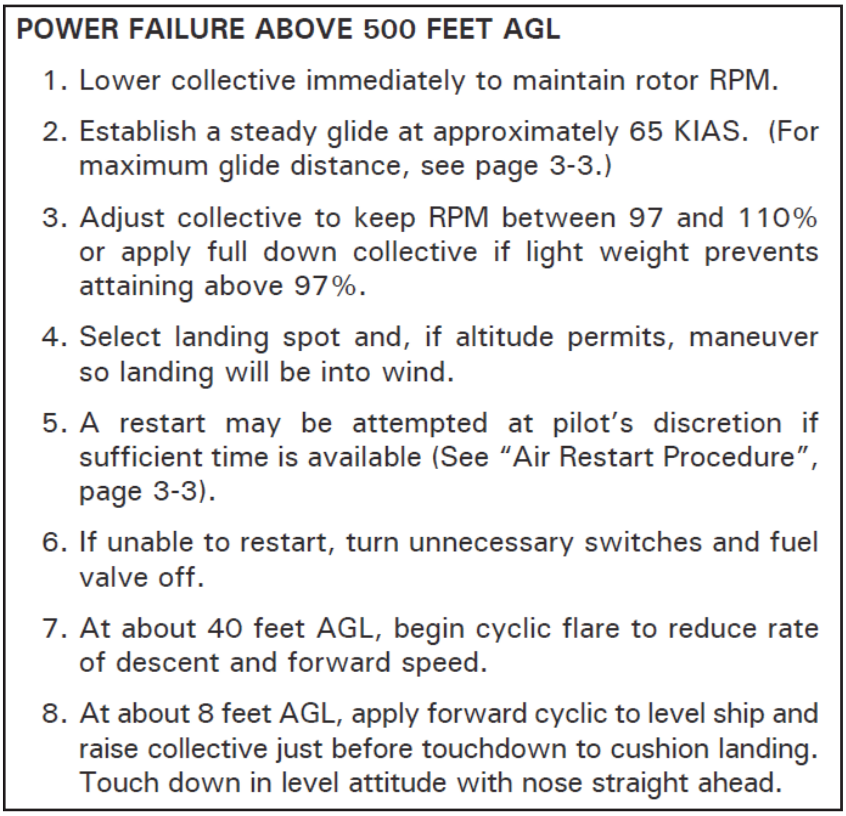
Figure 8

Belt fragments

Other information

Autorotation

If a helicopter's engine fails in flight or if drive is lost to the main rotor the pilot can safely land the helicopter by descending in autorotation. During autorotation the up-flowing air generated by descending is sufficient to maintain rotor rpm. The procedure for the R22 is given in the pilot operating handbook (Figure 9).



POWER FAILURE ABOVE 500 FEET AGL

1. Lower collective immediately to maintain rotor RPM.
2. Establish a steady glide at approximately 65 KIAS. (For maximum glide distance, see page 3-3.)
3. Adjust collective to keep RPM between 97 and 110% or apply full down collective if light weight prevents attaining above 97%.
4. Select landing spot and, if altitude permits, maneuver so landing will be into wind.
5. A restart may be attempted at pilot's discretion if sufficient time is available (See "Air Restart Procedure", page 3-3).
6. If unable to restart, turn unnecessary switches and fuel valve off.
7. At about 40 feet AGL, begin cyclic flare to reduce rate of descent and forward speed.
8. At about 8 feet AGL, apply forward cyclic to level ship and raise collective just before touchdown to cushion landing. Touch down in level attitude with nose straight ahead.

Figure 9

Robinson R22 procedure for power failure above 500 ft

It is important to maintain the rotor rpm between 97 and 110% to ensure there is sufficient energy in the rotor to arrest the rate of descent for landing. If the rotor rpm drops below 97% a low rpm light illuminates and a horn sounds. The handbook contains the caution:

> *'The R22 has a light, low-inertia rotor system. Most of the energy required for an autorotation is stored in the forward momentum of the aircraft, not in the rotor. Therefore, a well-timed cyclic flare is required and rotor RPM must be kept in the green until just before ground contact.'*

The procedure recommends descending at approximately 65 kt. Pilots can shorten the glide distance by reducing airspeed below this value, but the airspeed should be increased again before 40 ft to give sufficient airspeed to arrest the rate of descent before landing.

Similar events

During 2012, the Australian Transport Safety Bureau became aware of several accidents and serious incidents involving Robinson R22 helicopters in which failure of either one or both rotor drive v-belts had occurred. The report of a subsequent study[2] identified eight belt related occurrences in Australia between 2004 and 2011 of which two were fatal and one involved serious injury.

A survey of information available from the UK, USA, Canada and New Zealand, published in the same report, identified 21 similar occurrences outside Australia between 1991 and 2012, of which one was fatal. During this period the modification states of belts and pulleys changed and evolved so the reports do not necessarily relate to the same belt/pulley configuration.

Analysis

Drive belt failure

A tensile failure was found on the drive belt found lying in a field. No evidence of degradation of belt strength was found during its laboratory analysis. There was no damage or witness marks on the running surfaces of the belt to indicate that it had "de-railed" or suffered foreign object contamination whilst running. The failure was thus consistent with that of a belt of the correct strength being overloaded in tension.

The fragments of the other belt found amongst the wreckage had become eroded with removal of most of the belt cross-section indicating that it had run for a period with the belt not correctly seated on one or both pulleys. The belt was in several fragments and most of its length was not recovered.

It is possible that the fragmented belt had operated incorrectly, for an unknown reason, and had largely been eroded away before breaking. The automatic tensioner had caused the actuator to increase the tension in the second belt so that the correct total tension force

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Footnote

[2] ATSB report 'Reliability of the Robinson R22 helicopter belt drive system' - http://www.atsb.gov.au/media/4120236/ai-2009-038_final.pdf [accessed 4 April 2019]

was exerted, but that force was balanced by tension in only one belt. This would cause approximately twice the normal stress in the remaining belt, or more if sudden failure of the first belt and operation of the tensioner caused the total load to overshoot the desired tension. This high load in the remaining belt would probably have led to its failure in tensile overload, as evidenced on the belt located in the field.

The Australian report suggested several possible causes for incorrect operation of the drive belts, although no single specific cause could be identified. Similarly, the cause of the incorrect operation that led to the initial belt failure in G-OODX was not determined.

Autorotation

The pilot recognised the loss of drive to the rotor and established the helicopter in autorotation. During the descent he reduced airspeed to shorten the glide range to land in a suitable field. Rotor rpm during the descent is not known but the pilot reported that the low rpm horn was on throughout the descent. At approximately 60 ft the recorded data showed the helicopter was back at the correct airspeed to flare for landing. The pilot reported that he flared the helicopter, but the tail struck the ground. It is not known if the pilot misjudged the flare or if the rotor rpm was insufficient to arrest the rate of descent sufficiently before landing.

Conclusion

The drive belts connecting the engine to the drive shaft failed causing a loss of drive to the rotor system. The cause of the initial belt failure could not be determined.

The pilot recognised the failure, entered autorotation and landed in a field. Both occupants were able to exit the helicopter with only minor injuries but the helicopter was extensively damaged.

Published 19 September 2019.

AAIB Correspondence Reports

These are reports on accidents and incidents which were not subject to a Field Investigation.

They are wholly, or largely, based on information provided by the aircraft commander in an Aircraft Accident Report Form (AARF) and in some cases additional information from other sources.

The accuracy of the information provided cannot be assured.

ACCIDENT

Aircraft Type and Registration:	Airbus A320-232, HA-LPL	
No & Type of Engines:	2 IAE V2500 turbofan engines	
Year of Manufacture:	2007	
Date & Time (UTC):	23 March 2019 at 2110 hrs	
Location:	Stand 2, Bristol Airport	
Type of Flight:	Commercial Air Transport (Passenger)	
Persons on Board:	Crew - 6	Passengers - 159
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Torque link lock plate and nut damaged on nose landing gear	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	40 years	
Commander's Flying Experience:	8,313 hours (of which 3,500 were on type) Last 90 days - 150 hours Last 28 days - 43 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries made by the AAIB	

Synopsis

The aircraft was being pushed back from its stand by a 'towbarless' tug when the pilots detected a "major shake" from the aircraft nose landing gear. On inspection, damage was found on the torque link pivot of the nose landing gear and the aircraft had to be taken out of service. The damage had been the result of incorrect alignment of the tug lifting paddles. This was caused by the tug laser alignment system being lined up on the nose gear main forging whilst the nosewheels were 10° to 15° off centre. The handling company have taken four safety actions to prevent recurrence.

Sequence of events

An Airbus 320 at Stand No 2 at Bristol Airport had been given clearance and was being made ready for pushback. The nosewheel steering bypass pin had been installed and the TLD 200MT lift tug was aligned with the aircraft nose landing gear main forging. The tug was being driven by a driver undergoing his first pushback in this model and type of tug, under the direct supervision of a trainer seated alongside in the cab.

The tug was being brought forward using its laser guidance system and joystick and was at the point where the 'paddles' close around the nosewheels. Whilst this was taking place the trainer observed movement of the nose gear followed by a bang.

The driver immediately stopped the procedure, the brakes were applied, and the trainer and driver exited the cab to investigate the cause of the bang. On inspection they found that the paddle on the left side of the aircraft had contacted, and damaged, the nut on the torque link centre pivot. There also was a significant witness mark on the paddle.

They then informed the aircraft commander and the aircraft maintenance company. The scheduled flight was cancelled, and the aircraft taken out of service. There were no injuries reported by the passengers or the crews of the aircraft and tug.

Subsequent investigation and findings

The handling company carried out a detailed investigation of the events during the incident to establish the cause along with any contributory factors.

The cause of the damage to the aircraft

The movement of the aircraft nosewheels described by the trainer was a result of the tug paddle first contacting the edge of the torque link nut. Then, as the paddle closed further under hydraulic force, the edge of the nut failed and the paddle slipped past it with a jolt and a bang, as heard by the trainer.

Alignment of the tug

There were several factors which undermined the ability of the tug to pick up the aircraft nosewheels correctly. The aircraft had been parked with its nosewheels 10° to 15° off centre. This is unremarkable in most circumstances. However, in this case, the position of the wheels was important. The handling company training department confirmed that with this type and model of tug, the laser guidance system must be aligned with the nosewheels and not the nose gear leg as occurred in this case.

The tug has an automated positioning system and can align with aircraft selected from a menu. If the wrong type of aircraft is approached the system will not allow positioning. However, if the correct aircraft is selected but the tug is aligned to the nose leg and not the wheel position, the paddles are not automatically prevented from closing because the system cannot detect that the nosewheels are offset.

Driver and trainer

The driver was fully trained in pushback procedures and principles and had several years experience on conventional tow bar tugs. The driver had already been trained on the TLD 100E towbarless tug and the TLD 200MT was the second of two types of towbarless tug training being undertaken.

The trainer was a qualified ramp trainer for towbarless pushback tugs.

Discussion

It is not clear why the event occurred. The handling company confirmed that the training and knowledge of the requirement to align with the nosewheels was in place. However, in this case it is possible that a momentary lapse in concentration led to the system being aligned to the nose leg rather than the nose wheels. This error is likely to have gone unnoticed because the 10° to 15° offset of the nosewheels was not significant enough to indicate a problem.

Safety actions

It was noted that aligning with the nosewheels is vital. Lining up on the nose gear leg potentially leads to misalignments of up to 250 mm. This can result in significant damage to the components on the lower articulated part of the nose landing gear on this and many other aircraft types.

The handling company has taken several safety actions as follows;

The towbarless tug training was reviewed to confirm the correct procedures are being taught. There is now a specific emphasis made on the requirement to ensure the tug is always aligned with the nosewheels.

Pushback crews have been briefed to be more aware of the importance of the nosewheel position and have been asked to make the aircraft crew aware that, if possible, the nosewheels should be straight.

The handling company are consulting with the tug manufacturer to identify and if possible, trial a system, that warns the tug operator of wheel misalignment.

The A320 has been identified as the most potentially susceptible aircraft type to sustain nose landing gear damage whilst using the TLD 200MT tug. When possible on the A320 series of aircraft, the handling company will use either the conventional tow bar and tug or the TLD 100E towbarless tug.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 767-322, N657UA
No & Type of Engines:	2 Pratt & Whitney PW4000 turbofan engines
Year of Manufacture:	1993 (Serial no: 27112 LN:479)
Date & Time (UTC):	29 April 2019 at 0835 hrs
Location:	Departure from London Heathrow Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 11 Passengers - 86
Injuries:	Crew - None Passengers - None
Nature of Damage:	Arcing and heat damage within a wiring harness
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	18,250 hours (of which 1,850 were on type) Last 90 days - 218 hours Last 28 days - 34 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries made by the AAIB

Synopsis

The aircraft was climbing through 15,000 feet after departure from London Heathrow (LHR) when it was reported that an electrical burning smell, smoke and haze, was apparent in the cabin. The crew obtained clearance to return to LHR and, after carrying out the 'smoke and fumes' checklist, the problem was alleviated. The aircraft landed without further incident. A small section of wiring within the cabin ceiling lighting harness was found to have been the source of the smoke and fumes. Damage to the harness was found to have been caused by an electrical event leading to arcing between two of the insulated wires within the harness. The exact nature of this event could not be determined.

History of the flight

The aircraft had departed Heathrow, on route to Chicago O'Hare, and was climbing through 15,000 feet when the commander received a call from the cabin staff informing him of smoke in the cabin. It was reported that an electrical burning smell and haze was apparent near to Row 20. Rather than divert, the crew decided the aircraft should return to LHR. The commander declared a PAN to London ATC and permission was given to return. The crew carried out the smoke and fumes checklist, which included selecting the utility bus switches to OFF. After this had been done the purser reported that the smoke and haze had dispersed, although the electrical burning smell was still noticeable although dissipating.

The commander carried out the QRH requirements for an overweight landing and configured the aircraft accordingly. ATC and the commander agreed that, unless the situation deteriorated after landing, the aircraft should be turned off the runway and stop at a convenient location to enable the airport fire service to make an assessment.

The aircraft landed without further incident and stopped at a remote stand. The fire service boarded the aircraft and found no signs of heat or fire. There were no injuries to the passengers and crew.

Investigation

One of the passengers on the flight reported that they had seen a momentary flash above the overhead ceiling panels near Row 20. The operator carried out an examination of the area and identified the source of the smoke and haze. Wiring in the cabin ceiling lighting harness above Row 19/20 on the left side showed evidence of electrical arcing and heat damage. There was also soot on the insulation surrounding a section of wiring, as shown in Figure 1.

Figure 1

Damage to the wiring harness and surrounding material

The circuit breaker (CB) protecting the circuit was found to have tripped. The wiring harness, CB and the lighting ballast connected to the harness were removed for further examination by the manufacturer. The CB and lighting ballast passed functional tests.

Conclusion

Damage to the harness was found to have been caused by an unidentified electrical event between two of the insulated wires within the harness. The electrical event led to arcing between the wires which generated significant heat, enough to cause localised melting of the copper strands in the wires. The exact nature of this event could not be determined.

ACCIDENT

Aircraft Type and Registration:	Cessna FA152 Aerobat, G-WACH	
No & Type of Engines:	1 Lycoming O-235-N2C piston engine	
Year of Manufacture:	1986 (Serial no: 425)	
Date & Time (UTC):	7 May 2019 at 0950 hrs	
Location:	Field near Quainton, Buckinghamshire	
Type of Flight:	Training	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Nose and wings damaged	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	59 years	
Commander's Flying Experience:	1,890 hours (of which 480 were on type) Last 90 days - 87 hours Last 28 days - 35 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot, AAIB enquiries and examination of the engine	

Synopsis

The aircraft struck a hedge and concealed ditch while making a forced landing in a field following a loss of engine power. There were no injuries. Examination of the engine did not identify any technical reason for the loss of power and the flying school considered insufficient or inconsistent fuel flow to the engine as a likely cause. Additionally, the possibility of carburettor icing could not be excluded.

History of the flight

The training flight was planned as a navigation progress check, during which the student pilot was to be assessed on his ability to navigate and make command decisions. Before departure the flying instructor performed an initial walk-round inspection which included a visual check of fuel and oil levels. The student then performed a detailed walk-round using the checklist and took readings of the fuel and oil levels using calibrated dip sticks.

The navigation task was conducted at an altitude of 2,500 ft and the flight initially proceeded uneventfully but during the return to Wycombe Air Park, the instructor noticed the engine speed begin to fluctuate between 2,200 and 1,900 rpm.

The instructor reported that he took control, applied more carburettor heat and gently increased the throttle but the engine speed continued to fluctuate and then gradually decreased, settling in the range of 1,500 to 1,800 rpm. He initially decided to perform a precautionary landing with power-on, on the cross runway at Westcott, a disused airfield, and positioned the aircraft downwind accordingly. It became clear to him that there was insufficient power available to safely complete the landing and he elected instead to perform a forced landing with power-off, having identified a suitable field ahead in which to land. He made a MAYDAY call to ATC at Oxford Airport and prepared the aircraft for landing.

After avoiding telegraph wires in the selected field, the instructor carried out an uneventful touchdown. Despite applying braking, its effectiveness was limited by damp grass and he was unable stop the aircraft before it struck the perimeter hedge and a concealed ditch (Figure 1) at low speed. Both occupants were uninjured and exited the aircraft without assistance.

Figure 1

G-WACH after coming to rest

Aircraft information

The most recent maintenance check was a 150-hour check completed on 3 March 2019. Since then, the aircraft had accumulated 7 flying hours. The technical log indicated that there were 60 litres of fuel on board prior to the flight and there were no relevant defects recorded.

Flying school's internal investigation

Following the accident, the flying school's maintenance organisation undertook a detailed examination of the aircraft and engine. Approximately 12 litres of fuel were drained from the aircraft at the accident site. Fuel was also present in the gascolator and carburettor; no evidence of water, or other contaminants was found. Examination of the fuel, oil and ignition systems did not identify any anomalies and cylinder compression ratios were good. The carburettor was removed and sent to specialist maintenance facility for operational and leak testing and no anomalies were noted.

The flying school considered that the loss of engine power was most likely caused by insufficient or inconsistent fuel flow to the engine.

Meteorological information

Although not specifically noted by the instructor in his report, weather information provided by Oxford ATC indicated that at the time of the accident the surface temperature was 12°C and the dewpoint was 5°C. Figure 2 illustrates the probability of carburettor icing for values of air temperature and dewpoint. Assuming a reducing temperature and similar dewpoint above the surface, this indicates that the flight was operating in the blue region: 'serious icing at any power'.

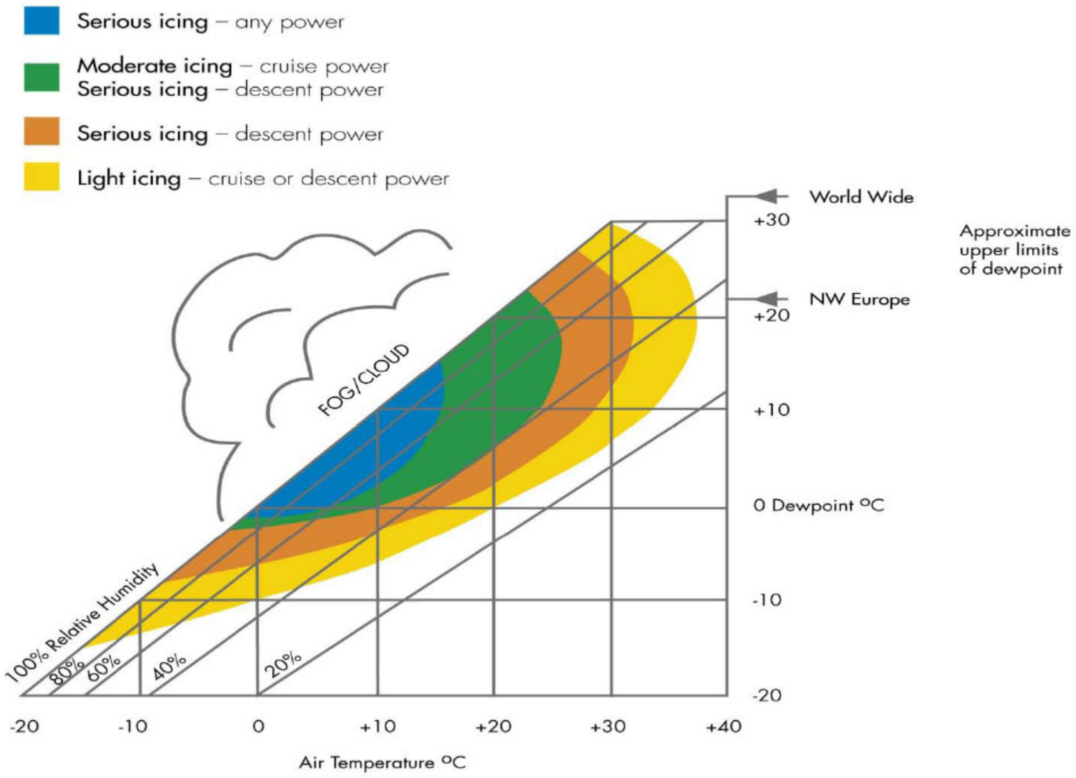

Figure 2

Carburettor icing probability chart

Other information

The instructor commented that the flying school's normal procedure during cruise is to select carburettor heat to ON for a period of 30 seconds, every 15 minutes. He recalled discussing the risk of carburettor icing with the student prior to departure but noted during the flight that the student was not applying carburettor heat as often as he should. The instructor did not consider that these intervals were sufficiently long to be detrimental to the flight but documented it as a debrief point for the student. He stated that the student had completed a carburettor heat check just prior to the onset of engine speed fluctuations.

The instructor also commented that when he had previously experienced serious carburettor icing the engine response had been different to that experienced on the accident flight. But acknowledged that, given the probability of serious carburettor icing on the day, it was not possible to rule out the presence of carburettor icing.

Discussion

The flying school considered that the engine speed fluctuations were probably caused by insufficient or inconsistent fuel flow, but its maintenance organisation did not identify any technical findings which could have led to the loss of power.

The weather conditions prevalent at the time of the accident were conducive to the formation of serious carburettor icing at any power setting. Although the instructor reported the use of carburettor heat both prior to, and following the onset of engine speed fluctuations, the possibility that carburettor icing may have contributed to the loss of engine power could not be excluded.

CAA Safety Sense Leaflet 14, *'Piston Engine Icing'*, contains useful information and guidance concerning induction system icing, including the recommend technique for use of carburettor heat in different phases of flight.

Conclusion

The reason for the loss of engine power was not identified but a fuel flow anomaly or carburettor icing were considered possible.

The instructor made a successful forced landing because his training and practice enabled him to identify a suitable landing site within the glide range of the aircraft. Braking action was less effective than anticipated due to the damp grass surface causing the aircraft to strike a hedge and concealed ditch.

ACCIDENT

Aircraft Type and Registration:	Starduster Too SA300, G-BOBT	
No & Type of Engines:	1 Lycoming O-360-A1F6 piston engine	
Year of Manufacture:	1983 (Serial no: CJ-01)	
Date & Time (UTC):	13 May 2019 at 1200 hrs	
Location:	White Waltham Airfield, Berkshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damaged propeller and undercarriage, engine shock-loaded	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	59 years	
Commander's Flying Experience:	315 hours (of which 101 were on type) Last 90 days - 1 hour Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The pilot was returning to the airfield after a flight in the local area. He reported an uneventful approach behind a Piper PA-28 and he considered his speed and rate of descent to be normal. The wind was reported to be 7 to 10 kt from 120° and the pilot was landing on Runway 11.

After a three-point touchdown the aircraft bounced twice with the second bounce being more severe than the first. The pilot reported that the final landing "was very heavy and led to the collapse of the undercarriage". In hindsight, he considered that he should have initiated a go-around after the first bounce.

ACCIDENT

Aircraft Type and Registration:	Cameron A-400, G-VBAJ	
No & Type of Engines:	4 x Stratus Quad Burner	
Year of Manufacture:	2015 (Serial no: 11869)	
Date & Time (UTC):	12 May 2019 at 0725 hrs	
Location:	Hargham Hall, Attleborough, Norfolk	
Type of Flight:	Commercial Air Transport (Passenger)	
Persons on Board:	Crew - 1	Passengers - 16
Injuries:	Crew - None	Passengers - 1 (Serious)
Nature of Damage:	None	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	59 years	
Commander's Flying Experience:	2,320 hours (of which 410 were on type) Last 90 days - 32 hours Last 28 days - 5 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The balloon made a gentle landing with the balloon and basket upright. The commander asked four passengers to exit the basket and help the ground crew hold the crown line[1] to ensure a positive deflation. Passenger assistance for the deflation was not essential on this occasion but was offered to the passengers as part of the ballooning experience.

Alighting from the basket in the upright position required passengers to put one leg over the side and climb down steps inset in the side of the basket (Figure 1). One of the passengers placed his left foot in the top step but could not locate the bottom step with his other foot. He attempted to alight by placing his right foot straight down to the floor but fell. He was wearing a large boot and his left foot was stuck in the top step when he fell, resulting in a serious injury.

Prior to this the passenger had felt comfortable to exit the balloon unaided and to assist with the ground tasks. Following the accident, the operator has changed procedure to enable ground crew to assist all passengers with disembarkation.

Footnote

[1] A rope attached to the top of the balloon envelope at one end. It is used by a member of the crew to stabilise the balloon during inflation and deflation.

Figure 1

The basket steps

The British Association of Balloon Operators commented that passenger assistance is sometimes requested by the operating pilot, due to the conditions or the ground crew being unable to access the landing site in time. However, they would generally expect that commercial operators would limit passenger involvement to times when it is necessary.

ACCIDENT

Aircraft Type and Registration:	Ikarus C42 FB100 Bravo, G-IRED	
No & Type of Engines:	1 Rotax 912ULS piston engine	
Year of Manufacture:	2012 (Serial no: 1207-7210)	
Date & Time (UTC):	16 July 2019 at 1735 hrs	
Location:	3 miles west of Popham Airfield, Hampshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Nose landing gear bent rearwards and vertical stabiliser damaged	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	50 years	
Commander's Flying Experience:	74 hours (of which 64 were on type) Last 90 days - 21 hours Last 28 days - 5 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The aircraft was being flown back to its base airfield after maintenance. Approximately 16 minutes into the flight, the oil pressure reduced to zero and the engine stopped. The pilot carried out a forced landing in a wheat field and during the landing the aircraft nosed over and came to rest inverted. The pilot was later informed that there was an unspecified problem with one of the engine pushrod tube seals which resulted in an oil loss.

History of the flight

The aircraft was being flown from Clench Common Airfield (near Marlborough) back to its home base at Deanland Airfield after engine maintenance. The pilot carried out a five minute engine run and completed preparations for takeoff during which everything was normal. Approximately 16 minutes after takeoff the pilot observed the engine oil pressure fall to zero on the gauge. The pilot informed ATC of his intention to divert to Popham Airfield. After a further 30 to 45 seconds the engine abruptly stopped, and the pilot carried out a forced landing in a wheat field. During the landing the aircraft nosed over and came to rest inverted as shown in Figure 1. The pilot vacated the upturned aircraft uninjured.

Figure 1

G-IRED accident site

Conclusion

A film of engine oil covered the underside of the fuselage. An initial examination of the engine found there had been a complete loss of engine oil during the short flight. The pilot was later informed that there was an unspecified problem with one of the engine pushrod tube seals, which had resulted in the oil loss.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15-912, G-BZSS	
No & Type of Engines:	1 Rotax 912 piston engine	
Year of Manufacture:	2001 (Serial no: 7770)	
Date & Time (UTC):	20 April 2019 at 1400 hrs	
Location:	RAF Oakley (disused), Buckinghamshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Minor)	Passengers - 1 (Minor)
Nature of Damage:	Substantial	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	56 years	
Commander's Flying Experience:	413 hours (of which 23 were on type) Last 90 days - 5 hours Last 28 days - 4 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

During the approach to Holmbeck Farm Airfield, the aircraft encountered 'sink' on final approach. The pilot was unable to arrest the high rate of descent despite adding power and flaring. The aircraft made a hard landing that caused substantial damage; including to its base tube, front strut, right main and nose landing gear, Figures 1 and 2. This damage resulted in the foot throttle becoming jammed at a high power setting.

Figure 1

Damage including bent front strut and displaced right main landing gear

Figure 2

Damage to base tube

The pilot decided to continue to climb away from the resulting bounce as the throttle was now stuck at a high power setting. He also decided to return to RAF Oakley (now disused), his home base, as it had a larger concrete runway.

During the return flight, the pilot alerted emergency services using the emergency frequency.

After a short hold overhead, to allow arrival of the emergency services, the pilot selected the ignition systems OFF and carried out a successful ‘dead-stick’ emergency landing. The pilot and passenger received minor injuries and were assisted by the emergency services.

AAIB Record-Only Investigations

This section provides details of accidents and incidents which were not subject to a Field or full Correspondence Investigation.

They are wholly, or largely, based on information provided by the aircraft commander at the time of reporting and in some cases additional information from other sources.

The accuracy of the information provided cannot be assured.

Record-only investigations reviewed July - August 2019

31-Jan-19 **Cessna 172** **G-MEGS** Meppershall Airfield, Beds

The aircraft landed long resulting in a runway excursion and aircraft damage.

19-Feb-19 **Grumman American GA-7 Cougar** **G-BOXR** Stapleford Airport, Essex

During the taxi, after a successful landing, the nose gear collapsed causing damage to the forward fuselage and both propellers.

18-Mar-19 **Boeing A75L300 Stearman** **G-CGPY** Kingstanding Farm, Oxfordshire

During final approach the aircraft struck power lines at the threshold of the runway, damaging the propeller, engine, flying wires and lower wing. The aircraft landed safely.

01-Apr-19 **Jabiru UL-450** **G-NIGC** Weston Zoyland

The aircraft veered off the runway and collided with a fence on landing due to the left main wheel locking on brake application.

03-Apr-19 **Jabiru UL-450** **G-KEVH** Welshpool Airport, Powys, Wales

Runway excursion on landing. The aircraft then struck a fence causing damage to the propeller. There were no injuries.

Note: This entry was corrected online on 14 November 2019, a detailed correction will be printed in the December 2019 Bulletin.

08-Apr-19 **Cessna 152** **G-BKAZ** 2 miles east of Coupar Angus, Perthshire

The aircraft ran out of fuel, the nose gear collapsed during the forced landing in the field.

17-Apr-19 **Tecnam P92-EA Echo** **G-CBAX** Watchford Farm, Airfield, Devon

The aircraft landed hard on the nosewheel, resulting in damage to the nosewheel post, engine frame and propeller.

19-Apr-19 **Sherwood Ranger XP** **G-CIYY** North of Goodwood Aerodrome

The aircraft struck a barbed wire fence during the ground roll after a forced landing because of an engine failure.

20-Apr-19 **Falco F8L** **G-GREC** Kittyhawk Airfield, Ripe, East Sussex

The aircraft overran the runway and collided with a hedge whilst landing. The pilot reported that the left brake failed to engage so he could not apply symmetric braking.

Record-only investigations reviewed July - August 2019 cont

21-Apr-19 **Vans RV-8** **G-RVIS** Keevil Airfield, Wiltshire

The aircraft veered to the right and ground looped following a downwind landing, sustaining damage to the left main landing gear, tail wheel and wing fairings.

07-May-19 **Skyranger** **G-CCKG** Otherton Airfield, Staffordshire

Whilst landing, the aircraft overran the wet grass runway and came to rest in an adjacent field.

11-May-19 **Vans RV-7** **G-OKER** Midlem Airstrip, Scottish Borders

The aircraft was slightly high and fast on approach to land but, instead of going around, the pilot deliberately ground looped to avoid an overrun into a fence. However, the aircraft suffered damage when it encountered a rut.

15-May-19 **PA-25 Pawnee** **G-AZPA** Near Talgarth Airfield, Brecon

Having run out of fuel, the pilot made a forced landing in a grass field short of his intended touchdown on Runway 15. The landing gear collapsed, and the right wing suffered damage, but the pilot was uninjured.

19-May-19 **Cessna 195A** **G-BSPK** Jersey Airport, Jersey

The left wing struck the tail of a parked aircraft during taxi.

19-May-19 **Merlin 100UL** **G-CKZI** Romney Marsh, Kent

A rough running engine led to a precautionary landing. On landing the wing contacted the ground causing minor damage.

20-May-19 **Thruster T600N 450 Sprint** **G-OHYE** Old Park Farm Airstrip, Margam, near Port Talbot

During climb out at around 300 ft the engine failed. The pilot turned back to the airfield but stalled and came down short of the runway. The aircraft flipped over and inverted but the two occupants were secured by four-point harnesses and did not suffer any significant injury.

14-Jun-19 **Aeronca 0-58B Grasshopper** **G-BRHP** Private grass airstrip near Ashprington, Devon

The pilot lost control shortly after lifting off in gusty conditions. He re-landed the aircraft, but it yawed rapidly right into an open hangar when it struck the structure and the right wing detached.

18-Jun-19 **RANS S6-ESD** **G-MWHP** Horton, Lancashire

Following an engine failure the forced landing required a change of field at a late stage due to power lines ahead. The nose landing gear detached during the landing. A cylinder-head gasket failure was identified subsequently, which probably allowed coolant into at least one cylinder.

Record-only investigations reviewed July - August 2019 cont

21-Jun-19	**Grumman AA5B**	**G-ORLY**	Elstree Aerodrome, Hertfordshire	Following the subsequent touchdown after a bounced landing, the nose gear collapsed, and the right main gear also suffered damage. The pilot advised that the wind had lifted the aircraft during the initial landing.
22-Jun-19	**Piper PA-28-181**	**G-DIXY**	Clacton Airfield, Essex	During landing after a go-around, the aircraft floated, touched down late and skidded into a hedge on braking.
27-Jun-19	**DH82A Tiger Moth**	**G-ARAZ**	Duxford Airfield	The Tiger Moth taxied into a stationary Cessna 152 on the grass manoeuvring area.
28-Jun-19	**TL-3000 Sirius**	**G-CKKG**	Old Warden Airfield, Bedfordshire	Loss of control during a bounced landing resulting in a heavy touchdown following which the aircraft inverted. The pilot advised that he had not reacted quickly enough to initiate a go-around.
29-Jun-19	**Ryan STM-2**	**NC17343**	Oaksey Park airfield	The aircraft rolled onto its wingtip during landing and came to rest on its nose.
29-Jun-19	**Tiger Moth**	**G-APAP**	Derby Airfield (adjacent field)	After takeoff, approaching 200 ft in the climb, the aircraft lost power. The pilot made a forced landing in a ‘grass ridge/furrow type field’ beyond the runway. At touchdown the aircraft’s wheels hit a ridge, causing the undercarriage to collapse. There were no reported injuries.
29-Jun-19	**CFM Shadow Series CD**	**G-MTHT**	East Fortune Airfield, North Berwick, Scotland	Following a change to a tailwind which went unnoticed by the pilot, the lower fin detached when it struck a wire fence during takeoff. The aircraft flew a circuit to a successful landing.
30-Jun-19	**Cessna 152**	**G-BOLW**	Southend Airport	During engine start a fire developed in the engine air intake. The pilot used a fire extinguisher to put out the fire.
01-Jul-19	**Denney Kitfox Mk 2**	**G-RSSF**	Near Haxey Airfield, North Lincolnshire	The engine stopped whilst downwind to land and the aircraft inverted after the subsequent forced landing in a wheat field.

Record-only investigations reviewed July - August 2019 cont

05-Jul-19 **Cirrus SR22** **G-MAKS** Tingwall Airport, Shetland Islands

During the second landing, following a go-around, the aircraft bounced causing damage to the nosewheel. The aircraft then went around again before landing safely.

06-Jul-19 **Grumman AA-5B** **G-MPFC** Sandown, Isle of Wight

Whilst taxiing, the nose leg failed leading to damage to the propeller and engine. There were no injuries.

Note: This entry was corrected online on 14 November 2019, a detailed correction will be printed in the December 2019 Bulletin.

14-Jul-19 **Jodel** **G-BHZV** Brook Farm Airstrip, south of Morecambe Bay

The aircraft veered left and caught its wing in a crop. The aircraft spun and the right landing gear collapsed.

15-Jul-19 **De Havilland DH82A Tiger Moth** **G-ANEZ** Newport, Isle of Wight

The aircraft carried out a forced landing after loss of power on takeoff.

16-Jul-19 **Piper PA-38** **G-BSOU** Cumbernauld Airport, North Lanarkshire

After power loss on finals, the aircraft landed in the undershoot and turned over. The occupants were uninjured.

16-Jul-19 **Avid Speedwing** **G-CURV** Fen End Farm, near Cambridge

A loss of control on landing meant the aircraft left the runway and entered the adjacent field.

16-Jul-19 **Piper PA-28** **G-ASSW** Liverpool

During the landing the pilot experienced a gust of wind and the aircraft ran off the side of the runway and onto the grass.

21-Jul-19 **Mainair Blade 912S** **G-CBOO** Kilkeel, Northern Ireland

The aircraft rolled over on landing in a crosswind.

21-Jul-19 **Gyroplane** **G-CFGY** Beccles Airfield, Suffolk

The aircraft ran off the runway during landing.

22-Jul-19 **RotorSport UK MTOSport** **G-HATB** Rochester Airport

The aircraft tipped onto its side during takeoff.

Record-only investigations reviewed July - August 2019 cont

23-Jul-19 **Hispano HA-1112 M4L Buchon** **G-AWHC** Sywell Aerodrome

The aircraft was caught in crosswind, causing the wing to dip before colliding with a runway edge light. The takeoff was aborted.

26-Jul-19 **Piper PA-28** **G-CDMA** Shipdham Airfield, Norfolk

The aircraft landed short of the runway into a field due to a misjudged approach.

03-Aug-19 **Grumman AA5A** **G-BHZO** Manchester Barton Airport

The pilot perceived slow acceleration so aborted the takeoff but braked heavily and skidded to a halt in a hedge.

Miscellaneous

This section contains Addenda, Corrections and a list of the ten most recent Aircraft Accident ('Formal') Reports published by the AAIB.

The complete reports can be downloaded from the AAIB website (www.aaib.gov.uk).

TEN MOST RECENTLY PUBLISHED FORMAL REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2/2014 Eurocopter EC225 LP Super Puma
G-REDW, 34 nm east of Aberdeen,
Scotland on 10 May 2012
and
G-CHCN, 32 nm south-west of
Sumburgh, Shetland Islands
on 22 October 2012.

Published June 2014.

3/2014 Agusta A109E, G-CRST
Near Vauxhall Bridge,
Central London
on 16 January 2013.

Published September 2014.

1/2015 Airbus A319-131, G-EUOE
London Heathrow Airport
on 24 May 2013.

Published July 2015.

2/2015 Boeing B787-8, ET-AOP
London Heathrow Airport
on 12 July 2013.

Published August 2015.

3/2015 Eurocopter (Deutschland)
EC135 T2+, G-SPAO
Glasgow City Centre, Scotland
on 29 November 2013.

Published October 2015.

1/2016 AS332 L2 Super Puma, G-WNSB
on approach to Sumburgh Airport
on 23 August 2013.

Published March 2016.

2/2016 Saab 2000, G-LGNO
approximately 7 nm east of
Sumburgh Airport, Shetland
on 15 December 2014.

Published September 2016.

1/2017 Hawker Hunter T7, G-BXFI
near Shoreham Airport
on 22 August 2015.

Published March 2017.

1/2018 Sikorsky S-92A, G-WNSR
West Franklin wellhead platform,
North Sea
on 28 December 2016.

Published March 2018.

2/2018 Boeing 737-86J, C-FWGH
Belfast International Airport
on 21 July 2017.

Published November 2018.

Unabridged versions of all AAIB Formal Reports, published back to and including 1971, are available in full on the AAIB Website

http://www.aaib.gov.uk

GLOSSARY OF ABBREVIATIONS

aal	above airfield level
ACAS	Airborne Collision Avoidance System
ACARS	Automatic Communications And Reporting System
ADF	Automatic Direction Finding equipment
AFIS(O)	Aerodrome Flight Information Service (Officer)
agl	above ground level
AIC	Aeronautical Information Circular
amsl	above mean sea level
AOM	Aerodrome Operating Minima
APU	Auxiliary Power Unit
ASI	airspeed indicator
ATC(C)(O)	Air Traffic Control (Centre)(Officer)
ATIS	Automatic Terminal Information Service
ATPL	Airline Transport Pilot's Licence
BMAA	British Microlight Aircraft Association
BGA	British Gliding Association
BBAC	British Balloon and Airship Club
BHPA	British Hang Gliding & Paragliding Association
CAA	Civil Aviation Authority
CAVOK	Ceiling And Visibility OK (for VFR flight)
CAS	calibrated airspeed
cc	cubic centimetres
CG	Centre of Gravity
cm	centimetre(s)
CPL	Commercial Pilot's Licence
°C,F,M,T	Celsius, Fahrenheit, magnetic, true
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
DME	Distance Measuring Equipment
EAS	equivalent airspeed
EASA	European Aviation Safety Agency
ECAM	Electronic Centralised Aircraft Monitoring
EGPWS	Enhanced GPWS
EGT	Exhaust Gas Temperature
EICAS	Engine Indication and Crew Alerting System
EPR	Engine Pressure Ratio
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration (USA)
FIR	Flight Information Region
FL	Flight Level
ft	feet
ft/min	feet per minute
g	acceleration due to Earth's gravity
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
hrs	hours (clock time as in 1200 hrs)
HP	high pressure
hPa	hectopascal (equivalent unit to mb)
IAS	indicated airspeed
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IP	Intermediate Pressure
IR	Instrument Rating
ISA	International Standard Atmosphere
kg	kilogram(s)
KCAS	knots calibrated airspeed
KIAS	knots indicated airspeed
KTAS	knots true airspeed
km	kilometre(s)
kt	knot(s)
lb	pound(s)
LP	low pressure
LAA	Light Aircraft Association
LDA	Landing Distance Available
LPC	Licence Proficiency Check
m	metre(s)
mb	millibar(s)
MDA	Minimum Descent Altitude
METAR	a timed aerodrome meteorological report
min	minutes
mm	millimetre(s)
mph	miles per hour
MTWA	Maximum Total Weight Authorised
N	Newtons
N_R	Main rotor rotation speed (rotorcraft)
N_g	Gas generator rotation speed (rotorcraft)
N_1	engine fan or LP compressor speed
NDB	Non-Directional radio Beacon
nm	nautical mile(s)
NOTAM	Notice to Airmen
OAT	Outside Air Temperature
OPC	Operator Proficiency Check
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring
POH	Pilot's Operating Handbook
PPL	Private Pilot's Licence
psi	pounds per square inch
QFE	altimeter pressure setting to indicate height above aerodrome
QNH	altimeter pressure setting to indicate elevation amsl
RA	Resolution Advisory
RFFS	Rescue and Fire Fighting Service
rpm	revolutions per minute
RTF	radiotelephony
RVR	Runway Visual Range
SAR	Search and Rescue
SB	Service Bulletin
SSR	Secondary Surveillance Radar
TA	Traffic Advisory
TAF	Terminal Aerodrome Forecast
TAS	true airspeed
TAWS	Terrain Awareness and Warning System
TCAS	Traffic Collision Avoidance System
TODA	Takeoff Distance Available
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
USG	US gallons
UTC	Co-ordinated Universal Time (GMT)
V	Volt(s)
V_1	Takeoff decision speed
V_2	Takeoff safety speed
V_R	Rotation speed
V_{REF}	Reference airspeed (approach)
V_{NE}	Never Exceed airspeed
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional radio Range

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Air Accidents Investigation Branch