AAIB
Air Accidents Investigation Branch

AAIB Bulletin 1/2019

TO REPORT AN ACCIDENT OR INCIDENT PLEASE CALL OUR 24 HOUR REPORTING LINE

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The sole objective of the investigation of an accident or incident under these Regulations is the prevention of future accidents and incidents. It is not the purpose of such an investigation to apportion blame or liability.

Accordingly, it is inappropriate that AAIB reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

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This bulletin contains facts which have been determined up to the time of compilation.

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AAIB Special Bulletins and Interim Reports

This section contains Special Bulletins and Interim Reports that have been published since the last AAIB monthly bulletin.

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AAIB Bulletin S1/2018 *SPECIAL*

ACCIDENT

Aircraft Type and Registration:	Agusta AW169, G-VSKP
No & Type of Engines:	2 Pratt & Whitney Canada PW210A turboshaft engines
Year of Manufacture:	2016 (Serial no: 69018)
Location	King Power Stadium, Leicester
Date & Time (UTC):	27 October 2018 at 1937 hrs
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 4
Injuries:	Crew - 1 (Fatal) Passengers - 4 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Airline Transport Pilot's Licence (A and H)
Commander's Age:	53 years
Commander's Flying Experience:	To be confirmed Last 90 days - 40 hours Last 28 days - 7 hours
Information Source:	AAIB Field Investigation

The investigation

The accident occurred at 1937[1] hours on 27 October 2018. This Special Bulletin is published to provide preliminary information gathered from the site investigation, subsequent technical investigation, recorded data, and other sources.

Footnote

[1] All times in this bulletin are UTC and have been taken from a variety of sources which have yet to be fully correlated. All times quoted should be taken as approximate at this stage.

In accordance with established international arrangements, the Agenzia Nazionale per la Sicurezza del Volo (ANSV) of Italy, representing the State of Design and Manufacture of the helicopter, appointed an Accredited Representative (Accrep) to participate in the investigation. The Accrep is supported by advisers from the helicopter manufacturer. The Transportation Safety Board of Canada, representing the State of Design and Manufacture for the helicopter's engines, has also appointed an Accrep. Experts have been appointed by the Aircraft Accident Investigation Committee of Thailand and the State Commission on Aircraft Accidents Investigation of Poland. The European Aviation Safety Agency (EASA), the UK Civil Aviation Authority (CAA) and the helicopter operator are also assisting the AAIB.

History of the flight

The helicopter took off on its first flight of the day from Fairoaks Airport, Surrey, at 1340 hrs on Saturday 27 October 2018. The pilot and one passenger were on board. At 1404 hrs the helicopter landed at London Heliport (Battersea) where three additional passengers boarded. The helicopter then lifted off from Battersea at 1414 hrs and flew to the Belvoir Drive Training Ground, Leicester, landing at 1459 hrs.

The helicopter was shut down at the training ground and all persons on board went to the King Power Stadium, Leicester. The pilot and one passenger returned to the training ground at 1837 hrs and at 1844 hrs the helicopter lifted off, with two persons on board, for the short flight to the King Power Stadium, 1 nm to the north.

The approach to the King Power Stadium was made from a southerly direction. After landing, the helicopter parked on the centre circle of the pitch, on a north-easterly heading, and was shut down at 1847 hrs. The pilot and passenger left the helicopter.

Between 1900 hrs and 1930 hrs the pilot and four passengers boarded the helicopter for a flight to London Stansted Airport. The helicopter started up at 1934 hrs and at 1937 hrs it lifted from the centre circle, yawed 15° left and moved forward a few metres.

The helicopter then began a climb on a rearward flight path[1] while maintaining a northerly heading. Gear retraction started as it passed through a height of approximately 320 ft. The climb then paused. Heading changes consistent with the direction of pedal movements were recorded initially, then the helicopter entered an increasing right yaw contrary to the pilot's left pedal command. The helicopter reached a radio height[2] of approximately 430 ft before descending with a high rotation rate.

The helicopter struck the ground in an approximately upright position on a stepped concrete surface, with the landing gear retracted, and rolled onto its left side. The helicopter was rapidly engulfed in an intense post-impact fire. Stadium staff and emergency services were quickly at the scene but were not able to gain access to the helicopter because of the intensity of the fire.

Footnote

1 A planned procedure.
2 Height determined by a radar altimeter system on the aircraft.

Weather

At the time of the accident the weather was clear with good visibility and no cloud below 1,000 ft. The general wind direction was north-westerly with a strength of 10 to 12 kt at the surface and around 25 to 30 kt at 1,000 ft.

Wreckage

The aircraft came to rest on an area of land adjacent to the football stadium car park. The post-impact fire resulted in substantial damage to the predominantly composite structure of the helicopter. Several sections of the airframe were almost completely consumed by the fire and large sections of the remaining fuselage suffered significant loss of structural integrity.

The wreckage was recovered to the AAIB's facilities in Hampshire, where detailed forensic assessment of the helicopter's structure and systems is ongoing.

Safety action

The manufacturer of the helicopter has issued Alert Service Bulletin (ASB) 169-120 for AW169 helicopters, giving instructions for a precautionary inspection of the tail rotor control assembly on all helicopters in the global fleet. The manufacturer also issued ASB 189-213 for AW189 helicopters, which have a similar tail rotor control system.

These inspections have been mandated by the EASA, in its capacity as the regulator responsible for the type design approval of the AW169 and AW189. Airworthiness Directive 2018-0241-E has been issued to accomplish this.

Ongoing investigation

The cause of the apparent loss of yaw control has yet to be determined. Investigation of the tail rotor control system is being carried out as a priority. The AAIB investigation will also continue to conduct a comprehensive examination of the helicopter wreckage, recovery and analysis of recorded data from the Combined Voice and Flight Data Recorder (CVFDR), aircraft systems and other sources, and an assessment of the operation, maintenance, design and manufacture of the aircraft. The AAIB will report any significant developments as the investigation progresses.

Published 14 November 2018.

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AAIB Bulletin S2/2018 *SPECIAL*

ACCIDENT

Aircraft Type and Registration:	Agusta AW169, G-VSKP
No & Type of Engines:	2 Pratt & Whitney Canada PW210A turboshaft engines
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Commander's Age:	53 years
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The investigation

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Footnote

1 All times in this bulletin are UTC and have been taken from a variety of sources which have yet to be fully correlated. All times quoted should be taken as approximate at this stage.

This Special Bulletin contains facts which have been determined up to the time of issue. It is published to inform the aviation industry and the public of the general circumstances of accidents and serious incidents and should be regarded as tentative and subject to alteration or correction if additional evidence becomes available.

This second Special Bulletin provides information on the findings to date of a detailed examination of the helicopter's yaw control system.

Description of the AW169 yaw control system

Yaw pedals in the cockpit are connected to the tail rotor control system by a flexible cable running on ball bearings within an outer casing. This is connected to one end of a rigid control rod via a bellcrank. The range of movement of the bellcrank is limited in each direction, providing the primary control stops for the yaw system (Figure 1).

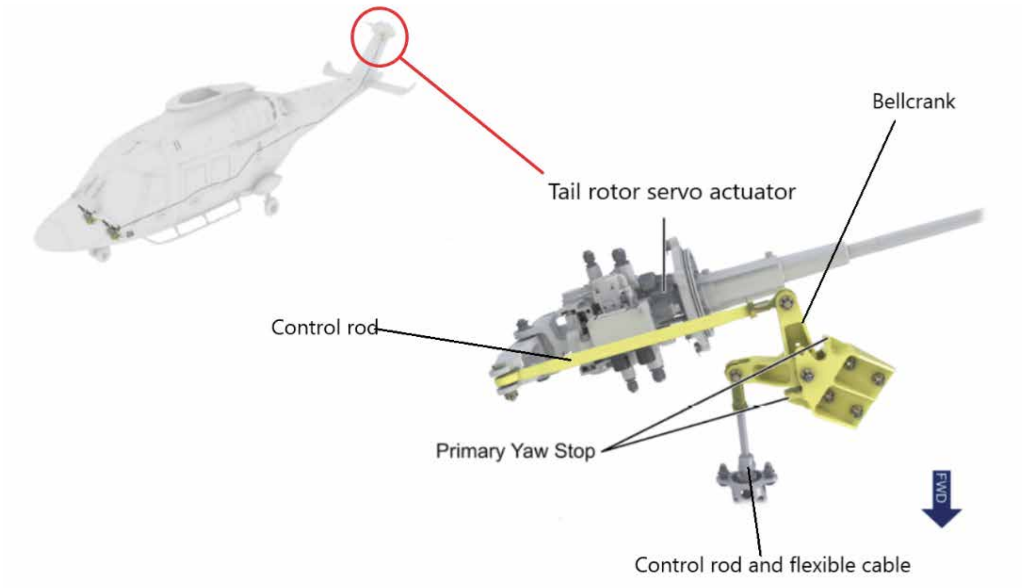

Figure 1
AW169 tail rotor control yaw stops

The other end of the control rod is connected to one end of a lever mechanism which forms part of the tail rotor servo actuator. The lever mechanism transmits the pilot's yaw commands to the servo actuator and, through a feedback mechanism, stops movement of the actuator when the commanded position has been reached.

The middle of the lever is connected via a solenoid valve to the hydraulic servo shuttle valve, and the other end of the lever is connected to the hydraulic servo control shaft by a connecting pin and pin carrier.

The pin carrier is secured to the shaft by a castellated locking nut, which attaches to a threaded section on the end of the shaft. The nut has a torque load applied before a split pin is fitted between the castellations of the nut and through a hole in the shaft. It is also wire locked in place (Figure 2).

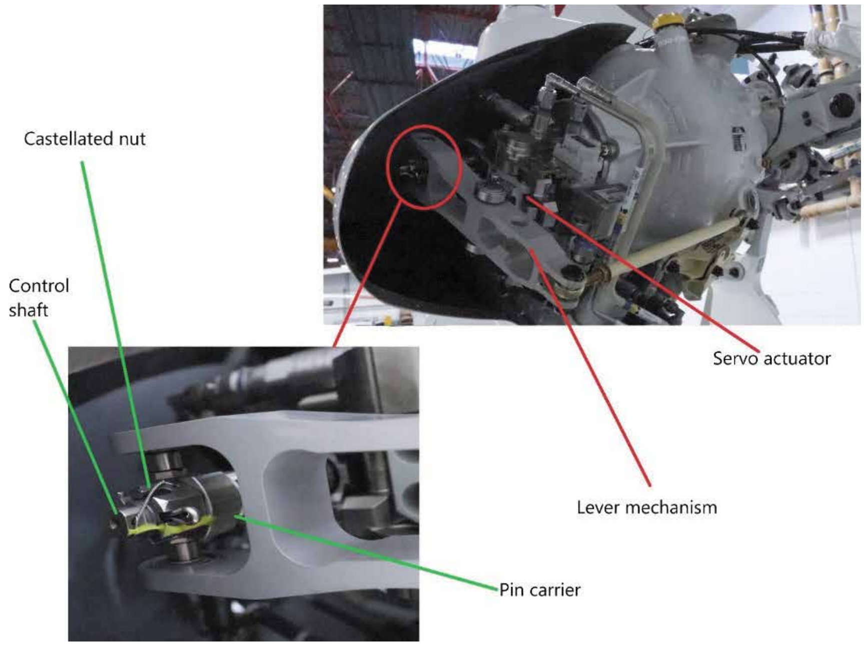

Figure 2

Tail rotor actuator control input mechanism

The control shaft passes through an outer shaft, which forms part of the tail rotor hydraulic actuator piston, and continues through a tunnel in the gearbox and engages with the inner race of a duplex bearing installed in the tail rotor slider/spider assembly (Figure 3). The control shaft is secured to the inner race of the bearing with a second, larger, castellated nut and split pin.

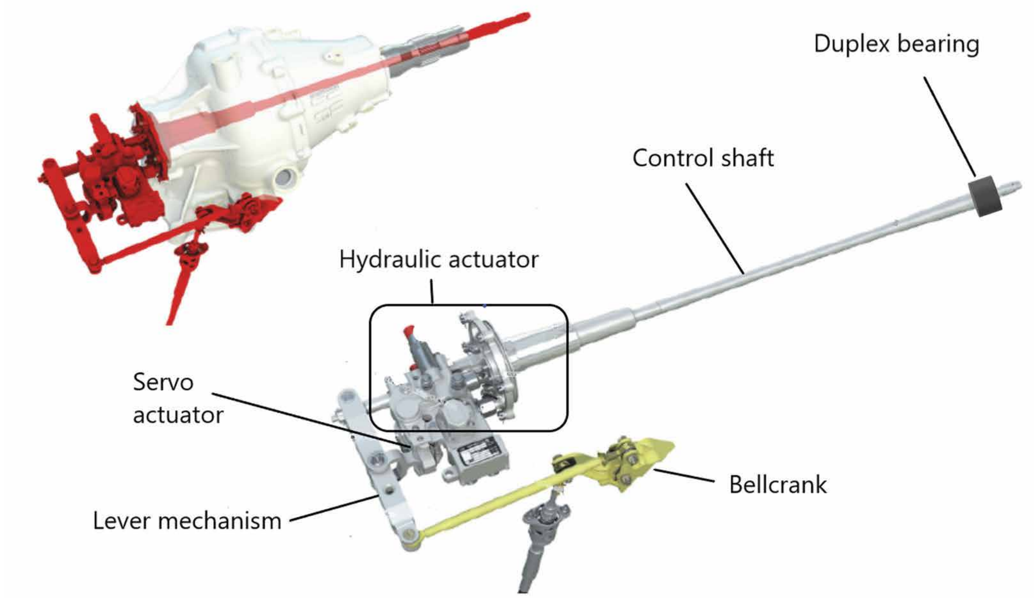

Figure 3

AW169 tail rotor actuator and duplex bearing

Each arm of the spider is connected by a rod to the rear of a tail rotor blade. The spider/slider assembly rotates with the outer race of the duplex bearing, while the control shaft attached to the inner race remains stationary (Figure 4).

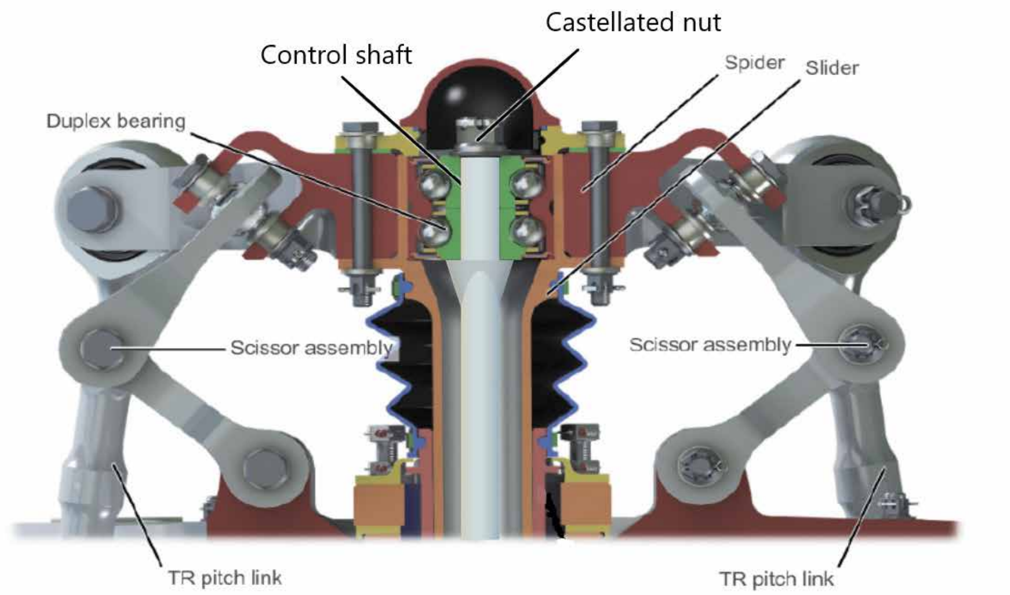

Figure 4
Tail rotor spider and pitch link assembly

Tail rotor control operation

When the pilot applies a yaw pedal input it moves the control cable and rotates the bellcrank. This movement is transferred to the lever mechanism by the control rod. The lever pivots around the connection at the control shaft end and creates a demand on the hydraulic system via the solenoid valve, which moves the hydraulic piston and control shaft of the actuator. Movement of the shaft is transmitted to the tail rotor blades via the spider/slider assembly and the blade control rods, which change the tail rotor pitch to meet the pilot's command. As the shaft moves it moves the lever mechanism, closing the solenoid valve and stopping movement of the actuator when the tail rotor blade pitch matches the control input.

Findings from the technical investigation

The tail rotor control system was first inspected at the crash site. This identified that the input lever mechanism was not attached to the control shaft. The pin, spacers and one of the locating bearings were missing from the lever. The locking nut and pin carrier were found loose in the tail rotor fairing and were bonded together (they should be separate components). The threads of the nut appeared to be undamaged. There was no evidence of the split pin, and the control shaft threaded section had moved inside the outer shaft and was no longer visible.

The control shaft, the locking nut and pin carrier, and the duplex bearing/sliding unit assembly were removed from the wreckage and inspected in detail. The locking nut on the bearing end of the control shaft was found to have a torque load significantly higher than the required assembly value. The inner races of the bearing could only be rotated a few degrees in either direction by hand. There was a build-up of black grease inside the slider unit around the inboard face of the duplex bearing. The section of the control shaft adjacent to this bearing face showed evidence of burnt-on grease and was discoloured along its length (Figure 5).

Figure 5

Duplex bearing location on tail rotor actuator control shaft after removal

The components were then inspected using a Computed Tomography (CT) Scanner. This uses x-rays to image the inside of the components, then recreates them as a 3-D model. The results showed that the nut and pin carrier were friction welded together. The threaded portion of the control shaft, at the actuator end, was inside the outer shaft and contained the remains of the split pin. The top and bottom of the split pin had been sheared off in rotation (Figure 6).

The scan of the bearing showed fractures to the bearing cages and significant damage to the surface of the inner bearing races, the damage being worse on the inboard bearing race (Figure 7) where there was also evidence of sub-surface damage.

The scan also showed evidence of debris accumulating in the bearing raceways (Figure 8).

The bearing was then removed from the sliding unit and disassembled, revealing evidence of relative rotation between the sliding unit and the bearing outer ring. The debris present on the CT scan was identified as a combination of black dust and metallic particles. No grease, in its original form, remained in the bearing. Visual inspection of the surface of the bearing races confirmed the extent of the damage seen in the CT scans.

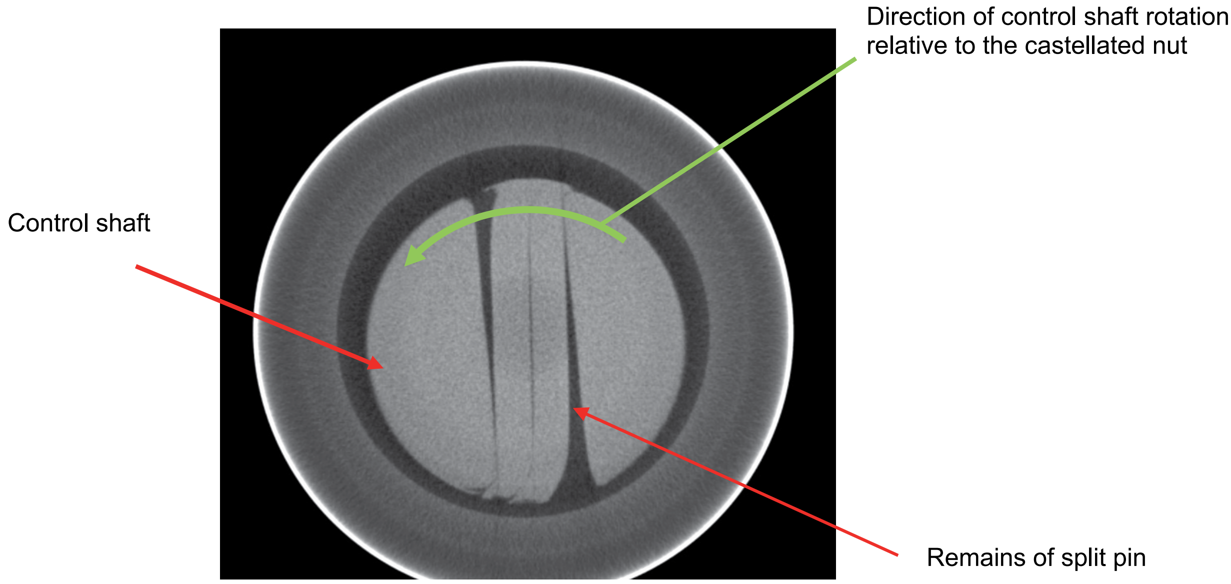

Figure 6
CT Scan through tail rotor actuator control shaft (viewed from actuator end)

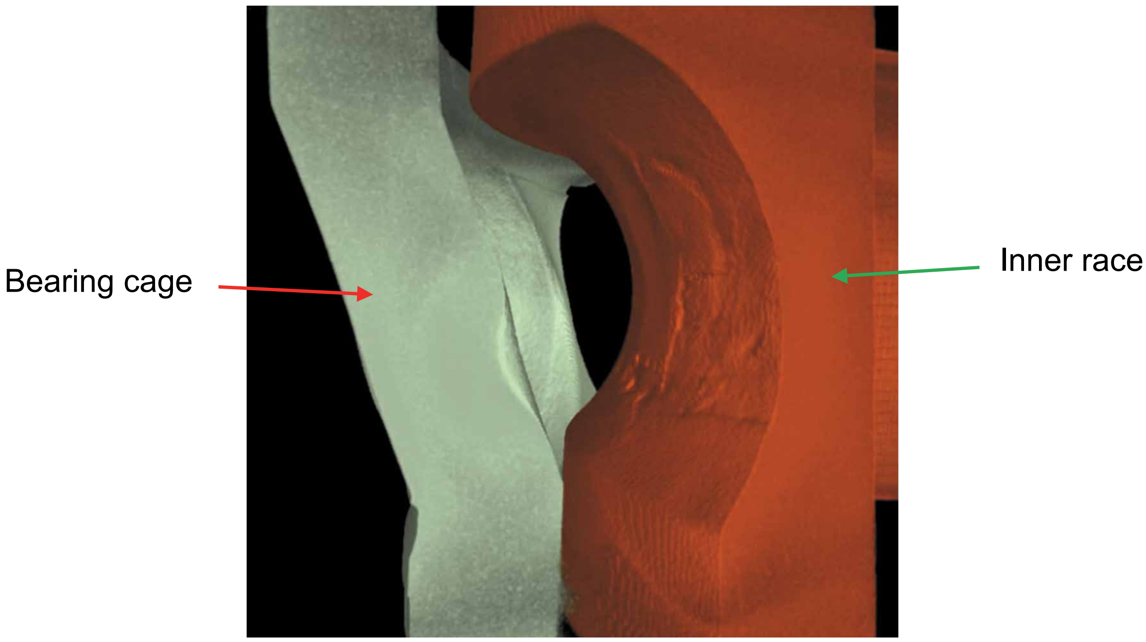

Figure 7
CT imagery of duplex bearing inboard inner ring surface damage

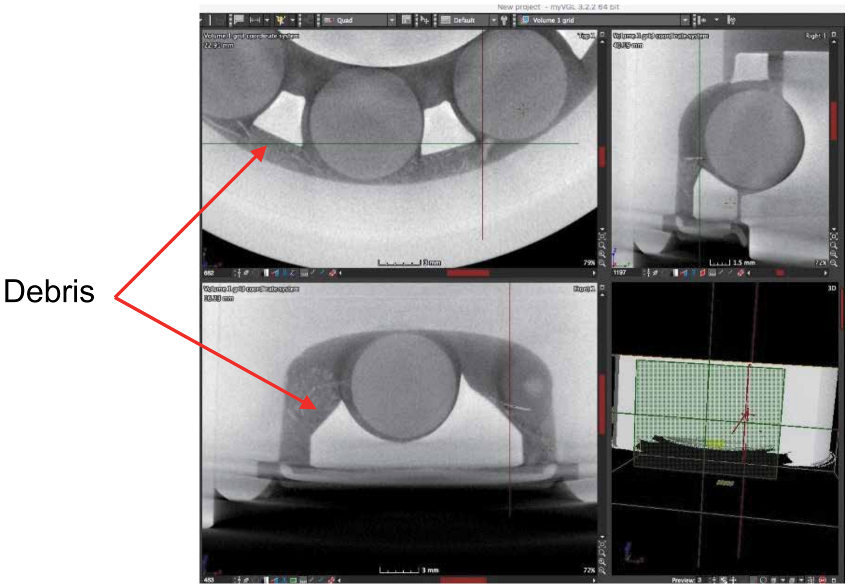

Figure 8

Scan images of duplex bearing showing raceway debris accumulation

Failure sequence

The evidence gathered to date shows that the loss of control of the helicopter resulted from the tail rotor actuator control shaft becoming disconnected from the actuator lever mechanism. Disconnection of the control shaft from the lever prevented the feedback mechanism for the tail rotor actuator from operating and the tail rotor actuator from responding to yaw control inputs. Loss of the feedback mechanism rendered the yaw stops ineffective, allowing the tail rotor actuator to continue changing the pitch of the tail rotor blades until they reached the physical limit of their travel. This resulted in an uncontrollable right yaw.

Sufficient force and torque had been applied to the castellated nut on the actuator end of the control shaft to friction weld it to the pin carrier and to shear the installed split pin. The observed condition of the duplex bearing and the increased torque load on the castellated nut that remained on the spider end of the shaft is consistent with rotation of the tail rotor actuator control shaft. Whilst the shaft was rotating and a yaw control input was applied, the shaft "unscrewed" from the nut, disconnecting the shaft from the actuator lever mechanism, and causing the nut to become welded to the pin carrier.

Safety actions

On 5 November 2018 the manufacturer of the helicopter issued Alert Service Bulletin (ASB) 169-120 for AW169 helicopters, giving instructions for a precautionary inspection of the tail rotor control assembly on all helicopters in the global fleet. On 6 November the manufacturer also issued ASB 189-213 for AW189 helicopters, which have a similar tail rotor control system.

The European Aviation Safety Agency (EASA), in its capacity as the regulator responsible for the type design approval of the AW169 and AW189, issued Airworthiness Directive 2018-0241-E dated 7 November 2018 to mandate these inspections.

On 19 November 2018 the EASA issued AD 2018-0250-E, superseding AD 2018-0241-E, to require a precautionary one-time inspection of the tail rotor duplex bearing and, depending on findings, applicable corrective actions.

On 21 November 2018 the helicopter manufacturer published Emergency Alert Service Bulletin ASB169-125 for AW169 helicopters, and ASB189-214 for AW189 helicopters, giving further instructions for a one-time inspection of the tail rotor duplex bearing. The EASA issued AD 2018-0252-E on 21 November 2018, superseding AD 2018-0250-E and mandating this inspection.

On 30 November 2018 the helicopter manufacturer published Emergency Alert Service Bulletin ASB 169-126 for AW169 helicopters, and ASB 189-217 for AW189 helicopters, introducing repetitive inspections of the castellated nut that secures the tail rotor actuator control shaft to the actuator lever mechanism, and the tail rotor duplex bearing. The EASA issued AD 2018-0261-E on 30 November 2018 mandating the repetitive inspections.

Ongoing investigation

The initiating cause and exact sequence of the failure that resulted in the loss of tail rotor control is being investigated as a priority. Work continues to identify the cause of the damage observed to the duplex bearing and to establish its contribution to the failure sequence. The AAIB is working with relevant organisations to identify any other factors that may have contributed to the loss of tail rotor control.

The other areas of investigation specified in Special Bulletin S1/2018 will continue, and the AAIB will report any significant developments as the investigation progresses.

Published 6 December 2018.

Summaries of Aircraft Accident Reports

This section contains summaries of
Aircraft Accident ('Formal') Reports
published since the last AAIB monthly bulletin.

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

Aircraft Accident Report No: 2/2018

This report was published on 21 November 2018 and is available in full on the AAIB Website www.gov.uk

Report on the serious incident to
Boeing 737-86J, C-FWGH
Belfast International Airport
21 July 2017

Registered Owner and Operator:	Sunwing Airlines Inc.
Aircraft Type:	Boeing 737-86J
Nationality:	Canadian
Registration:	C-FWGH
Place of Serious Incident:	On takeoff from Belfast International Airport
Date and Time:	21 July 2017 at 1539 hrs (all times in this report are UTC unless stated otherwise)

Introduction

The Air Accidents Investigation Branch (AAIB) became aware of this serious incident during the morning of 24 July 2017. In exercise of his powers, the Chief Inspector of Air Accidents ordered an investigation to be carried out in accordance with the provisions of Regulation EU 996/2010 and the UK Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996 and, subsequently, 2018.

The sole objective of the investigation of an accident or incident under these Regulations is the prevention of accidents and incidents. It shall not be the purpose of such an investigation to apportion blame or liability.

In accordance with established international arrangements, both the National Transportation Safety Board (NTSB) of the USA, representing the State of Design and Manufacture of the aircraft, and the Transportation Safety Board (TSB) of Canada, representing the State of Registration and the Operator, appointed Accredited Representatives to the investigation. The aircraft operator, the aircraft manufacturer, the European Aviation Safety Agency (EASA), and the UK Civil Aviation Authority (CAA) also assisted the AAIB.

Summary

At 1539 hrs on 21 July 2017, a Boeing 737-800 took off from Belfast International Airport (BFS) with insufficient power to meet regulated performance requirements. The aircraft struck a supplementary runway approach light, which was 36 cm tall and 29 m beyond the end of the takeoff runway.

An outside air temperature (OAT) of -52°C had been entered into the Flight Management Computer (FMC) instead of the actual OAT of 16°C. This, together with the correctly calculated assumed temperature thrust reduction of 48°C[1], meant the aircraft engines were delivering only 60% of their maximum rated thrust. The low acceleration of the aircraft was not recognised by the crew until the aircraft was rapidly approaching the end of the runway. The aircraft rotated at the extreme end of the runway and climbed away at a very low rate. The crew did not apply full thrust until the aircraft was approximately 4 km from the end of the runway, at around 800 ft aal.

There was no damage to the aircraft, which continued its flight to Corfu, Greece without further incident. However, it was only the benign nature of the runway clearway and terrain elevation beyond, and the lack of obstacles in the climb-out path which allowed the aircraft to climb away without further collision after it struck the runway light. Had an engine failed at a critical moment during the takeoff, the consequences could have been catastrophic.

The investigation found the following causal factors for this serious incident:

1. An incorrect OAT was entered into the FMC, which caused the FMC to calculate an N_1[2] setting for takeoff which was significantly below that required for the aircraft weight and environmental conditions.

2. The incorrect OAT was not identified subsequently by the operating crew.

3. The abnormal acceleration during the takeoff run was not identified until the aircraft was rapidly approaching the end of the runway, and no action was taken to either reject the takeoff or increase engine thrust.

The investigation found the following contributory factors for this serious incident:

1. The aircraft's FMC did not have the capability to alert the flight crew to the fact that they had entered the incorrect OAT into the FMC, although this capability existed in a later FMC software standard available at the time.

2. The Electronic Flight Bags (EFB) did not display N_1 on their performance application (some applications do), which meant that the crew could not verify the FMC-calculated N_1 against an independently-calculated value.

3. The crew were unlikely to detect the abnormally low acceleration because of normal limitations in human performance.

The investigation identified other examples of accidents or serious incidents where there was a gross failure of an aircraft to achieve its expected takeoff performance, and found that technical solutions to address this serious safety issue are now feasible.

Footnote

[1] See 1.1.3 for further information.
[2] N_1: engine fan or low pressure compressor speed.

AAIB Special Bulletin S2/2017[3], published on 20 September 2017, provided initial information on the circumstances of this serious incident, clarification about the reporting of accidents and serious incidents, and made two safety recommendations related to FMC software updates. In this report, the AAIB makes four safety recommendations: one supersedes a recommendation made in Special Bulletin S2/2017; one concerns procedures to verify engine takeoff power settings; and two concern the development of Takeoff Acceleration Monitoring Systems.

Findings

1. The crew were properly licensed and qualified to perform the flight.

2. The pilots independently calculated the correct takeoff performance using their EFBs based on the airfield ATIS and the load instruction form.

3. During pre-flight programming of the FMC an incorrect figure (-47°C) was entered into the OAT field of the N1 LIMIT page.

4. The correct figure for the assumed temperature derate (47°C) was entered into the SEL field on the N1 LIMIT page.

5. Following an operational delay and an updated performance calculation, the correct value for the new assumed temperature (48°C) was entered into the FMC, but another incorrect figure (-52°C) was entered into the OAT field of the N1 LIMIT page.

6. Although the commander felt well rested, it was possible that he was suffering from jet lag, which might have had an adverse affect on his performance when programming the FMC.

7. The incorrect value of OAT, when combined with the correct value for the assumed temperature, meant that the FMC calculated a value of N_1 for takeoff which was significantly below the value required for the aircraft weight and environmental conditions.

8. The risk controls in place did not prevent the aircraft from beginning its takeoff run with insufficient power for the aircraft weight and environmental conditions:

   a. Pre-flight performance calculations were performed correctly twice on the EFB.

   b. The FMC was programmed incorrectly twice but a crew crosscheck, if carried out, did not highlight the incorrect value of OAT or the abnormally low value of N_1.

Footnote

[3] https://assets.publishing.service.gov.uk/media/59c2302140f0b60d848fd9ad/AAIB_S2-2017_C-FWGH.pdf [accessed September 2018].

9. The FMC software on C-FWGH was at revision U10.8A, which did not include an automated crosscheck of a manually-entered OAT against the OAT sensed by the aircraft.

10. Two manufacturer's service bulletins were available which installed FMC software revision U12.0 and which introduced an OAT crosscheck that would have alerted the crew to their erroneous OAT entry. Service bulletins are not mandatory, but Boeing recommends compliance with these bulletins by January 2019.

11. The risk of this type of error leading to a serious incident or accident would be reduced if the N_1 calculated by the FMC was crosschecked with the N_1 produced by an independently-assured source, such as a performance application on an EFB.

12. There is no requirement for EFB performance applications to display N_1 on the performance calculation output page (EFBs are not regulated), and not all operators use EFBs.

13. The low takeoff thrust meant that the takeoff was abnormal in terms of:

    a. Low acceleration.

    b. Distance along the runway to achieve V_1 and V_R.

    c. Low rotation rate.

    d. Low climb rate.

    e. Marginal ability of the aircraft to stop during an RTO from V_1.

    f. Inability of the aircraft to continue the takeoff following an engine failure at V_1 without increased thrust.

14. Once the aircraft began its takeoff run with insufficient thrust, the risk controls in place did not alert the crew to act to recover the situation because, in general:

    a. Pilots are unlikely to recognise that actual acceleration is below a threshold value for a particular runway.

    b. The use of autothrust de-couples pilots from the thrust levers.

    c. Pilots are disposed only to reduce thrust to idle during takeoff (in case of RTO).

    d. Pilots remove their hands from the thrust levers at V_1.

    e. Pilots do not have to increase thrust during a takeoff in the event of an engine failure.

15. The takeoff run was significantly longer than expected and the aircraft lifted off at the extreme end of Runway 07.

16. The aircraft struck a Runway 25 supplementary approach light which was in the stopway, 29 m beyond the end of the Runway 07.

17. Thrust was not increased until the aircraft was approximately 4 km from the end of the runway and 800 ft aal.

18. Once the thrust was increased the aircraft climbed away normally and the flight proceeded to CFU without further incident.

19. There was no damage to the aircraft.

20. There were no injuries.

21. The investigation found no faults with the aircraft which could have contributed to this serious incident.

22. Had the crew of C-FWGH been alerted to the abnormally low acceleration while still at low speed, the takeoff could have been rejected and the aircraft brought to a halt well before the end of the runway.

23. Previous attempts to develop technical specifications for TOPMS have failed because the work tended to focus on the more sophisticated options, which were complex in nature.

24. TAMS reduces the complexity of the problem by only considering acceleration during the early stages of a takeoff, and the solution is data-driven.

25. The TAMS trialled in this investigation would have alerted the crew to the abnormally low acceleration during this takeoff.

26. There is currently no technical specification or certification standard for either TOPMS or TAMS.

27. Safety margins built into TODR calculations, which cater for normal variations in operational performance, are rendered unreliable or ineffective when there is a data entry error because of the random (and possibly gross) nature of the effect.

28. It was the benign nature of the runway clearway and terrain elevation beyond, and the lack of obstacles in the climb-out path, which allowed the aircraft to climb away without further collision after it struck the runway light.

29. Staff at BFS ATC attempted to contact the crew through the watch manager at ScACC. The crew were finally contacted by the operator when the aircraft was on the ground in CFU.

30. Although BFS ATC filed an MOR, neither the commander, aircraft operator, nor tour operator informed the AAIB directly as they were required to do for a serious incident of this nature.

Safety Recommendations and Actions

Safety Recommendations

Two Safety Recommendations were made in Special Bulletin S2/2017, published in September 2017, which are reproduced below along with the response from the addressee:

Safety Recommendation 2017-016

It is recommended that the Federal Aviation Administration mandate the use of Flight Management Computer software revision U12.0, or later revision incorporating the outside air temperature crosscheck, for operators of Boeing 737 Next Generation aircraft.

The FAA, in its initial response to this recommendation, stated that there might be hardware and fleet compatibility issues and cost implications for some operators which it would need to understand before responding substantively. It undertook to provide an updated response by December 2018.

The AAIB classified this response as: Superceded.

Safety Recommendation 2017-017

It is recommended that The Boeing Company promulgates to all 737 operators the information contained within this Special Bulletin and reminds them of previous similar occurrences reported in the Boeing 737 Flight Crew Operations Manual Bulletin dated December 2014.

On 13 July 2018, Boeing issued a Multi Operator Message which described the potential for FMC OAT entry errors referring to this, and other serious incidents. The message also reminded operators of the associated service bulletins recommending the installation of revision U12.0 of the FMS OPS software and BP15 update of the CDS[4]. The message reminded operators that the final compliance date for the recommended action was 10 January 2019.

The AAIB classified this response as: Adequate – Closed.

Footnote

[4] See 1.16.3.2.

The following Safety Recommendation is made in this report, which supersedes Safety Recommendation 2017-016:

Safety Recommendation 2018-012

It is recommended that the Federal Aviation Administration mandate the use of Flight Management Computer OPS software revision U12.0, or later, and the Common Display System Block Point 15 update where this is required, to enable the outside air temperature crosscheck on all applicable Boeing 737 aircraft.

The following additional Safety Recommendations are made in this report:

Safety Recommendation 2018-013

It is recommended that Boeing Commercial Airplanes give guidance to operators of Boeing 737 aircraft on how they might verify the FMC-calculated value of N_1 against an independentlycalculated value.

Safety Recommendation 2018-014

It is recommended that the European Aviation Safety Agency, in conjunction with the Federal Aviation Administration, sponsor the development of technical specifications and, subsequently, develop certification standards for a Takeoff Acceleration Monitoring System which will alert the crew of an aircraft to abnormally low acceleration during takeoff.

Safety Recommendation 2018-015

It is recommended that the International Civil Aviation Organization note the conclusions of this report and introduce provisions addressing Takeoff Acceleration Monitoring Systems.

Safety Action

This report presents the following safety action:

Safety Action by the aircraft operator

As a result of the initial findings of this investigation into this serious incident the aircraft operator began a programme of upgrading their fleet of B737s to FMC Update 13 and CDU BP15 in order that the OAT alerting function would be available. They also updated their EFB software to display N_1 and included a crosscheck of this figure in their SOPs.

Safety Action by the UK CAA

After this serious incident, the CAA amended MATS Part 1 such that the senior controllers at ATSUs providing air traffic services at an aerodrome are required to notify the AAIB by telephone as part of their initial reporting actions following an aircraft accident or serious incident.

The CAA also amended CAP 797, *Flight Information Service Officer Manual,* to require air traffic services personnel to notify the AAIB by telephone as part of their initial reporting actions following an aircraft accident or serious incident.

In addition to the action above, a link to Regulation (EU) 996/2010 was put into MATS Part 1 and CAP 797 pointing to typical examples of what are likely to be classified as serious incidents.

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.

ACCIDENT

Aircraft Type and Registration:	EMB-145EP, G-CKAG
No & Type of Engines:	2 Rolls-Royce AE3007A1 turbofan engines
Year of Manufacture:	1998 (Serial no: 145118)
Date & Time (UTC):	22 December 2017 at 1137 hrs
Location:	Runway 27 at Bristol Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 22
Injuries:	Crew - None Passengers - None
Nature of Damage:	Left main landing gear fairing strut broken; wheel rims and tyres damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	8,600 hours (of which 5,100 were on type) Last 90 days - 97 hours Last 28 days - 51 hours
Information Source:	AAIB Field Investigation

Synopsis

The flight crew were conducting an ILS Category II[1] approach and landing on Runway 27 at Bristol Airport. On touchdown they noticed that the aircraft de-rotated sharply. The pilot flying (PF) was unable to maintain directional control during the landing roll and the aircraft ran off the left side of the runway onto the grass. At some point during the landing the throttles were moved forward, reducing the rate of deceleration. As the aircraft left the paved surface the crew realised that the landing had been carried out with the Emergency/Parking brake set. The aircraft may have remained on the runway surface but for the addition of forward thrust during the landing roll.

Following the accident, the operator introduced a revision to the Landing Checklist to require the handling pilot to confirm the parking brake is OFF.

History of the flight

The flight crew reported for duty at Bristol Airport at 0540 hrs for a flight from Bristol Airport to Frankfurt and back; the accident occurred on the return sector. Occupying the left seat was a captain-under-training, new to both the operator and the aircraft type. Occupying the right seat was a company training captain, who was the commander of the flight.

Footnote

[1] Decision height lower than 200 ft but not lower than 100 ft and RVR of not less than 350 m.

The outbound sector to Frankfurt was uneventful with the captain-under-training designated as PF; a Category II approach and landing was carried out. The return sector was also flown by the captain-under-training and a Category II approach and landing was planned for Runway 27 at Bristol due to the meteorological forecast for fog.

The approach briefing was started by the captain-under-training during the descent at 1113 hrs but, just as he began, the aircraft came within range of the ATIS broadcast. The briefing was deferred while the crew noted the 1050 hrs Bristol ATIS: Runway 27, surface damp, low visibility procedures in force, surface wind variable 3 kt, visibility 150 m, Runway Visual Range (RVR) Runway 27 400 m, fog, sky obscured, temperature 10°C, dewpoint 10°C and pressure 1035 hPa. The briefing resumed but was then delayed further by a series of interruptions for gathering additional weather information, ATC instructions and cabin crew communications.

At 1120 hrs, London ATC instructed the aircraft to descend to FL160 and reduce speed to 250 kt, and the crew were advised to expect holding for arrivals at Bristol. At 1125 hrs, the aircraft was transferred to Bristol ATC and, after confirming that an approach in the prevailing weather conditions was acceptable, the crew were advised they were number one for the approach. The aircraft was descending through FL 140 and Bristol ATC asked if 30 track miles was sufficient distance. The crew discussed the distance and accepted the routeing.

The PF decided to deploy the speed brake to lose the excess height and announced: "SPEED BRAKE COMING ON". However, the speed brake parameter recorded on the FDR did not indicate that the speed brake had deployed. The approach briefing was completed at 1127 hrs.

At 1129 hrs, each pilot carried out a radio altimeter test generating a sequence of aural alerts, which interrupted crew communications over the next two minutes. During this time the commander commented that engaging speed mode and deploying speed brake was the quickest way to lose height. The PF acknowledged and responded that it was already open, but his reply came just as the commander responded to an ATC call and went unnoticed.

At 1130 hrs, the commander suggested directly that the speed brake should be used and the PF responded: "IT IS, OH NO ITS NOT, WHO CLOSED THAT?". He deployed the speed brake, which now indicated on the FDR data, and asked the commander to request another five track-miles from ATC.

The aircraft was routed by ATC through the extended runway centreline to provide the requested additional distance before being turned to intercept the ILS localiser from the south. The descent checklist was completed and the approach checklist was started. At the second item, '*Seatbelt Sign ….ON',* the commander instead read out "PARK BRAKE" and the PF responded "ON" (Figure 1). This was immediately followed by an instruction from ATC to descend to 2,500 ft and turn right heading 360°. The crew followed the ATC instructions and then, because of the interruption, the commander restarted the approach checklist from the beginning, this time completing it as published.

APPROACH

Altimeters........................LP/RP XXXX SET & X-CHKD
Seatbelt Sign....................ON
Fuel Crossfeed.................OFF
Cabin Report....................RECEIVED

Figure 1

Approach checklist

The approach continued, the required visual references for landing were achieved and, at 80 ft agl, the PF disconnected the autopilot in accordance with procedures for a manual landing.

On touchdown, the PF noticed an unusually rapid de-rotation and then found he had difficulty in maintaining directional control despite using corrective rudder. The commander thought that the PF might be "riding the brakes", a common error during training, and advised him to take his feet off the brakes. The PF, still unable to control the aircraft, attempted to use the steering tiller but when the commander noticed this he called out "NO NO DON'T USE THE NOSEWHEEL STEERING". The PF recalled afterwards that he had considered using asymmetric thrust but did not think he had moved the thrust levers. The aircraft ran off to the left side of the runway, at which point the commander realised the parking brake was ON, and onto the grass, continuing for 120 m before coming to a halt. In the confusion on the runway after touchdown, the thrust levers had been advanced and as the aircraft stopped the PF, realising they were forward, closed them.

The crew reviewed the situation, using their company failure management process, to stop, think and consider the options. They assessed that the aircraft was in a safe condition and decided not to initiate an evacuation. The commander contacted ATC, the initial post-accident communications are shown at Table 1.

Time	Station	Transmission
1137:52	Aircraft (commander)	"ER [CALLSIGN] ONE EIGHT TWO TWO WE'RE OFF THE RUNWAY"
1137:59	ATC	"[CALLSIGN] ONE EIGHT TWO TWO COPIED [UNINTELLIGIBLE] GOLF X-RAY"
1138:03	Aircraft (commander)	"NEGATIVE WE'RE OFF THE RUNWAY"
1138:07	ATC	"ROGER"
1138:16	ATC	"[CALLSIGN] ONE EIGHT TWO TWO YOUR APPROXIMATE POSITION"
1138:20	Aircraft (commander)	"ER JUST OPPOSITE FOXTROT"
1138:21	ATC	"ROGER EQUIPMENT ON THE WAY"

Table 1

Post-accident communications

While the commander was communicating with ATC, the captain-under-training made an announcement to the cabin to advise the passengers to remain seated. The crew then carried out their normal shutdown procedures and started the Auxiliary Power Unit (APU).

Once ATC realised that the aircraft had left the paved surface, the controller activated the crash alarm and alerted the Rescue and Fire Fighting Services (RFFS). ATC asked the commander whether they were evacuating the aircraft. He responded that they were not and advised that the engines were shut down with the APU running. The RFFS vehicles arrived at the aircraft within three minutes of the accident and two-way communications were established on the dedicated frequency 121.6 MHz.

The captain-under-training had a good recollection of events during the flight and soon after the aircraft had come to rest identified that he must have set the parking brake instead of deploying the speed brake. He could not recall having increased the thrust during the landing roll.

Meteorology

A ridge of high pressure extended across the UK and a slow moving, weak occlusion affected the southern part. The slack pressure gradient gave rise to a light and variable surface flow around Bristol Airport.

The terminal area forecast for Bristol Airport, issued at 0505 hrs on 22 December 2017 was: surface wind from 240° at 5 kt, visibility 300 m, fog, overcast cloud on the surface, with temporary changes in conditions.

The meteorological report from Bristol Airport issued at 1120 hrs was: surface wind variable at 2 kt, visibility 300 m, Runway 27 visibility 500 m, fog, sky obscured, temperature 10 °C, dewpoint 10 °C and pressure 1035 hPa.

Airfield information

Bristol Airport is the ninth largest UK airport in terms of number of movements of Commercial Air Transport aircraft and in terms of passenger numbers per annum.

The frequency of the implementation of Low Visibility Procedures at Bristol Airport is not recorded. Surface Movement Radar is not installed at the airport and in foggy conditions ATC personnel in the visual control room may not be able to see a landing aircraft. The airport Manual of Air Traffic Services (MATS) Part II includes a Fog Search Plan which is activated when: '*there is a suspicion of an Aircraft Accident/Ground Incident or in the event of a sudden and sustained loss of communication between ATC and an aircraft'.* Once activated no further aircraft movements are authorised on the manoeuvring area and a search can begin. The aerodrome is divided into discrete search zones with the primary one being the runway strip. ATC provides all available information to the RFFS to assist them in the decision as to which locations to search.

Personnel information

The captain-under-training had recently joined the operator having previously been qualified on the SAAB 2000 with another operator. He had completed 17 hours of flight time on the Embraer 145; this was his eighth sector, his fourth Category II approach and his second in actual low visibility conditions. His training had progressed well up to the time of the accident.

Recorded information

More than two hours of audio and 50 hours of data were recovered from the aircraft CVR and FDR respectively. Other sources of recorded data supporting the investigation were the airfield recordings of radio transmissions and airfield primary radar, airfield CCTV cameras, and NATS Clee Hill secondary radar. Some of the content of the recordings are reflected in other parts of the report.

Figure 2 shows pertinent extracts from the CVR and FDR overlaid on the radar track of the aircraft. There was significantly more RT than shown due to the weather, and ATC vectoring and management of another aircraft with marginal capability given the runway visibility. There were also significantly more crew communications than shown relating to checklists, minima, alternate airports and other operational issues.

There was no recorded parameter for the parking brake. At the point of ATC handover to Bristol, the PF expressed the intent to set the speed brake but the recorded parameter for the speed brake did not change from closed.

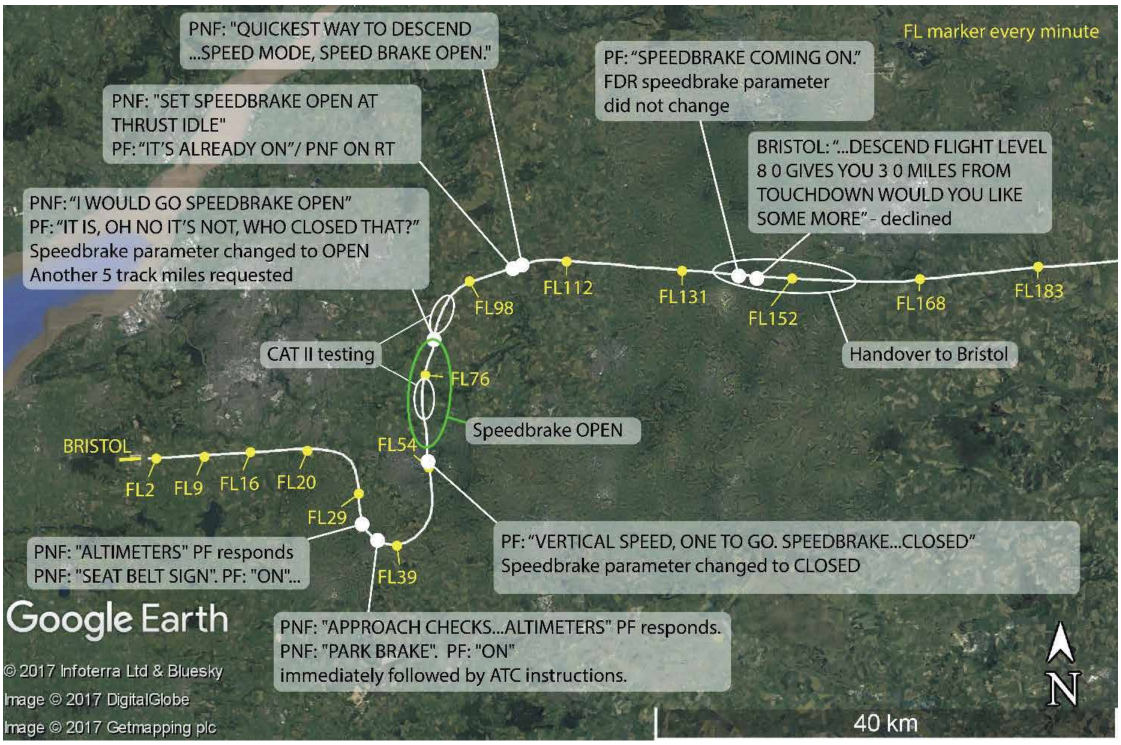

Figure 2

Pertinent extracts from the CVR and FDR overlaid on the aircraft radar track

Figure 3, shows pertinent extracts from the CVR and FDR during the landing. The autopilot was disengaged at about 80 ft aal and the aircraft touched down on the centreline. The aircraft started tracking right of the runway centreline and opposite rudder was used. The aircraft heading swung to the left of the centreline, skidding approximately along the centreline as indicated by the localizer (the antenna is in the tail). Right rudder was applied but the yawing to the left continued. With a heading of between 15 and 30° to the left of the runway heading the thrust levers were advanced, slightly more left thrust than right. The aircraft carried on yawing to the left and the previous longitudinal deceleration was eroded. The divergence from the runway heading peaked at approximately 50° before starting to reduce, but with thrust applied the aircraft tracked to the left and went off the side of the runway with a groundspeed of approximately 45 kt. The aircraft was decelerating and as the groundspeed reduced to approximately 20 kt the thrust levers were brought back to IDLE. The aircraft came to a stop about three seconds later. The crew identified that the parking brake was applied as the aircraft left the runway.

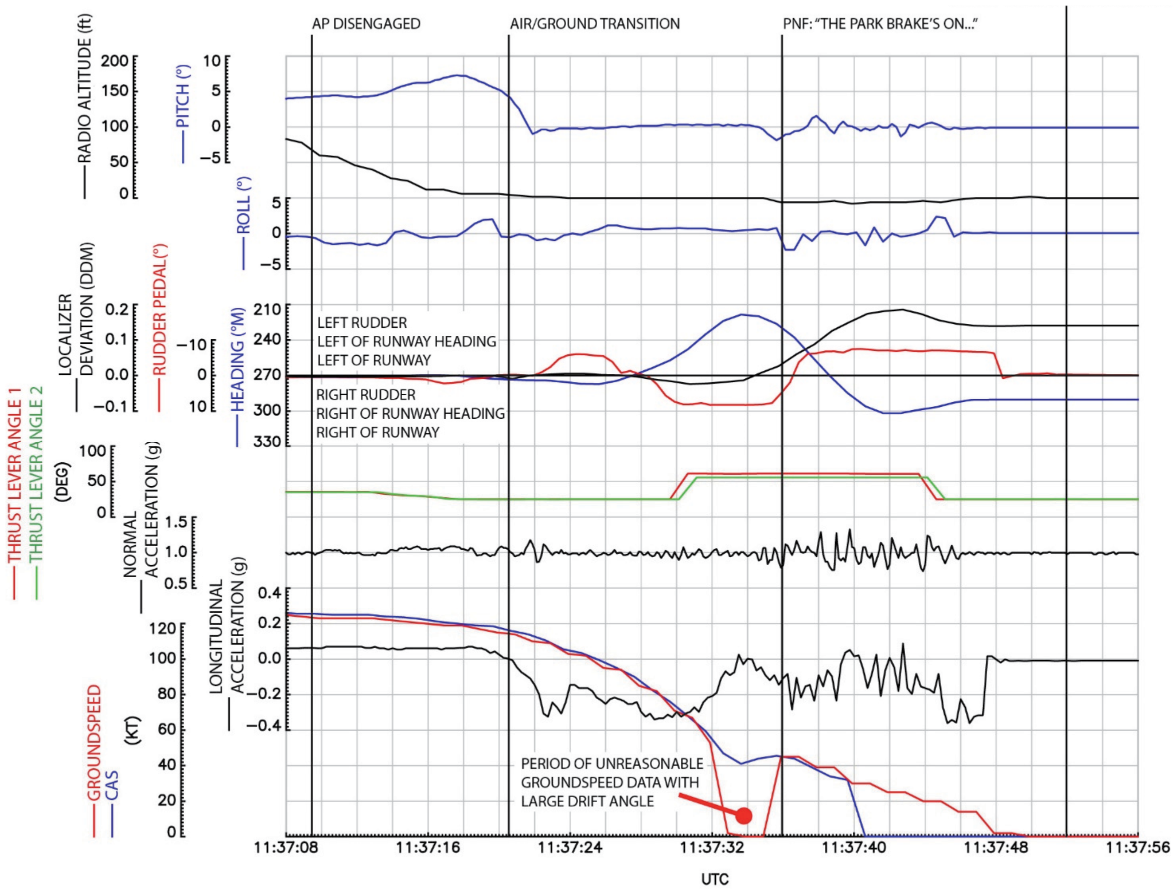

Figure 3

Pertinent extracts from the CVR and FDR during the landing

CCTV

There were various CCTV cameras around the airfield covering the path taken by the aircraft during the landing roll but, despite being in the camera field of view, the aircraft was not always visible in the recordings because of the poor visibility.

Accident site and aircraft damage

Figure 4 shows the aircraft where it had come to rest and the poor visibility shortly after the time of the accident. Marks and rubber fragments on the runway defined the touchdown point, approximately 468 m from the threshold, and showed the aircraft initially tracking on the runway centreline before drifting first slightly to the right of the centreline and then veering left over 280 m. Overheated fragments of vulcanised rubber were found at various points along the runway, with a cluster of larger fragments approximately 400 m from the touchdown point over an area of approximately 40 m by 3 m. After this point there were faint but reasonably clear lines left on the runway surface made by the wheel rims up to the point where the aircraft left the runway and continued onto the grass.

Figure 4
G-CKAG off the runway

Once on the grass the aircraft left deep furrows in the top soil up to where it traversed a disused taxiway with further deep furrows beyond leading to its final position. The distance from where the aircraft left the main runway until coming to stop was approximately 120 m. Marks showed that it had 'fishtailed' from right to left whilst on the grass. The path of the aircraft from the runway is shown in Figure 5.

The aircraft stopped on a heading of 296º(M) and all four main wheels were buried up to their axles. The components attached to the front of the left and right main landing gear were clogged with soil and turf. Apart from the detached and loose lower fairing mounting strut on the left landing gear, there appeared to be no other damage. The nose landing gear, fuselage, wings and engines were undamaged although the left wing leading edge had soil residue along its length. Figure 6 shows the extent that aircraft main wheels and landing gear had dug in.

The aircraft was lifted using a combination of hydraulic jacks and air-bags with excavation beneath the main wheels.

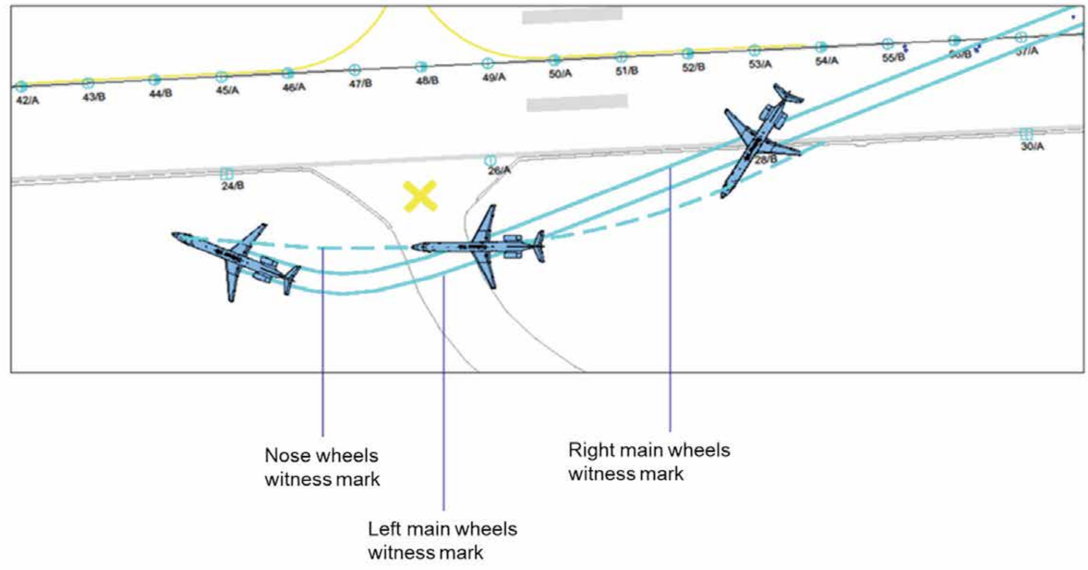

Figure 5

The aircraft's path leaving the runway

Figure 6

The extent of the entrapment of the main wheels and landing gear
(left side shown, the right side was similar)

Wheels and tyres

The wheels were removed and examined on site. The damage to all the main wheel tyres was similar and they were all deflated.

The wear pattern on the tyres showed the tread surface abraded through leaving ragged edges and missing material. Abrasion then carried on symmetrically though the sidewalls over an approximately 140º arc down to the wheel rims. There was also abrasion of some of the wheel rims where they had contacted the runway surface. None of the tyre beads de-seated and the fusible plugs and valves were not affected. Figure 7 shows the damage to one of the main wheel and tyre assemblies. The other main wheels and tyres exhibited the same extent of damage.

Figure 7

Main wheel and tyre damage

The brake packs were examined and found to be within wear limits and undamaged. The brake hydraulic pipes were undamaged and free from leakage and the anti-skid system wiring and associated components were intact.

Cockpit controls

The aircraft had been shut down and made safe by the crew with the parking brake left in the OFF position. During examination of the aircraft, the parking brake was operated and, with aircraft electrical power on, the parking brake indicator on the centre panel illuminated. However, the nomenclature on the light did not appear to be as well defined as would be expected, consistent with one of its filaments having failed. Figure 8 shows the parking brake indicator.

Figure 8

Parking brake indicator

Aircraft information

The Embraer 145 is a twin-engine, pressurised fixed-wing aeroplane designed for short haul passenger operations. Thrust reversers are optional equipment and were fitted to G-CKAG.

Spoiler system

The aircraft is fitted with a system of four spoilers designed to slow the aircraft in flight and reduce lift on the ground to increase braking effectiveness.

The hydraulically actuated spoilers are installed on the upper wing surface in front of the outboard and inboard flaps. The outboard spoilers provide both speed brake and ground spoiler functions whilst the inboard only provide a ground spoiler function.

The speed brake function is electrically controlled by a small lever next to the power levers on the left side of the centre console (Figure 9). A green 'OPN' caption is displayed on the lower right area of the central Engine Indication and Crew Alerting System[2] (EICAS) screen when any of the surfaces are open.

Landing gear

The aircraft is fitted with retractable tricycle landing gear with a steerable nose wheel. The main landing gear is fitted with double wheel and tyre assemblies. The main wheels are mounted on a fixed axle and their bearing design allows them to rotate independently of

Footnote

[2] EICAS provides flight crew with a three-level alerting and message indication system: warning, caution and advisory.

each other. Shock absorption is carried out by a conventional air-oil strut on the nose landing gear and cantilever air-oil strut with trailing link assemblies on the main landing gear. The main wheels were fitted with cross-ply tubeless tyres with a speed rating of 210 mph (182 kt).

Braking system

The aircraft is fitted with multiple disc brake packs on all four main wheels with brake actuation pressure supplied from hydraulic Systems One and Two. The outer main wheel brakes are powered by System One and the inner main wheel brakes by System Two. All are controlled by an electronic brake control unit which takes its inputs from the toe brake levers fitted on the rudder pedals. The system includes an electronic anti-lock system. Friction pad wear indicator pins are fitted to all four brake pack assemblies.

The aircraft is fitted with a combined parking and emergency braking system. This consists of an accumulator which is charged and kept at working pressure by System Two. Pressure from the accumulator is supplied to all four main wheel brakes. The emergency and parking brake system is controlled and operated by a handle, painted with yellow and black stripes, on the left side of the centre console just behind the speed brake lever (Figure 9). When emergency braking is required the handle is pulled upwards and can be modulated to apply varying pressure to the main wheel brakes as required. This action opens and closes a variable port valve which allows pressure from the parking brake accumulator into the system. When parking brake is required, the handle is pulled fully up and twisted anti-clockwise to lock it in position. This opens the valve fully and traps pressurised hydraulic fluid in the system which holds the brakes on. This system bypasses the brake control unit and the anti-skid system is not available during parking or emergency brake use. The accumulator is designed to allow six complete actuations of the emergency brake system and can hold the parking brake on for up to 24 hours. The parking brake emergency function requires the system to be a simple design without the inhibition of interlocks linked to other landing gear and braking systems within the aircraft. This ensures the emergency brake is always available and cannot be affected by malfunctions of associated systems, and hence the parking brake can be applied with the landing gear retracted.

Apart from the extended position of the parking brake handle when the parking brake is applied, the only other brake condition indication is on a small illuminated indicator on the instrument panel marked BRAKE ON. Figure 9 shows the location of the controls on the centre console and Figure 10 shows the parking brake in the ON condition.

Figure 10 shows the left seat in its rearwards position. When the seat is towards its fully forward position the parking brake handle is out of the seat occupant's direct line of sight and is likely to be operated by 'feel'. When the aircraft is on the ground with the parking brake set to ON there is a warning feature built into the system which displays an EICAS caution NO TAKEOFF CONFIG if the power levers are advanced to 60%. This system does not apply when the aircraft is airborne.

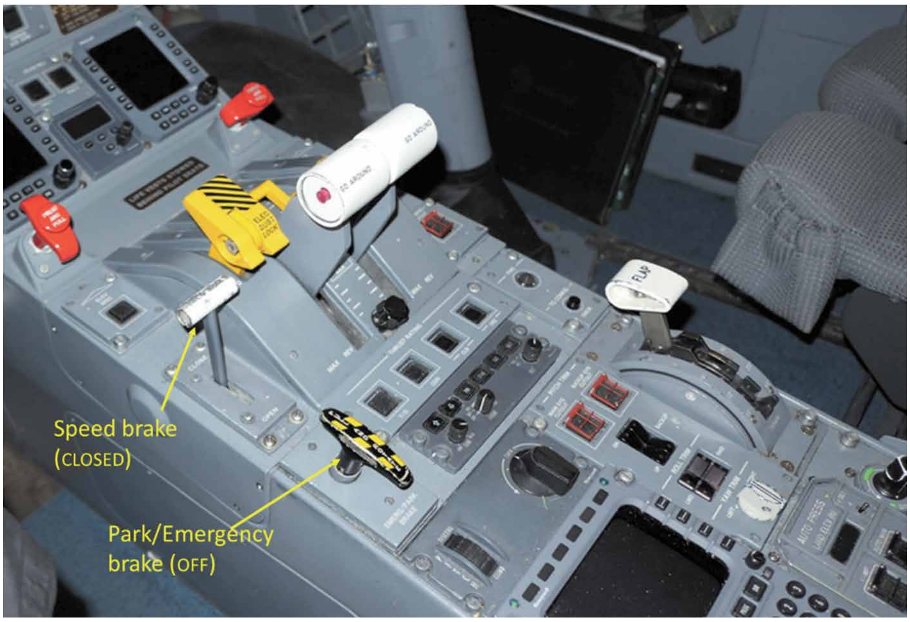

Figure 9

Location of the controls on the centre console (viewed from the left)

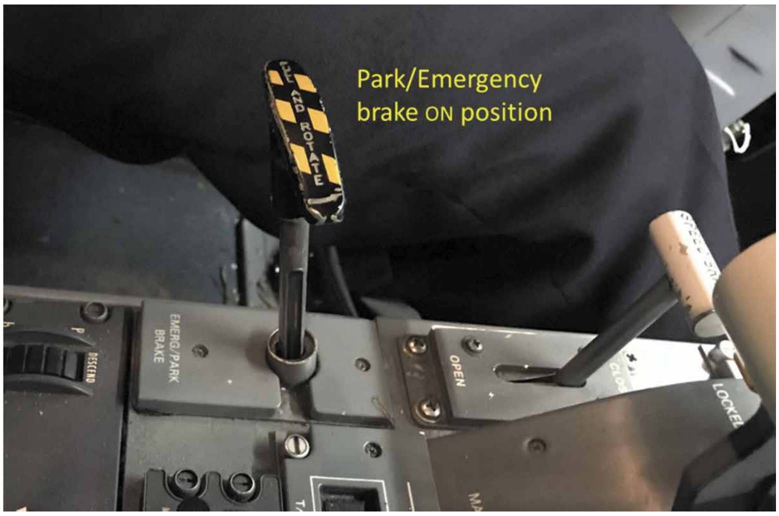

Figure 10

Parking/Emergency brake ON (viewed from the right, seat in most rearwards position)

The manufacturer's aircraft systems safety case classified the severity of landing with the parking brake on as major but the likelihood that it would happen due to a system fault was determined as 1 in 10^{-9} flight hours (extremely improbable) and therefore the risk was considered acceptable. The inadvertent selection of the parking brake while airborne was not considered as part of the safety case and the manufacturer advised the AAIB that '*it does not have a plan to conduct a system review related to the parking brake status.*'

Dependent on the aircraft build standard there are two different locations, both on the centre panel, for the parking brake ON indication. The first, as fitted to G-CKAG, is on the lower right section of the centre panel and the alternative, to accommodate the introduction of a dual FMS configuration for the newer aircraft, is higher up on the centre panel adjacent to the landing gear selector lever.

Certification standard

The EMB-145 received its original Type Certificate from Centro Tecnico Aeroespacial (CTA), Brazil National Aviation Authority, in November 1996. The Federal Aviation Administration's (FAA) official type certification was in December 1996 and European type certification was in May 1997.

Federal Aviation Administration (FAA) Advisory Circular (AC) AC No: 25 .1309-1A describes various acceptable means for showing compliance with the requirements for FAA certification. This includes the FAA Fail-Safe Design concept which uses a set of design principles to ensure a safe design and is reflected in European Aviation Safety Agency Certification Specifications for Large Aeroplanes, CS-25. One of these principles is: '*Error-Tolerance that considers adverse effects of foreseeable errors during the airplane's design, test, manufacture, operation, and maintenance.*'

Weight and balance

The aircraft had a calculated takeoff weight of 17,865 kg. Its maximum landing weight was 18,700 kg and at the time of the accident the aircraft weight was approximately 16,150 kg. The CG was within limits and the aircraft landed with approximately 1,700 kg of fuel. The aircraft essential documents were all in date and the technical log showed nothing of any relevance to the accident.

Human factors

Civil Aviation Authority publication '*CAP 737 Flight-crew human factors handbook'* identifies 'slips' and 'lapses' as unintended actions or omissions and 'mistakes' as intended, but mistaken, actions.

Cognitive intrusion speech errors

According to Harley (2014)[3] there are many different types of speech error. Cognitive intrusion errors occur when material unrelated to the speech being produced intrudes into it. The names of objects or words noticed in the outside environment can intrude into speech. Internal thoughts not related to the intended speech can also intrude. People monitor their speech but not perfectly accurately. In many cases, when finishing speaking, a person may not be aware that they have made an error.

Pincott (2012)[4] stated that speech errors are very common. For every 1,000 words spoken, an individual may make one or two errors. Every day, most people make between 7 and 22 verbal slips. Stressors, such as distraction or time pressure, make verbal slips more likely.

Footnote

3 Harley, T.A. (2014) The psychology of language: From data to theory 4th edition. Routledge: Abingdon.
4 Pincott, J.E. (2012). Slips of the Tongue. Psychology Today. March 2012.

Organisational information

The training captain advised the AAIB that it was common practice, but not a Standard Operating Procedure (SOP), for the pilot flying to announce use of the speed brake, to keep the pilot monitoring informed.

Several of the operator's aircraft are fitted with thrust reversers, including G-CKAG, but because the greater number of aircraft in the fleet do not have them, their use is prohibited.

Since the accident, the operator has introduced a revision to the Landing Checklist in their Operations Manual which requires the handling pilot to confirm the parking brake is OFF.

Previous similar events

Landing with parking brake set

The aircraft manufacturer advised that within the ERJ family (E135/140/145) there had been two previous instances in which a landing occurred with the Emergency/Parking Brake set[5]. Neither of these incidents was investigated because neither resulted in a runway excursion. One of the incident aircraft was equipped with the original panel layout (the same as G-CKAG), and the other was equipped with the newer panel layout, with the parking brake light located higher on the centre panel and adjacent to the landing gear selector.

The AAIB investigated an incident to Airbus A319-131, registration G-DBCI, which occurred on 24 January 2007 (AAIB Bulletin 12/2008), where the parking brake was inadvertently selected to ON when the intention was to select landing flap. All four mainwheel tyres deflated on landing, but the aircraft remained on the runway surface. The Flight Warning Computer (FWC), as fitted to G-DBCI at the time, did not provide a master caution light or activate an audible 'attention getter' tone for Park Brake set in flight. For aircraft fitted with a later standard of FWC, and for all subsequent FWC standards, a master caution light and audio alert are generated if the Park Brake is set in flight.

Selection of wrong control

On 31 March 1986 and 30 June 1987, there were two similar incidents of double engine flameouts on Boeing 767 aircraft during the initial climb phase after takeoff. Both incidents were attributed to the pilot's selection of the two engine fuel control switches to OFF instead of the intended selection of the engine electronic control (EEC) switches. The switches were dissimilar in shape and action but located close to each other, on the console aft of the thrust levers. The engines were subsequently restarted in flight.

The AAIB investigated two events in February 2016 in which flap was retracted shortly after takeoff instead of the landing gear being selected UP. The location, shape and feel of the respective controls are different, but the mis-selections still occurred.

Footnote

5 MSN 145-0025 / August 24, 2000 / Newark, NJ, USA and MSN 145-0521 / August 08, 2008 / Nashville, TN, USA.

Analysis

Conduct of the flight

The crew anticipated that a Category II approach would be required and planned accordingly. However, on arrival in the Bristol area the expected holding was cancelled and the approach timeframe thereby shortened. Also, the approach briefing was delayed until after the ATIS was available and was then interrupted several times. Thus, although not unduly rushed, the crew requested additional track mileage and the approach briefing was conducted with numerous interruptions. Despite this the pre-landing checks were completed, the approach was stable, the required visual references for landing were acquired and a normal touchdown was achieved.

Effect on the wheels and tyres

The material evidence supported the conclusion that the aircraft landed with all the main wheel brakes locked on which did not allow any rotation of the main wheels.

The crew noted a more rapid than normal de-rotation on touchdown consistent with the effect of higher drag loads imparted by the tyres as they contacted the runway surface. The small overheated tyre material 'rubbings' suggested the tyres did not immediately burst or deflate on touchdown. However, the cluster of larger fragments and ply material approximately 400 m from touchdown suggested that all the tyres burst either simultaneously or in very quick succession at that point. This left the sidewalls to take the weight and abrade uniformly down to the wheel rims, evidenced by the marks left on the runway, until the aircraft traversed on to the grass.

Effect of increased thrust

During the skid the aircraft was directionally unstable as shown by it drifting to the right and then to the left of the runway centreline. The action of increasing the thrust on the runway exacerbated the loss of directional control and probably led to the runway excursion because, when thrust was applied, the nose of the aircraft was pointing to the left of the runway centreline. It might have been intended as an attempt to maintain directional control by using asymmetric thrust but the captain-under-training did not recall having moved the thrust levers. It could also have occurred inadvertently through a biomechanical reaction as the aircraft decelerated. The increased thrust reduced the deceleration and, with the nose pointing to the left, applied a thrust vector which took the aircraft further from the runway centreline. The interaction between the thrust, damaged wheels and the soft ground exacerbated the tendency of the aircraft to 'fishtail' before it eventually came to a stop.

Inadvertent parking brake application

Inadvertent application of the parking brake in flight is possible using the normal action of the handle, and there are no mechanical interlocks to prevent the wheel brakes locking the mainwheels. The Emergency/Parking Brake handle has its own unique action and has a different appearance, feel and action to the nearby speed brake lever, and these characteristics should reduce the likelihood of inadvertent parking brake application in flight.

Once the parking brake has been inadvertently set, the extended position of the handle and the BRAKE ON indication light may alert crews to the condition. In this event, however, neither the extended handle nor the partially lit BRAKE ON light were noticed.

On G-CKAG, the BRAKE ON light is situated out of the normal field of view of a pilot in the right seat. For some other variants of the type it is situated higher on the centre panel, next to the landing gear selector lever and closer to the normal field of view, thereby providing an additional opportunity to notice that the light is on when lowering the landing gear. Although this is likely to be a more effective position, the aircraft in one of the two previous events recorded had this configuration. Thus, there was insufficient evidence to draw conclusions about the effectiveness of the different panel layouts in preventing this type of accident.

It is not anticipated that a parking brake will be selected in flight and yet it has happened on three recorded occasions, each resulting in a landing with the parking brake applied. This suggests that the design of the Emergency/Parking brake handle and BRAKE ON light do not function as effective risk controls on all occasions. The aircraft systems safety case conducted by the manufacturer classified the severity of landing with the parking brake on due to a system fault as 'major' but with a likelihood classified as extremely improbable; the overall risk was classified as 'acceptable'. There was no consideration given to the possibility that the parking brake would be applied before landing because of an operational error.

The design requirement for FAA and EASA type certification is to consider possible system failure modes including the adverse effects of foreseeable errors during operation. This report has shown that inadvertent application of the parking brake does occur during operation, but there was not enough evidence to quantify the likelihood and, therefore, the risk associated with this type of operational error. Further, it was probably the application of power while the aircraft was on the runway which caused the aircraft to leave the paved surface, not the act of landing with the parking brake applied; in previous similar incidents, the aircraft have remained on the runway. The manufacturer stated that, in the circumstances, it did not intend to conduct a system review relating to the parking brake status.

Opportunities to detect that the parking brake was applied

The selection of the parking brake instead of the speed brake is an example of a slip, an appropriate action which is carried out incorrectly. There was a moment when the captain-under-training might have resolved the situation, when he remarked on the speed brake having been 'closed', (comment, "WHO CLOSED THAT") but he did not explore the inconsistency further, perhaps because there were multiple interruptions on the flight deck and he was focussed on other tasks.

During the approach checklist the commander read out "PARK BRAKE" instead of the second checklist item '*seatbelt sign*'. This is an example of a cognitive intrusion error and might indicate that on some level the commander had the parking brake in mind. The commander might have seen the illuminated parking brake indicator without consciously processing it and this unconsciously intruded into his speech. The speech error had the potential to trigger one or both crew members to check the status of the parking brake if they had noticed it. However, the checklist was interrupted immediately after this by an ATC instruction and this reduced the crew's opportunity to notice the speech error. It was then not repeated the second time the checklist was carried out.

Conclusion

The accident arose as a result of the inadvertent selection of the Emergency/Parking brake instead of the speed brake. The levers are of similar shape and sited close to each other but with a different appearance and mode of action. There is also a BRAKE ON indicator light. These risk controls proved ineffective in preventing the inadvertent selection of the Emergency/parking brake both on this occasion and on at least two previous occasions. Once the parking brake had been set there were opportunities to detect and correct the error, but a busy flight deck environment together with a high workload contributed to it going unnoticed.

After touchdown, the aircraft may have remained on the runway surface but for the addition of forward thrust during the landing roll.

The manufacturer stated that it did not intend to conduct a system review relating to the parking brake status.

Safety action

Following this accident, safety action was taken as follows:

> The operator introduced a revision to the Landing Checklist in the Operations Manual which requires the handling pilot to confirm the parking brake is OFF.

ACCIDENT

Aircraft Type and Registration:	DH82A Tiger Moth, G-ADXT	
No & Type of Engines:	1 De Havilland Gipsy Major 1H piston engine	
Year of Manufacture:	1935 (Serial no: 3436)	
Date & Time (UTC):	26 August 2017 at 0828 hrs	
Location:	Near Compton Abbas Airfield, Dorset	
Type of Flight:	Introductory Flight	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Fatal)	Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	64 years	
Commander's Flying Experience:	22,240 hours (of which 512 were on type) Last 90 days - 50 hours Last 28 days - 24 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft was carrying out an introductory flight with the pilot and a passenger aboard. As it became airborne from Runway 08, the engine was heard to misfire, but the aircraft continued to climb before making a left turn. Shortly afterwards, the pilot reported an engine problem and his intention to return to the airfield. The aircraft was on the base leg of an approach for Runway 26 when the nose pitched down, and it appeared to enter a steep descending turn to the left from which it did not recover before impact in a crop field. Both occupants were fatally injured.

History of the flight

The flight was intended to be an introductory flight for the passenger, which the operator referred to as an "air experience flight", and was the aircraft's first flight of the day. The pilot arrived at the airfield and was seen to carry out a full pre-flight inspection of the aircraft including checking the fuel tank quantity, which was full, and performing a water check of a fuel sample.

The passenger arrived at the airfield at about 0730 hrs and completed the required documentation before receiving a briefing on the aircraft and associated safety matters. He was then dressed in flying clothing, including a flight suit, leather gloves, flying jacket, goggles, and a helmet with a built-in headset and microphone.

The passenger was taken to the aircraft and assisted into the front cockpit by a member of the ground crew who ensured his safety harness was secure and that the headset lead was connected. He also pointed out the flying controls and other items to remain clear of. The pilot then occupied the rear seat. His normal habit was to carry out his general and safety brief of the passenger. The flight was to last for 30 minutes and was to overfly Shaftsbury, followed by the Steam Fair at Blandford Forum, before returning to the airfield.

The weather at the time of the accident was not recorded but included light and variable wind, clear skies and good visibility with a small amount of fog in the valley to the north of the airfield (Figure 1). The temperature and dew point were not recorded at the airfield.

Another member of the ground crew was responsible for starting the engine by hand swinging the propeller. The normal procedure of priming the fuel line and cylinders was followed and on the second swing of the propeller the engine briefly ran backwards.

With the possibility of an over-primed engine, the propeller was turned backwards several rotations in accordance with the operating manual and a second attempt to start was made but was unsuccessful. On the third start cycle, at the second attempt, the engine started and was warmed up before the magneto checks were performed by the pilot, which sounded normal with no rough running.

The wheel chocks were removed and the aircraft taxied to the threshold of Runway 08. It was seen to accelerate along the runway before becoming airborne at about the 300 m marker. At that point, the engine was heard to misfire but the aircraft continued to climb.

Witness recollections indicate that the aircraft probably made a left turn to the north, which was the intended direction after departure. The airfield does not record radio transmissions on its air/ground frequency but the operator heard the pilot transmit in an apparently calm voice that he had a "rough running engine" and was making a 180º turn to land on Runway 26. The radio operator responded that the wind was light and northerly. The engine could not be heard by witnesses at the airfield.

The perceived direction of turn differed between witnesses, but during the turn or when rolling out of it, the aircraft appeared to be slow and in one witness' description, it appeared slow and became unstable before a wing dropped sharply and the aircraft descended rapidly in a turn which they thought was to the right. One witness thought that as it departed the airfield, it pulled up sharply before making a right turn and descending steeply towards the ground. A witness approximately 1,500 m south of the accident site heard and then saw the aircraft climbing slowly at low airspeed, with the engine "sounding awful and misfiring" before it descended "corkscrewing down".

A flying instructor, who had been speaking to the accident pilot earlier, was next to the radio operator when he heard the transmission indicating engine trouble. He looked out of the window and located the aircraft heading north approximately 1 to 2 nm from the airfield at about 500 feet above airfield elevation. He saw it make a gentle, descending left turn onto a right base leg for Runway 26 and when above some high trees at the eastern end of the field, at about twice their height and some 200 m beyond them, the nose pitched sharply down and the aircraft rolled to the left in a steep descending turn. Shortly afterwards a column of smoke was seen.

Two witnesses at a farm approximately 350 m from the accident site heard the aircraft takeoff. One saw it briefly above trees before losing sight of it behind a barn, after which they heard the engine stop. Driving towards the scene they could see smoke and on arrival at the wreckage they were unable to assist the occupants.

The aircraft had struck the surface of a crop field in a steep nose-down attitude and caught fire. The airfield fire and rescue service attended the scene and controlled the fire using foam and dry powder. Both the pilot and passenger were fatally injured. The police control room log recorded that the accident was reported at 0828 hrs[1]; the first person reporting it thought that they did so approximately 30 seconds after the accident.

Figure 1 below shows the aircraft immediately prior to departure with the weather as described and the fog at the western end of the valley north of the airfield.

Figure 1
G-ADXT before the accident

Footnote

1 The control room log does not record the exact time in minutes and seconds and, therefore the log was started between 08:28:00 and 08:28:59.

Accident site and initial assessment of the wreckage

The accident site was in a cornfield approximately 0.4 nm east of the threshold of Compton Abbas Runway 26. Examination of the wreckage indicated that the aircraft was structurally intact prior to the accident.

The aircraft struck the ground in a steep nose-down attitude, coming to rest on a heading of approximately 130ºM.

A significant post-crash fire consumed most of the fabric covering of the aircraft and cockpit structure including the seats, instruments, instrument panels and electrical wiring. The steel frame of the fuselage structure was distorted due to loads imparted in the accident. The wooden wing spars and associated structure had burned to varying degrees, with the right wing being more badly affected than the left. The fire had consumed both safety harnesses, but the harness lugs were found to be fully engaged and locked in their respective buckles. The front cockpit shoulder harness attachment cable had failed due to overload.

One of the propeller blades had broken from the hub and its remains were found embedded in the soil beneath the aircraft. The root of the second blade remained attached to the hub but was partially burnt. Both blades had broken approximately mid-span and they had both come to rest to the left of the aircraft centreline.

The investigation determined that the flying controls and their operating mechanisms were intact prior to the accident.

Approximately two litres of residual fuel were siphoned from the aircraft fuel tank, which had ruptured.

The wreckage was recovered to the AAIB at Farnborough for detailed examination.

Aircraft information

General

The De Havilland DH82A Tiger Moth is a single-engine wire-braced biplane with two open cockpits in tandem.

The fuselage is constructed of welded steel tubing covered in fabric and the floor and cockpit decking are of plywood. The engine cowling is of metal construction with hinged side panels, and the wings are primarily constructed from wood with fabric covering.

Flying controls

Dual controls consisting of a conventional control stick and rudder pedals allow the aircraft to be flown from either cockpit, although with a single pilot it is normally flown from the rear cockpit.

The primary flying controls consist of a rudder, elevators and ailerons; the latter on the lower wings only. The control surfaces are of wooden construction with fabric covering but the trailing edges of the elevators and the rudder are made from light alloy tubing.

G-ADXT was fitted with slots on the leading edges of the upper wings which, when unlocked, deploy automatically at high angles of attack. It was not equipped with the optional anti-spin strakes fitted to some Tiger Moths. The strakes were introduced after the Royal Aircraft Establishment studied spin characteristics in 1941 when aircraft were fitted with aileron mass balance weights and bomb racks. Aircraft performance limits are not affected but the aft centre of gravity limit is reduced if strakes are not fitted.

Safety harnesses

The original 'Sutton-type' harness was designed to '*keep the wearer firmly in his seat*' and the specification dated from circa 1940. The harness was not part of an integrated crashworthy aircraft design in which energy absorption and survivable space were considered to the extent that they are for more modern aircraft.

G-ADXT was fitted with 'Z' type harnesses. The shoulder straps were fixed to the aircraft by a cable running across the fuselage, and the lap straps were attached to the fuselage structure. A CAA mandatory airworthiness directive was issued in 2000 to introduce higher strength transverse cables for the attachment of the shoulder straps.

Fuel system

An aerofoil section fuel tank manufactured from tinned steel sheet is fitted above the front cockpit between the upper wings. The tank has a capacity of 19 Imperial gallons (IG) (approximately 86 litres). G-ADXT was not equipped with the optional extended range tank.

Fuel is fed by gravity. It leaves the tank via a shut-off valve and flows through a copper pipe before passing through a filter on the right of the engine compartment. A flexible hose delivers the fuel from the filter to a carburettor.

The fuel shut-off valve can be opened and closed from either cockpit by interconnected push-pull rods. Fuel is turned on and off by moving the control forwards and backwards, respectively. A mandatory airworthiness directive, applicable to all Tiger Moths operating on the UK CAA register, requires the installation of a locking device to ensure that the shut-off valve cannot be closed inadvertently in flight. Compliance with the directive was not recorded in the airframe log book but the locking device was found amongst the wreckage and its condition indicated that it was serviceable prior to the accident.

Oil system

Engine oil is contained in a welded aluminium tank fitted to the outside of the left fuselage immediately behind the engine cowling. The oil tank has a capacity of 2.1 IG (approximately 9.5 litres).

Engine and controls

G-ADXT was equipped with a Gipsy Major 1H engine driving a fixed-pitch, two-bladed, wooden propeller. The Gipsy Major is a four-cylinder, air-cooled, inline inverted engine.

The engine is equipped with two independent ignition systems comprising two magnetos, one on each side of the engine, each feeding four spark plugs. The right magneto is fitted with an impulse coupling, which retards the ignition to aid engine starting. Two pairs of ignition (magneto) switches are fitted outside each cockpit on the left-side of the fuselage. The front switch of each pair controls the right magneto and the rear switch of each pair controls the left magneto.

A control in each cockpit operates the throttle by means of metal control rods. Throttle and magneto controls are interconnected so that when the throttle is closed the ignition is fully retarded. The throttle is moved forward to increase engine power and an engine rpm gauge is fitted in both cockpits.

G-ADXT was equipped with an automatic carburettor heating system, designed to minimise the risk of carburettor icing. The Tiger Moth air intake is of a two-way construction such that cold air can be drawn from an air scoop or warmer air can be drawn from the vicinity of the engine crankcase. The source of the air is determined by the position of a flap valve inside the air intake. The valve is interconnected with the throttle so that when the throttle is fully open cold air is admitted, but at lower power settings, warm air from the engine bay is admitted. A return spring is used to bias the valve to the warm air position when the engine is not running at high power.

Engine starting

G-ADXT was not equipped with an electronic starting mechanism, so the engine was started by hand swinging the propeller. The Bristol Siddeley Gipsy Major handbook, dated December 1958, gave the procedure as follows:

‘1. *Ensure that all oil cocks, if fitted, are turned* ON.

2. *Ensure that both magnetos are switched* OFF.

3. *Turn* ON *the fuel cock.*

4. *Set the throttle lever in the* FULLY CLOSED *position.*

5. *Set the mixture (altitude) control in the* FULLY RICH *position. On some installations a catch on the throttle lever ensures that the mixture control is automatically returned to* RICH *as the throttle is closed.*

6. *Where a manual air-intake control is fitted (Mk.7 embodying Mod. G.1483) set the hot-and-cold air intake control on the* COLD AIR *position.*

7. *Where the fuel supply is by gravity (Tiger Moth 2 installation) depress the carburettor flooder valve knob. Where engine driven pumps are fitted (Magister 1 and Auster T7 installations) operate one of the fuel pumps through the full range of travel whilst holding* OUT *the carburettor flooding device.*

> 8. *Turn the engine through several revolutions by the propeller in order to prime the cylinders.*
> 9. *Move the throttle lever forward about ½ in. from the fully closed position.*
> 10. *Switch* ON *the starboard magneto.*
> 11. *Swing the propeller cleanly through the compression stroke to start the engine. When the propeller is being swung, it is advisable for a second operator to be ready to adjust the throttle lever setting if required, as the engine starts.*
> 12. *When the engine is running switch on the port magneto.'*

The handbook states:

> *'The engine should start easily in normal weather.'*

and

> *'The most likely cause of trouble is over-priming. If this occurs, switch* OFF *both magnetos, and with the throttle fully open turn the engine backwards by hand. If the engine still fails to start after two or three successive attempts reference should be made to Chapter 8 and a systematic investigation made.'*

Chapter 8 of the handbook contains a list of possible defects, over-priming and insufficient priming being the first two scenarios to be considered if the engine fails to start.

Weight and balance

The aircraft was estimated to weigh 1,780 lbs at takeoff with a CG position 12 inches aft of the datum[2]. The CG limits were +7.0 inches to +13.5 inches when anti-spinning strips are not fitted as in the case of G-ADXT. The maximum permitted takeoff weight was 1,825 lbs.

Aircraft history

General

G-ADXT was built in 1935 and, according to the airframe logbook, had accumulated approximately 1,245 flying hours. The engine had accrued approximately 862 hours, which was within the defined 1,500 hours between overhauls.

In 2001, the aircraft was involved in an accident in which the engine had stopped during an inverted aerobatic manoeuvre[3]. The aircraft was repaired and returned to service.

Footnote

[2] The CG datum for this aircraft was the lower wing leading edge at the root.
[3] https://assets.digital.cabinet-office.gov.uk/media/5422f8b9e5274a13140006af/dft_avsafety_pdf_500228.pdf [accessed on 9 August 2018].

At the time of the accident in August 2017, the aircraft had a valid National Certificate of Airworthiness and a current Type Responsibility Agreement[4]. The available records indicated it was maintained in accordance with the Civil Aviation Authority Light Aircraft Maintenance Schedule.

Aircraft log book, technical log and operator's diary

The last 10 days of operations had not been incorporated into the airframe and engine log-books, but the technical log was comprehensive and there were no outstanding faults recorded.

The operator maintained an informal diary to enable the sharing of information within the local team. Diary entries were not attributable to individuals and the content varied. Nevertheless, it provided an insight into the recent operation of G-ADXT and information relating to 137 flights showed that approximately 85% of the engine starts were achieved within five swings of the propeller.

Recent maintenance history

In September 2016, the aircraft underwent a routine 50-hour service. Maintenance records indicate that low compression was identified on two cylinders and all four cylinder heads were removed and returned to an authorised repair organisation. The repair agent stated that he was not told why the components were removed and only the cylinder heads and valves were returned; the aircraft maintenance organisation retained the valve springs and rocker arms. Four new exhaust valve guides were fitted; the valves were reworked and their clearances were checked before the assemblies were recertified and refitted to G-ADXT.

Approximately 25 flying hours later, in February 2017, the aircraft underwent an annual check. Maintenance paperwork referred to a '*report of rough running engine'* and low compression was identified on two cylinders. The number 1 and 2 exhaust valves were found '*stuck open'* and the respective cylinder heads were removed and returned to the repair agent, complete with their valve springs. The repair agent identified that the number two exhaust valve was bent, and a replacement valve was installed; the replacement valve was inspected prior to use and was annotated with a local serial number. The repair agent reworked the assemblies and checked the valve clearances and spring forces before returning the equipment to the aircraft maintenance organisation.

The aircraft underwent its most recent scheduled maintenance in June 2017. The right magneto was removed for repair after difficulties starting the engine. Maintenance records indicate that the timing was adjusted and four new spark plugs were installed.

Footnote

4 If an aircraft type is no longer supported by a UK Type Certificate Holder, the UK CAA allows an owner to obtain a National Certificate of Airworthiness if a suitably capable organisation has entered into a Type Responsibility Agreement with the CAA. The organisation must be capable of monitoring the continued airworthiness of the type and in the case of a Tiger Moth, this organisation is de Havilland Support Ltd.

When the accident occurred, the aircraft had completed approximately 70 flying hours in 225 flights since the cylinder heads were reworked. It had completed 77 flights since the right magneto was refitted.

Previous report of a rough running engine

Thirteen days before the accident, during the first flight of the day, another pilot encountered a rough running engine while flying G-ADXT. With sufficient performance to maintain altitude he decided to return to Compton Abbas, but the symptoms cleared and he completed the flight in the local area. Six more flights were completed that day with no recurrence and the pilot considered it to have been an isolated event; he did not record it in the technical log. The aircraft completed approximately a further six flying hours in 19 flights before the accident.

Detailed examination of the wreckage

Flying controls

There was evidence the flying controls were connected before the accident, but it was not possible to establish the control surface positions at impact.

Instruments

The cockpit instrumentation was severely damaged in the accident and fire, except for an altimeter which had been thrown clear of the wreckage. The front cockpit engine rpm gauge was found to indicate approximately 1,175 rpm and examination using a computerised axial tomography scanning facility identified that the pointer had disengaged from its drive mechanism. The gauge was disassembled for closer examination, but it was not possible to validate the pointer reading. Typical engine speed in cruising flight is approximately 1,900 rpm, and approximately 2,100 rpm when climbing.

Fuel system

The fuel shut-off valve was found in the OFF position.

The fuel delivery pipe had broken at the filter and the fuel tank had ruptured along the length of one of its joints. The internal construction and cork float showed a combination of impact and fire damage, the varnish coating of the float having been severely degraded or burnt.

Analysis of the fluid that was siphoned from the tank after the accident was inconclusive because of the effects of thermal degradation. The aircraft technical log indicated that the fuel tank was full prior to the flight and a fuel receipt, signed by the accident pilot, showed that 27.78 litres of Avgas 100LL were supplied to G-ADXT on 22 August 2017. This was the last time the aircraft was refuelled prior to the accident and a combined total of 281 litres of Avgas 100LL was supplied to four other aircraft from the same facility on the same day with no reports of problems. Also, prior to the accident, there were another 48 supplies of Avgas 100LL from the same facility with no reports of anomalies. Analysis of a fuel sample retained from 22 August 2017 showed it to be typical of Avgas 100LL, though degraded during storage since the sample was taken.

Engine controls

It was not possible to determine the throttle position at impact because of the damage sustained in the accident.

Both sets of magneto switches were found and all four switches were in the ON position.

Engine

The engine was dismantled under the supervision of the AAIB.

The magnetos and ignition harnesses had been severely damaged and, apart from the impulse coupling, which was found to be in good condition, it was not possible to assess the pre-accident status of these components. The spark plugs in the number 1 cylinder had broken off during the accident. The electrodes of the other six spark plugs appeared normal.

The air intake and carburettor were severely damaged by the fire and their pre-accident status could not be assessed. The carburettor heat return spring arrangement was found to differ from that depicted in the maintenance manuals because two springs were connected in series instead of the correct single spring. The springs remained securely attached, but they were distorted by loads imparted during the accident. The material properties had been affected by the fire and their original stiffness was unknown. An engine test on a representative aircraft showed that when the aircraft was stationary and the spring was disconnected from the flap valve, simulating a spring failure, the valve continued to operate in the correct sense. This replicated the least favourable operating condition that could exist whilst the aircraft was stationary with the engine being warmed up. The CAA could not discount the possibility that they had approved the installation as a minor modification, which should be referenced in the aircraft records. The AAIB could not find a reference to the springs in the maintenance records that were reviewed as part of the investigation, none of which was dated before 2013. Witness evidence indicated that the aircraft had been operating in this condition for several years. The contents of the oil tank had been consumed by the fire but the oil that remained in the engine and filters was clean and free of debris.

The cylinder heads sustained impact damage in the accident and oil had leaked from the rocker covers. However, when the covers were removed the internal surfaces remained wet with oil and it was apparent that they had been adequately lubricated. Except for the No 1 exhaust valve, which was severely bent due to impact damage, the valves could be removed with some difficulty. Most of the valve stems were found to be slightly distorted but there was no evidence of adverse wear or contact with the piston crowns. The distortion would account for the difficulty in removing the valves and, given the damage sustained by the cylinder heads, must have occurred during the accident. Overall, there was no evidence that the engine had suffered a mechanical failure prior to the accident.

Personnel information

The pilot began his flying career in the Royal Air Force where he operated large transport aircraft before moving into commercial aviation at the end of his service career. He flew a number of large aircraft types, retiring from airline operations in 2007 as a Boeing 747 commander.

During that career, he had also flown light aircraft and gained a flying instructor rating. He started flying at Compton Abbas in July 2006. His last flight prior to the accident flight was on the previous day in a DHC-1 Chipmunk aircraft, carrying out 'spin avoidance training' as part of another instructor's annual training requirement.

The passenger had no background of flying training, and no previous experience of controlling an aircraft or flight simulator.

Meteorological information

There was low-level mist and a witness at the airfield, who assisted with starting the aircraft, stated that the aerodrome grass was wet. Another witness, who performed the runway inspection prior to the aircraft being started, stated that the runway and grass area adjacent to the signal square were dry and free of dew. The investigation did not discover any local temperature or dewpoint information.

The METAR for Bournemouth Airport, approximately 16 nm south-east of Compton Abbas, indicated an outside air temperature of 20ºC and a dew point of 14ºC. The METAR for Royal Naval Air Station Yeovilton, approximately 19 nm west of Compton Abbas, indicated an outside air temperature of 18ºC and a dew point of 15ºC.

Aerodrome information

Compton Abbas Airfield has a single grass runway orientated 08/26, 803 m in length. The airfield elevation is 811 ft amsl. Circuits are flown at 800 ft above airfield elevation, left hand on Runway 08 and right hand on Runway 26. To the north of the airfield is a steep sided valley, the bottom of which is some 300 ft below the airfield elevation. To the east of the airfield is a large irregular shaped field approximately 900 m long and 160 m wide, which at the time of the accident, was standing cereal crop of which, two rows had been cut with a combine harvester on the southern edge. (Figure 2)

The airfield has a rescue and firefighting service (RFFS) vehicle which provides initial emergency response to accidents or incidents within the airfield boundary. CAP 168 – '*Licensing of Aerodromes*', Appendix 8C sets out the requirements which cover RFFS at Compton Abbas, which is a Special Category aerodrome. There is no specified time within which the vehicle should reach the occurrence location but the RFFS should achieve '*a response as expeditiously as possible'*.

Figure 2

Extract from Ordnance Survey map of the local area

Recorded information

The aircraft was fitted with a video recording system. Remnants of electronic chips that may have related to this system were found in the wreckage but were too damaged for data recovery. A heat damaged USB[5] memory stick was also recovered from the wreckage. Recordings recovered from it were from a previous flight. No other recording devices were fitted.

The accident flight was not captured by radar.

A witness to the takeoff at the airfield provided a series of short video clips[6] taken during the flight preparation, takeoff roll and the initial climb; all while the aircraft was still within the airfield boundary. The video clips had embedded times enabling them to be aligned to each

Footnote

5 Universal serial bus.

6 The video clips were from "live" photographs which are very short video clips, in this case each approximately three seconds long, with an associated photograph.

other with an accuracy of one second. They did not form a complete record of the takeoff and initial climb but provided a basic timeline of events.

The engine was started at some point between two video clips recorded at 0811 hrs and 0819 hrs. The aircraft left its parking position at 0823 hrs. The next clip was just over a minute later, showing the aircraft having started its takeoff roll. There were three more gaps in the remaining sequence, the last clip showing the initial climb and ending at 0825 hrs.

Figure 3

At the beginning of the takeoff run showing the tops of cloud or fog in the valley to the west of the airfield

Figure 4

The cloud or fog conditions are not the same in the valley to the north of the airfield (separated from the westerly valley by a ridge).
The windsock indicates a light crosswind from the north

Figure 5

Abeam the camera location

Figure 6
Lifting off

Figure 7
Initial climb

Figure 8
Last video clip, initial climb

The propeller speeds were established from the images in the video clips. The aircraft engine was running at approximately 2,000 rpm when passing the camera location but had reduced to approximately 1,710 rpm by the end of the video clips.

Spectrum analysis of the video clip audio enabled measurement of the audio frequencies that related to the engine rotating speed, as they reached the camera. The recorded audio also reduced in frequency as the aircraft passed the camera location and flew into the distance. This was partly due to the reducing engine speed as identified using the video images, and partly due to the Doppler effect[7]. The groundspeed was then derived from the measured Doppler effect and the approximate flight path of the aircraft. This indicates that the aircraft took off with a groundspeed of approximately 50 mph, and the groundspeeds for the penultimate and final video clips were in the ranges of 52 to 60 mph and 48 to 56 mph respectively.

Footnote

7 An example of the Doppler effect is a siren on a police car that appears to drop in tone as it passes you, the faster it is travelling relative to you the bigger the shift in frequency.

No sudden changes in engine behaviour were detected during the video clips. It was not possible to observe throttle position in the imagery.

Previous flights

Video recordings created by the system fitted to the accident aircraft were obtained for two recent previous flights, one in the morning and one in the afternoon, flown by the same pilot on the same aircraft but with different passengers. These recordings had a groundspeed indication embedded in the image. The audio part of the recording provided engine related signatures except during periods of recorded speech. The data for these two flights is compared to the accident flight in Figure 9. The pilot use of the throttle lever was not evident from the videos.

The aftercasts for airfields in the area at the times of the flights indicated similar conditions across all three flights apart from an approximate 8 kt headwind on the day of the previous flights.

Figure 9 shows that during the takeoff of both the previous flights engine speeds were faster than those for the accident flight; there was also a marked difference between the previous two flights. The engine speed for the morning flight showed a reducing trend, which subsequently increased to engine speeds closer to those achieved during the afternoon flight. This was similar in behaviour to the accident flight but with only about half the reduction.

Medical and pathological information

Post mortem examination revealed no pre-existing medical conditions or diseases which might have contributed to the accident, and no drugs or alcohol were present.

Survival aspects

Post mortem

The pathologist considered that the injuries sustained by both pilot and passenger prior to the fire were not survivable.

Safety harnesses

The safety harnesses were consumed by the fire but the harness lugs were found securely locked in the quick release buckles.

The front shoulder harness attachment cable was found to have broken and this would have compromised the restraint of the front seat occupant. The aircraft maintenance records indicated that the higher strength attachment cables for the shoulder straps had been incorporated, but fuselage distortion caused by the accident had loaded the cable beyond its capability.

Fire

First responders from Compton Abbas airfield tackled the post-crash fire using a combination of aqueous film-forming foam (AFFF) and dry powder extinguishers.

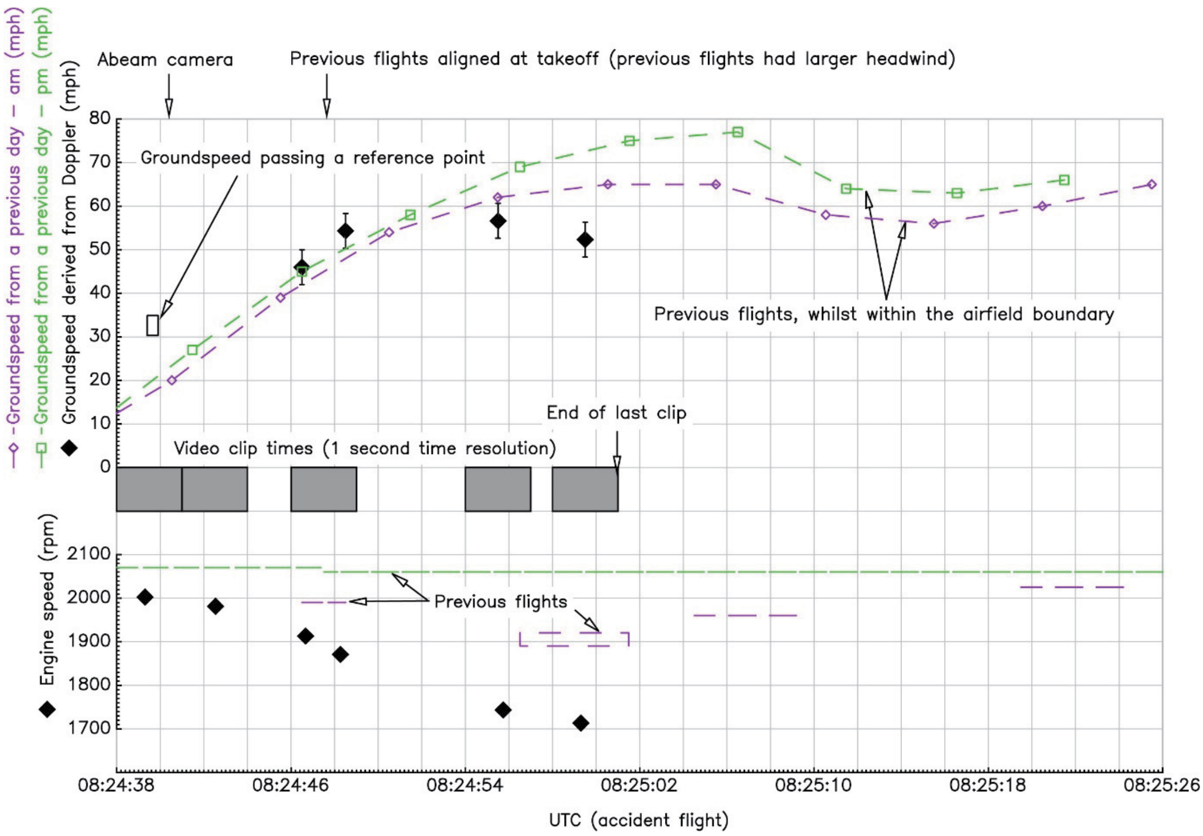

Figure 9

Accident flight parameters compared to previous flights aligned to the point in time of takeoff

Flight trials

The pilot had reported in his transmissions to the airfield that he had a "rough running engine" but did not report an engine failure. He appears to have made a gentle, descending left turn to return to the airfield with the intention of landing on Runway 26. No radar or recorded images of the flight path or performance data for the aircraft type were available to the investigation.

Initially, two trial flights were conducted as part of the investigation to establish takeoff, climb and descent performance at different airspeeds, using full power and throttle closed, with varying angles of bank in the turns. Two Tiger Moths of a similar specification to G-ADXT were used, and data recorded. From this data, height gained or lost against time and/or distance could be calculated. It was not possible to determine the effects, if any, of the "rough running engine" on the performance of the accident aircraft, the rates of climb recorded in these trials were greater than those estimated for the accident flight.

The aircraft used in the trials were as follows:

G-ACDI - TOW 1,760 lbs and CG 12.6 inches aft.
G-ANNG – TOW 1,790 lbs and CG 13.7 inches aft[8].

The indicated engine speed for takeoff and the initial climb was 2,100 rpm for G-ACDI and 2,050 rpm for G-ANNG.

The results are set out in Table 1 below:

Serial	Profile	Data	Remarks
1	Takeoff Run	300 m	Full power
2	Stabilised Climb	650 ft/min G-ACDI 500 ft/min G-ANNG	Full power
3	Climbing Turn	580 ft/min G-ACDI	Full power
4	Descending Turn	At 66 mph 860 ft/min	Throttle closed
5	Stalling – idle power	Approx 40-45 mph	Benign – full back stick no wing drop
6	Turn Back (180º turn)	Height loss 400 ft	Throttle closed
7	Descent at Stall Speed	1,200 ft/min	Throttle closed

Table 1

Consolidated table of results from initial flight trials

The final two test points simulated turn back manoeuvres assuming a worst case in which the power available from the engine was equivalent to idle power. The aircraft was positioned and climbed at 66 mph to 800 ft QFE and the throttle closed. The aircraft nose was promptly lowered to target 66 mph and the aircraft rolled to a 45° angle of bank to commence a simulated turn back to the airfield.

The test pilot conducting the trials considered the aircraft flown to be typical and representative of Tiger Moths registered in the UK. Both had similarly benign stall characteristics at between 45-49 mph IAS[9], adopting a high angle of attack and rate of descent with the stick held full back and no tendency to drop a wing. The measured rates of descent were consistent with other Tiger Moths he had flown, but with a noticeable increase in rate of descent when flown at or just above the stall speed. The aircraft could be turned relatively easily with an increasing rate of turn, with approximately 45° bank being the optimum for a turn back towards an airfield. Height loss in turns through 180° was approximately 400 ft. The test pilot considered that starting such a manoeuvre much below 800 ft, with a total engine failure, would give the pilot little opportunity to manoeuvre onto the reciprocal runway[10].

Footnote

[8] G-ANNG had anti spin strakes fitted which increases the aft CofG limit to 15.3 inches aft.
[9] The Pilot's Notes state: '*Normal stall from a straight glide, engine off 40 mph (35Kts), engine on 30 mph (25 Kts)*'.
[10] A turn to intercept the reciprocal runway would require a combination of turns though more than 180°.

A third trial was undertaken to assess the takeoff and initial climb, using G-ANNG at the same takeoff weight as on the previous flights. The trial was undertaken from Runway 06 at Old Sarum Airfield, which has a grass surface 781 m long that was dry. During the trial the surface wind was calm but with a slight northerly drift. Conditions were CAVOK, with a surface temperature of 15˚C and QNH 1026 hPa.

The test points were:

1. Rejected takeoff performance
2. Climb performance at partial power (low engine rpm)
3. Aircraft attitude in a glide at minimum ROD airspeed

Rejected takeoff

Rejecting the takeoff in the Tiger Moth introduced a number of challenges. The aircraft was not fitted with wheel brakes, had a very crude steerable rear tail skid and was a 'tail dragger' configuration. Rejecting the takeoff when the wheels were still in contact with the runway required the throttle to be closed and the level attitude held initially before allowing the tail to drop gently as the airspeed reduced. During this period there was no braking and steering was entirely aerodynamic and reliant on airflow over the rudder (which was reduced with loss of propeller wash). This technique worked satisfactorily and, from being light on the wheels at 40 KIAS, the aircraft was brought to a halt in approximately 230 m after closing the throttle and following an initial takeoff run of 200 m.

The situation became slightly more problematic once the aircraft had become fully airborne. Typically, the aircraft would be landed in a 'three point' attitude, main wheel and tail skid contacting the runway at the same time in a stalled or semi stalled condition with a minimum ground and airspeed. Rejecting the takeoff once airborne at 40+ KIAS meant that the initial application of aft control stick would have potentially caused the aircraft to climb initially before the 'three point' landing attitude was reached which would have resulted in a heavy landing. The alternative was to retain the level attitude and close the throttle allowing the aircraft to descend back onto the runway initially on the main wheels and then complete the reject as described previously. Any delay in making the decision to reject once airborne would noticeably extend the distance required to complete the manoeuvre. Given the risks of performing such a manoeuvre once airborne it is unlikely that it was practised regularly, if at all.

This type of reject, once airborne, was attempted during the sortie with the aircraft having reached about 20 feet agl and a flying speed of 50KIAS. The test pilot summarised the test as follows:

> *'As the throttle was closed and the nose dropped to a level attitude for landing, it was considered that insufficient runway remained to complete the landing without risk and the power was re-applied to climb away.'*

Partial power

The aircraft was flown at 66 mph (58 KIAS) and a density altitude of 2,000 feet, the power being set using the rpm gauge. The height was noted every 15 seconds until a stable condition and rate of climb or descent could be ascertained. The results of the trial are set out in Table 2 below:

Serial	rpm	Remarks
1	1,700	The aircraft almost was able to remain in level flight but over a minute, indicated a very slight rate of descent of approximately 20 fpm.
2	1,800	The aircraft exhibited a barely discernible rate of climb of approximately 20 fpm.
3	1,900	A rate of climb of 200 fpm was established.
4	2,000	A rate of climb of 400 fpm was established.

Table 2

Consolidated table of partial power climb results

Pitch attitude

A manoeuvre was flown from level flight at 66 mph (58 KIAS). The throttle was closed rapidly and the attitude to glide at 66 mph (58 KIAS) adopted. A nose-down pitch attitude of approximately 10º was required.

It was also noted that the front cockpit of the Tiger Moth was quite confined for a large person of the size of the passenger on the accident flight, whose weight was recorded as 16 stone. All engine and flight controls were operational and accessible to the passenger, and there was nothing to prevent a passenger restricting control stick or rudder movement.

Organisational information

Aircraft operation

The aircraft was owned and operated by an Approved Training Organisation (ATO), which was permitted to carry out introductory flights, referred to by the ATO as 'air experience flights'. The operation of such flights is explained in CAA Information Notice Number IN-2015/029, which refers to such flights as 'introductory flights'. EASA regulations define these as follows:

> *'"Introductory flight"' means any flight against remuneration or other valuable consideration consisting of an air tour of short duration, offered by an approved training organisation or an organisation created with the aim of promoting aerial sport or leisure aviation, for the purpose of attracting new trainees or new members.'*

Guidance material GM1 ARO.OPS.300 (Introductory Flights), published by the EASA, states:

> *'For introductory flights carried out in the territory of the Member State, the competent authority may establish additional conditions such as defined area of the operation, time period during which such operations are to be conducted, safety risk assessments to be accomplished, aircraft to be used, specific operating procedures, notification requirements, maximum distance flown, pilot qualification, maximum number of passengers on-board, further restrictions on the maximum take-off mass.'*

The CAA did not impose such conditions but instead recommended that operators apply their own conditions based on their assessment of the risk to the occupants of the aircraft, which should include:

> ' • *The experience and currency of the pilot particularly on the aircraft to be used and familiarity with its flight characteristics over the range of planned weight and CofG*.
>
> • *The pilot's familiarity with proposed route(s), airspace, operational restrictions and emergency procedures*.
>
> • *Weather minima to be observed, particularly visibility, cloudbase, wind strength and direction*.
>
> • *Any other criteria which should be considered to achieve the objective of a safe and enjoyable introductory flight for the participant(s*).
>
> ***Important Note**: The exemptions issued under the ANO[11] for national licences and Annex ii aircraft are not valid outside the airspace of the UK unless validated or otherwise accepted by the relevant authority of the State where the flight is to take place.'*

Under these conditions, the approved training organisation was permitted to conduct what they termed 'air experience' flights.

Additional information

Operation of the fuel shut-off valve

Analysis performed by the Civil Aviation Authority of New Zealand after a previous Tiger Moth accident (ZK-DHA) concluded that the fuel shut-off valve on this aircraft type can close because of structural deformation sustained during an accident. Tests that were performed as part of that previous investigation showed that if the valve was turned off with an engine running at full throttle, the engine continued to run for approximately 16 seconds before coming to an immediate stop.

Footnote

[11] Air Navigation Order.

Possible causes of a rough running or misfiring engine

The pilot reported that the engine was running rough and witnesses described it as misfiring.

The Gipsy Major Handbook includes a table of running defects, possible causes and recommended remedial actions. The appropriate sections are reproduced in Table 3 below.

Symptoms	**Possible Defect**
Missing or irregular firing	Defective sparking plugs
	Defective ignition
	Incorrect carburation
	Incorrect tappet clearance
Vibration and rough running	Defective ignition
	Incorrect carburation
	Mechanical defects
	Loss of compression
	Engine loose on mountings
	Induction manifold leakage
	Induction blockage
	Propeller hub loose on crankshaft
	Propeller out of balance
	Spinner out of truth
	Reduced valve spring loads

Table 3

Possible cause of misfiring and rough running

Carburettor icing

Carburettor icing is typically associated with rough running, gradual power loss and, eventually, engine stoppage. CAA Safety Sense Leaflet (SSL) No 14, '*Piston Engine Icing*' gives advice and guidance on how to recognise and avoid carburettor icing. It notes:

> *'the most common, earliest to show, and the most serious, is carburettor (carb) icing caused by a combination of the sudden temperature drop due to fuel vaporisation and pressure reduction as the mixture passes through the carburettor venturi and past the throttle valve.*
>
> *If the temperature drop brings the air below its dew point, condensation results, and if the drop brings the mixture temperature below freezing, the condensed water will form ice on the surfaces of the carburettor. This ice gradually blocks the venturi, which upsets the fuel/air ratio causing a progressive, smooth loss of power and slowly 'strangles' the engine.'*

The leaflet identifies several risk factors, including when the ground is wet (even with dew) and the wind is light; and in clear air where cloud or fog may have recently dispersed.

Previous research

The ATSB carried out an Aviation Research and Analysis, AR-2010-055, and produced a booklet, 'Avoidable Accidents No 3'. The aim of the booklet was to increase awareness among flying instructors and pilots of the issues relating to partial power loss after takeoff in single-engine aircraft.

The booklet set out the issues related to partial power loss as distinct from total loss of power and illustrated the analysis with case studies. It provided the following 'key messages':

> *'Most fatal and serious injury accidents resulting from partial power loss after takeoff are avoidable. This report will show that you can prevent or significantly minimise the risk of bodily harm following a partial or complete engine power loss after takeoff by using the strategies below:*
>
> 1. *Pre-flight decision making and planning for emergencies and abnormal situations for the particular aerodrome*
> 2. *Conducting a thorough pre-flight and engine ground run to reduce the risk of a partial power loss occurring*
> 3. *Taking positive action and maintaining aircraft control either when turning back to the aerodrome or conducting a forced landing until on the ground, while being aware of flare energy and aircraft stall speeds.'*

Analysis

Recorded data

Over the period covered by the video clips, the engine speed reduced from approximately 2,000 rpm to approximately 1,710 rpm. During takeoff on one of the previous two flights reviewed, a reduction in engine speed was also apparent, though to a higher value of approximately 1,900 rpm, before increasing again. Engine speed during the other takeoff reviewed was above 2,050 rpm. This demonstrates that the pattern of engine speeds during takeoff was not consistent. A reducing engine speed during takeoff was not unique to the accident flight and had previously resulted in a successful flight. The investigation did not determine how the pilot operated the throttle. Flight test results showed that the engine speed indicated by the last video clip would have been insufficient for the aircraft to climb, indicating that it did increase after that.

The reduced engine speeds of the recorded parts of the accident flight resulted in a slower groundspeed profile than at similar points in previous flights, even though the previous flights were flown with more headwind.

There was only intermittent video coverage of the initial takeoff and climb. The sound of the engine was not obviously unusual during these clips. Witnessed engine sounds and pilot-reported rough running either occurred between these recordings or after them.

Engine start

The first attempt to start the engine was unsuccessful and witnesses reported that it briefly ran backwards. This indicates the presence of a combustible fuel / air mixture and a source of ignition. As this was the first flight of the day, the possibility of a localised hot-spot inside the engine can be discounted. The only conceivable source of ignition in a cold engine is a spark from a spark plug. This indicates that the left magneto may have been ON, or that there was a timing anomaly with the right magneto or a problem with its impulse coupling. The impulse coupling was found to be in good condition after the accident and the timing of the right magneto could not be checked because of the extent of the damage sustained. If the right magneto timing was incorrect, this would have been the case since it was installed, and the engine would always have been susceptible to running backwards during start-up; the aircraft had completed 77 flights since the magneto was refitted. The engine cannot self-sustain if it runs backwards and when the engine was dismantled there was no evidence of any mechanical failures or damage that could not be attributed to the accident.

The pilot informed the groundcrew that he believed the engine had been over-primed. The appropriate procedures were followed, and the engine started.

Rough running engine

The pilot reported that the engine was "rough running" shortly after takeoff and witnesses described an engine misfire as the aircraft lifted off. The two witnesses at the farm reported that, shortly after they became aware of the aircraft, the engine stopped.

The Tiger Moth Maintenance and Repair Manual states that the engine should be warmed for four minutes prior to the magneto and power checks and the Bristol Siddeley Gipsy Major handbook states that the oil temperature should be at least 15ºC prior to takeoff. Photographic evidence showed that the engine was running at least four minutes before the aircraft left the parking area and witnesses reported that the magneto and power checks sounded normal.

Examination of the engine did not identify any pre-existing defects that would have prevented normal operation but damage sustained in the accident meant that it was not possible to establish the pre-accident status of the magnetos, ignition system and carburettor. The engine handbook states that a problem with any one of these items could result in the symptoms described by the pilot and witnesses.

Both sets of magneto switches were found, and all four switches were in the ON position, which is the normal flight position. The switches are ON when they are in the up position and it is considered unlikely that they changed during the accident.

The fuel shut-off valve was found in the OFF position but it was not possible to determine when the valve was closed. The mandatory locking device was found in the wreckage and its condition indicated that it was serviceable prior to the accident. Analysis performed after a previous Tiger Moth accident concluded that the valve can close because of structural deformation sustained during an accident. The possibility that the pilot closed the valve in preparation for a forced landing cannot be discounted, but this is considered to be less likely. Witnesses who saw the aircraft shortly before the accident reported that the engine was still running and a test conducted as part of a previous investigation established that the engine would run for approximately 16 seconds if the valve was closed when the engine was running at full power.

Both propeller blades had broken approximately mid-span and were embedded in the ground on the same side of the aircraft centreline. This indicates that the propeller was turning when the accident occurred. The fact that the wooden propeller did not shatter and that the broken parts were found close to the wreckage indicates that the propeller was probably turning slowly.

Carburettor icing

G-ADXT was equipped with an automatic carburettor heat system intended to minimise the possibility of carburettor icing. The installation differed from the configuration depicted in the maintenance manual but the aircraft had been operating in this condition for several years. Tests indicated that the air intake flap valve would still operate in the correct sense whilst the aircraft was stationary and the engine was being warmed up. When the pilot selected full power for takeoff, the intake flap would move to the cold air position as designed.

The chart included in SSL No 14 indicates that, at the temperatures recorded at Bournemouth and Yeovilton, moderate icing could be experienced at cruise power and serious icing could be experienced at descent power.

Over the period covered by the video clips, the engine speed reduced from approximately 2,000 rpm to approximately 1,710 rpm, but the cause is unknown. A test flight established that the aircraft could not have climbed at 1,710 rpm so the engine power must have increased after the last video clip.

Post-crash fire

The aircraft struck the ground in a steep nose-down attitude and a post-crash fire began before first responders arrived at the scene.

The fuel delivery pipe was found to have broken at the joint with the fuel filter. This would have given rise to a fuel leak, but the volume of fuel would have been limited because the fuel shut-off valve was closed. The fuel tank, which was full before the flight, was found to have ruptured along the length of a joint. This would have resulted in a significant fuel leak and it is possible that leaking or atomised fuel ignited when it contacted the hot engine.

First responders tackled the fire using a combination of AFFF and dry powder extinguishers. The fire had been extinguished prior to the arrival of the Fire and Rescue Services.

Flying controls

Examination of the flying controls showed no evidence of a pre-accident failure.

Operations

The pilot was properly licensed and qualified to carry out the flight, which was being operated in accordance with the regulations governing 'introductory flights'. The aircraft was being operated within its weight and balance envelope.

The post mortem examination did not identify any pre-existing medical condition that might have led to pilot or passenger incapacitation.

The weather was good with a light and variable wind, which at the time of the accident was given as northerly at less than five knots. No precise time was recorded for the flight but the last photograph showing the aircraft towards the eastern airfield boundary was taken at 0825 hrs and the police incident log commenced at 0828 hrs. This indicates the flight lasted between three and four minutes.

On takeoff, the engine was heard to misfire, but the aircraft continued to climb. It would have been possible to abandon the takeoff closing the throttle and attempting to stop on the runway. If the decision was made promptly, there would have been sufficient space remaining for the aircraft to stop or turn away from the obstacles at the eastern boundary. Once the aircraft was airborne, the pilot would have faced the same situation observed by the test pilot during sortie three of the flight trial.

During the accident takeoff, engine speed reduced to 1,710 rpm. This may have been a result of the pilot reducing throttle in order to reject the takeoff. However, the takeoff continued and he may have concluded that there was insufficient runway or other space on the airfield in which to stop.

Flight trials indicated that power settings, 1,700 and 1,800 rpm would not have been sufficient to achieve the height gained in the time available. Although the pilot had reported "rough running", the engine must have been producing sufficient power to achieve between 1,900 and 2,000 rpm at the best rate of climb speed in order to gain between 300 and 500 feet above airfield level in the time available.

Subsequently, both the turn and descent back towards the airfield were gentle manoeuvres and there were no additional transmissions from the pilot reporting any deterioration in his situation. No radar or GPS positions, heights or ground track were available to the investigation and witness evidence varied regarding the flight path, distance from the airfield and the direction of the turn back towards it. However, the aircraft's final manoeuvre was described consistently as a steep, nose down, rapidly descending turn. This was above and slightly beyond the trees at the eastern end of the airfield and at about twice their height, or approximately 200 ft above airfield elevation.

Up to this point, the gentle rate of descent suggests that the engine was still producing power but was not, and probably could not be, heard from outside the flying club if at reduced power. The pilot either made a normal approach throttling back and descending on the base leg or, if power available had reduced and he was unable to maintain height was forced to let the aircraft descend. With a rough running engine, the possibility of a total or increased loss of power is always a possibility and maintaining height until within gliding distance of the intended landing point is desirable in this situation if it can be achieved whilst maintaining sufficient speed.

The aircraft's nose was seen to pitch positively down some 30º, which when combined with the turn, would have caused the aircraft to lose height rapidly. Flight trials established that the rate of descent could have been at least 1,200 feet per minute if the aircraft was just above the stall at low speed and low power.

One witness had seen the aircraft briefly before the accident and reported hearing the engine "sounding rough". Shortly thereafter that witness and one other witness both heard the engine stop abruptly. Given the location of the witnesses and timings of the observations, the engine stoppage was most likely as a result of the aircraft impact with the ground, rather than an engine failure in flight or the pilot closing the throttle.

Three possible reasons for the final manoeuvre were considered:

1. Low airspeed resulting from trying to maintain height which caused a wing to drop at the stall, as described by one witness.
2. Low airspeed resulting in the need for a large nose down attitude change in order to regain airspeed but resulting in a significant rate of descent.
3. A late decision to change the landing area to the crop field, requiring a tight left turn. This would have required an increase in airspeed, obtained by the significant nose-down attitude change before the turn.

Either (1) or (2) may have caused the aircraft to descend below the minimum glide angle required to land at the airfield. In these cases, the pilot may have recognised that he was not able to return to the airfield and turned towards the large open area of crop field. Alternatively, the angle of the descent placed the aircraft at a height and position from which the pilot decided to change his landing area to the crop field. He may also have been attempting to recover from or avoid a loss of control at low airspeed.

Finally, there was either insufficient height to recover or a restriction of the controls that prevented recovery before impact. The accident aircraft was fitted with dual controls and, although the passenger had received a full cockpit and safety brief, it is possible the flying controls were involuntarily restricted as the passenger reacted to what would have been a very stressful situation.

Conclusion

The accident occurred when the pilot was attempting to return to the airfield after reporting a rough running engine. Damage sustained during the accident prevented an assessment of the magnetos, ignition system and carburettor. A problem with any one of these could have caused the reported symptoms. The possibility of carburettor icing could not be discounted.

At about 200 ft agl, the aircraft pitched suddenly and significantly nose down before descending in a left turn from which it did not recover before striking the surface of a crop field. The reason for this final manoeuvre was not determined.

Aviation Research and Analysis, AR-2010-055, *'Avoidable Accidents No 3'*, published by the Australian Transport Safety Bureau, considers issues related to partial power loss after takeoff in single-engine aircraft and contains valuable guidance when dealing with such an emergency and is potentially relevant to this accident.

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.

INCIDENT

Aircraft Type and Registration:	Airbus A320-214, G-EZOZ
No & Type of Engines:	2 CFM CFM56-5B4/3 turbofan engines
Year of Manufacture:	2015 (Serial no: 6918)
Date & Time (UTC):	24 June 2018 at 1900 hrs
Location:	On departure from Liverpool John Lennon Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 179
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	33 years
Commander's Flying Experience:	6,086 hours (of which 5,914 were on type) Last 90 days - 165 hours Last 28 days - 59 hours
Information Source:	Aircraft Accident Report Form submitted by the commander and the Operator's Report

Synopsis

After takeoff the commander inadvertently selected the flaps up instead of the landing gear. The flight crew quickly realised the error, returned the flaps to the takeoff setting and focused on flying the aircraft to achieve a safe flight path. It was not possible to determine why the inadvertent selection occurred.

History of the flight

The crew reported at Liverpool John Lennon Airport at 1050 hrs for a four sector day; the first two sectors were to and from Madrid Barajas International Airport. On the second sector a bird strike occurred on takeoff from Madrid; no damage was found and the flight continued without further incident.

The third sector was from Liverpool to Paris Charles de Gaulle airport. Weather conditions were CAVOK and the co-pilot was the pilot flying. Takeoff was planned from Runway 27 with Configuration 1+F[1] and an aircraft gross weight of 62.6 tonnes. The takeoff roll was normal. The commander reported that after lift-off the co-pilot called for "gear up"; the commander replied "gear" but inadvertently placed her hand on the flap lever instead of the landing gear lever and selected FLAP 0. She realised the error and moved the flap lever

Footnote

[1] Config 1+F - leading edge slats extended to 18° and trailing edge flaps extended to 10°.

back to the FLAP 1 position, whereby the slats remained extended but the flaps continued to retract.

The co-pilot recalled hearing the commander call “gear” and looking at the gear lever but not seeing the commander’s hand on the lever. However, by this time the flap lever had already been moved and returned. Both pilots reported that, realising what had happened, they focused on flying the aircraft. They reduced the pitch attitude to accelerate and, maintaining a positive rate of climb, retracted the landing gear. They considered using TOGA[2] thrust but decided this was not necessary. Throughout the incident the airspeed remained above V_{LS}[3]. Once the aircraft was stabilised, the autopilot was engaged and the slats were retracted. The flight continued without further incident.

After the incident neither pilot could identify any reason why the slip had occurred. They were not aware of any distraction and did not report feeling fatigued.

Recorded information

The aircraft FDR and CVR were not downloaded. The operator provided the AAIB with the QAR[4] data.

The data showed that on takeoff, passing 181 ft radar altitude (radalt) and at 162 kt, the flap and slat angle started to reduce. The slat angle reduced slightly from 18° to 17.2° but then returned to 18°. The flap angle continued to retract to 0°. No movement of the flap lever was recorded. However, flap lever position is only recorded every two seconds, so it is likely that the lever was moved and returned in less than this time.

Passing 330 ft radalt the landing gear was selected UP.

Climbing through 600 ft radalt, pitch angle was reduced to 10° and the airspeed started to increase. Passing 800 ft radalt, speed had increased to 185 kt and the pitch angle was increased to 15°.

Passing 1,350ft radalt the thrust levers were retarded to climb power and the pitch attitude reduced to 10°. Flap 0 was selected passing 1,650 ft as speed increased through 200 kt. By 2,000 ft radalt the slats had fully retracted.

Previous events

The AAIB reported on four similar flap mis-selection incidents in Bulletins 9/2017 (G-EZEW and G-EZWM) and 8/2016 (G-EZFA and G-EZTZ).

Footnote

2 TOGA - Takeoff/Go-around (thrust).
3 V_{LS} – the lowest selectable speed, represented by the top of the amber strip along the airspeed scale on the primary flight display.
4 Quick Access Recorder.

Aircraft information

Flap system logic

When the flap lever is moved to position 0 from CONFIG 1+F after takeoff, the flaps and slats begin retracting at the same time if the airspeed is above 148 kt. In flight, when the airspeed is above 100 kt, moving the flap lever from position 0 to 1 commands CONFIG 1 rather than CONFIG 1+F, extending the slats but not the flaps. If, after takeoff (and above 100 kt), the flap lever is moved from position 1 to 0 and then back to 1, the slats and flaps begin to retract but, although the slats will extend again, the flaps will continue to retract.

Operator's standard procedures

Following the previous incidents, the operator modified its standard operating procedures (SOPs) for selection of landing gear and flaps. The change introduced a pause before the selector of the landing gear or flap. The operator's change notification highlighted that the pause was introduced '*so that the PM cognitively confirms the proper lever has been selected'* and *'allows PF to intervene if he or she notices an incorrect selection is about to be made'*. The modified SOPs are shown in Figure 1.

2.3.90.6 Flaps Callout

Flaps Configuration	Callout
1	Flaps One
1 + F	Flaps One
0	Flaps Zero

The reply will be given when selecting the new flaps position. For example

	Callout	Remark
PF	"FLAPS ONE"	PF commands Flaps 1
PM	"SPEED CHECKED"	PM checks that the speed is: • Above F or S speed and accelerating (Takeoff/Go-around). • Below VFE NEXT and decelerating (Approach).
	"FLAPS"	To reduce inadvertent FLAPS selection, the PM places their hand on the FLAPS lever calls "FLAPS".
	"ONE"	PM selects the commanded position and calls the Flaps position by checking the blue number on the ECAM Flaps indicator to confirm the correct selection has been made.

2.3.90.7 Gear Callout

	Callout	Remark
PF	"GEAR UP (DOWN)"	PF commands Gear Up (Down) having checked that the speed is within placard limits.
PM		PM checks that the speed is appropriate.
	"GEAR"	To reduce inadvertent L/G selection, the PM places their hand on the L/G lever, calls "GEAR".
	"UP (DOWN)"	PM then states "UP" or "DOWN" and selects the commanded position.

Note: Crews are required to check the speed is within the Landing Gear operating limits before operating the Landing gear, this check can be silent.

Figure 1

Operator's SOPs for landing gear and flap selection

Operator's report on the incident

The operator's report stated:

> *'The flap retraction by the Captain was a 'selection error'. This is a type of 'action slip', where an out-of-sequence step (the flap selection) is included in a series of routine, well-learnt behaviours (take-off procedure). Action slips are related to variability of sensorimotor coordination, sometimes called 'motor memory'. Action slips are hard to detect as the action itself is not under conscious control from a human information processing perspective. Based on FRMS* [Fatigue Risk Management System] *analysis fatigue is not considered a contributory factor. It was not possible.'*

The report highlighted that the crew rapidly recognised the mis-selection and responded promptly to ensure a safe flight path in accordance with the operator's upset recovery training.

The operator reviewed the five safety actions that were taken following the previous incidents (Table 1).

Previous Safety Action	Review
It reviewed its current training and guidance to support crews in handling the aircraft in a low energy state at low altitude.	Following a review, training was provided to all pilots over two recurrent simulator checks.
Crews would be trained in 'active monitoring', focussing on switch selections and lever movements.	'Active monitoring' has featured in all recurrent checks since 2016 both as a briefing topic and as a key performance indicator.
It amended its SOPs for flap and landing gear selection to ensure the correct lever is identified before being moved.	SoPs for flap and gear selection were changed to establish a pause prior to selection of the lever.
It would develop training to help crews manage distractions (which had played a role in some events).	The issue of distraction has been addressed through 'active monitoring' training and enhanced briefing techniques focusing on 'how' the aircraft will be operated.
It would raise awareness amongst pilots of the events reviewed through a dedicated flight safety communication.	Two articles were published in the operator's flight safety bulletin.

Table 1

Operators previous safety action and review following this event

Analysis

After takeoff, the commander inadvertently selected the flaps up instead of the landing gear. The error was quickly recognised, the flap lever was returned to the FLAP 1 position and the flight crew focused on achieving a safe flight path in accordance with the operator's upset recovery training.

It was not possible to identify a definitive reason why the inadvertent selection occurred.

Following the incident, the commander stated that in future she will employ a longer pause to double check the correct lever selection and allow time for the pilot flying to intervene should they see the wrong lever has been selected.

The operator reviewed the action taken following previous events which highlighted that the training provided to manage the aircraft in a low energy state at low altitude had been effective in this incident.

ACCIDENT

Aircraft Type and Registration:	MBB-BK 117 D-2 EC145, G-RMAA
No & Type of Engines:	2 Safran Helicopter Engines Arriel 2E turboshaft engines
Year of Manufacture:	2017 (Serial no: 20166)
Date & Time (UTC):	3 May 2018 at 1400 hrs
Location:	Car park close to Molineux Stadium, Wolverhampton, West Midlands
Type of Flight:	Commercial Air Transport (Helicopter Emergency Medical Service)
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damaged frangible fenestron protector and distorted undercarriage cross tube
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	2,012 hours (of which 54 were on type) Last 90 days - 48 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot of the HEMS helicopter took off from a car park in variable wind conditions. Once airborne the helicopter yawed to the left and the pilot attempted to correct by applying opposite anti-torque pedal, but it continued to rotate. He lowered the collective and as the helicopter landed, its fenestron contacted a low wall on the perimeter of the car park. Most of the pilot's experience had been on another type of helicopter and he had made inputs consistent with controlling that aircraft, which were insufficient in this instance. The operator has reviewed the circumstances of the accident and has taken two safety actions as a result.

History of the flight

The pilot had landed the helicopter in a car park close to the site of a road traffic collision in preparation for transporting a patient to Queen Elizabeth Hospital in Birmingham (Figure 1).

Prior to restart, the pilot noted that the wind direction was variable in the location of the car park, so he walked closer to the road to better assess the wind. He determined it to be predominantly east to south-east in direction. As he had landed into the prevailing wind, the pilot did not plan to turn the helicopter during departure.

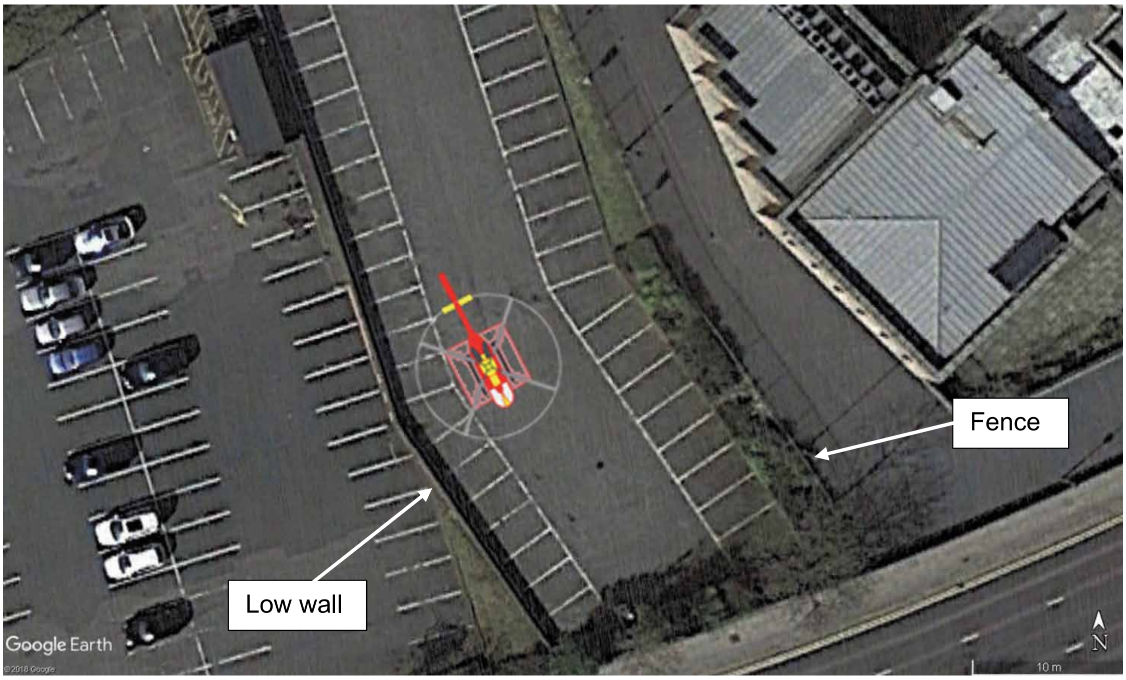

Figure 1

Approximate landing location of G-RMAA

Once the patient had been loaded and engines started, the paramedic boarded and the pilot prepared for takeoff. The engines were set to FLIGHT, the autopilot engaged and pre-takeoff checks were completed, with no abnormalities.

The pilot raised the collective slowly, with the anti-torque pedals level, and brought the helicopter into a low hover. He reported that as the helicopter became light on its skids, it began to yaw to the left. He applied opposite anti-torque pedal to counteract, but the helicopter continued to rotate left. The pilot reported that he was unhappy with the situation and made the decision to land and did so by rapidly lowering the collective.

The pilot shut down the aircraft and the occupants were vacated, with the patient being transported to hospital by road ambulance. The helicopter had turned approximately 40° to the left from its original parked position and had moved 3 to 4 ft rearwards. The frangible section of the tail boom had contacted a low wall and the landing gear cross tube had deformed as a result of the heavy landing (Figure 2). Subsequent examination of the helicopter by the operator's maintenance organisation found no technical issue that could have caused the loss of directional control.

A review of the flight data and a video taken by an onlooker showed that the left anti-torque pedal was slightly depressed prior to lift off. It remained in this position as the helicopter lifted but remained in contact with the ground. As the helicopter became airborne it started to yaw to the left. The pilot applied right anti-torque pedal, but it was insufficient to arrest the rate of yaw.

Figure 2

G-RMAA after the incident with the frangible section of the tail boom in contact with the low wall

Pilot's comments

The pilot, who had recently transferred to flying the EC145 from the EC135, considered that when confronted with the variable wind conditions he had made anti-torque pedal inputs consistent with controlling an EC135, which were insufficient for the EC145 in this instance.

Choice of landing site

The operator assessed the suitability of the landing site against EASA regulations and their operational procedures which defined the dimensional and obstruction requirements for HEMS operating sites.

The operator established that the landing site was compliant with EASA AMC1 SPA. HEMS.125(b)(4) and OM A HEMS requirements; however, it realised that an Operations Department Communication (ODC), providing more detailed guidance to pilots, had not been updated with the most recent EASA Acceptable Means of Compliance reference and did not directly state the dimensions of the EC145. Whilst this update would not have resulted in a different landing site being used, it provides clarity in future landing site selection.

Safety Actions

As a result of this event the operator has re-briefed all of its pilots on the possible consequences of remaining light on the skids when lifting into the hover.

The operator has also updated their ODC to reflect the most recent EASA Acceptable Means of Compliance and refer to dimensions of both the EC135 and the EC145.

ACCIDENT

Aircraft Type and Registration:	Spitfire MkT IX Spitfire, G-ILDA
No & Type of Engines:	1 Packard Merlin 266 piston engine
Year of Manufacture:	1945 (Serial no: CBAF 10164)
Date & Time (UTC):	16 July 2018 at 1658 hrs
Location:	Goodwood Aerodrome, Sussex
Type of Flight:	Passenger Flight
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Landing gear collapsed, propeller tips ground strike and distorted left flap
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	15,616 hours (of which 37 were on type) Last 90 days - 218 hours Last 28 days - 95 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and inquiries made by the AAIB

Synopsis

The aircraft had landed on Runway 14 at Goodwood after completing a passenger flight. As the aircraft was slowing, the pilot became aware that it had started to deviate from the centre line towards the left side of the runway, which he attempted to gently correct by braking. As he did so the aircraft veered to the right, into wind. Despite the application of full left rudder and brake, the aircraft rotated through 90° and the left main landing gear collapsed. The pilot made the aircraft safe and he and his passenger vacated the aircraft having sustained no injuries. The pilot considers the combination of the crosswind and unusually poor runway surface were contributory factors in this accident.

History of the flight

The pilot was completing his third flight of the day and reported his final approach to land at Goodwood on Runway 14. He was informed that the wind was 250°/13 kt. The pilot observed the windsock, which in his estimation was indicating a wind at 230°, so continued with the landing. The aircraft touched down satisfactorily and started to slow down. Just as the aircraft passed the intersection with Runway 24/06 it started to deviate from the centre line towards the left side of the runway. The pilot attempted to correct this by gently braking, but as the aircraft slowed to between 20 and 30 mph, and had travelled three-quarters of the way along the runway, it veered right, into wind. As it did so, the pilot applied full left rudder and brake but was unable to stop the 'swing'. As the aircraft turned through 90° the left landing gear collapsed, the right landing gear partially collapsed and the propeller struck the ground and stopped. The pilot made the aircraft safe and assisted his passenger to vacate the aircraft, both were uninjured. The aircraft sustained damage to its landing gear, propeller tips and left flap.

Contributory factors

The aircraft was regularly flown on experience flights with passengers around the south coast and Chichester area from Goodwood. On the day of the accident the wind direction would have normally made Runway 24 the most suitable. However, Runway 24 was out of service and a NOTAM issued accordingly. Runway 14 was therefore in use, but due to the recent prolonged abnormally hot and dry weather, the surface was degraded with hard dry areas and patchy grass.

A mark made by the left wheel appeared to indicate that it was locked and slipping over the surface as the aircraft ground looped. As the aircraft swung to the right the wheel was then presented side-on to the direction of travel. This increased friction combined with the runway surface and the aircraft's weight and momentum, caused the left landing gear leg to fold the 'wrong way' under the fuselage.

The pilot considers the combination of the crosswind and unusually poor runway surface were contributory factors in this accident.

ACCIDENT

Aircraft Type and Registration:	Europa XS, G-IMAB
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2002 (Serial no: PFA 247-13128)
Date & Time (UTC):	4 August 2018 at 1555 hrs
Location:	East Kirkby Airfield, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damaged fuselage, landing gear, engine and propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	4,002 hours (of which 9 were on type) Last 90 days - 120 hours Last 28 days - 35 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The landing gear and flaps retracted without selection during the takeoff roll and the aircraft slid for approximately 50 m before stopping. The pilot and his passenger were uninjured.

History of the flight

The pilot flew from Rufforth to Breighton where he refuelled the aircraft, before flying to East Kirkby to visit the airshow. He described the takeoff roll from East Kirkby as bumpy and, just as he was about to rotate, the passenger saw "the gear lever shoot forward without any external input". The main wheel, flaps and outriggers then retracted and the aircraft slid to a halt.

Description of the landing gear retraction lever

The Europa XS has a retractable mainwheel with a fixed tailwheel and retractable outriggers on the wings. The landing gear and flaps are selected by a single lever on the centre console between the seats (Figure 1). The lever has two gates at either end of its travel, coinciding with the UP and DOWN positions; it is biased to the right so that it naturally enters the gates. To avoid inadvertent retraction, a safety latch rotates under its own weight, dropping into the retraction lever slot. Some owners have installed a spring to assist the operation of the safety latch, but this was not the case with G-IMAB.

To retract the landing gear, positive action is required to lift the latch out of the slot before the lever can be moved sideways out of the gate and pushed forwards. By design, if the lever is inadvertently moved out of the DOWN gate, the landing gear over-centre mechanism should stop the lever moving forwards without input.

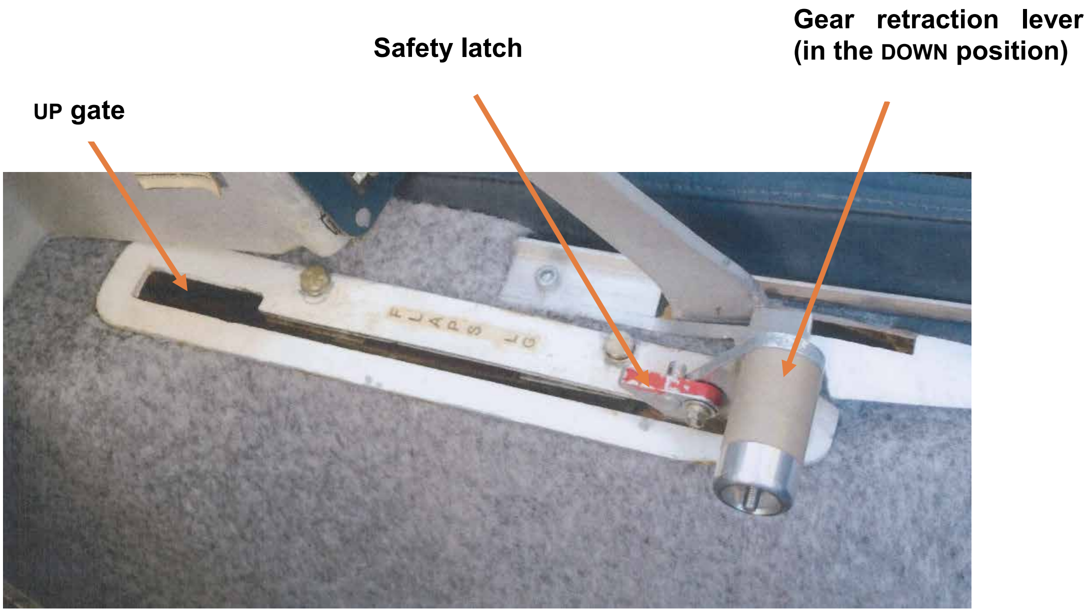

Figure 1

Landing gear operating lever

Pilot's assessment of the cause

The pilot had acquired G-IMAB a few months prior to the accident and his operating experience of the Europa XS was limited to this airframe. When describing the gear lever operation, he noted that "there appeared to be an undue amount of pressure required to engage the down position". Given his limited experience of the aircraft type, he considered this to be normal; a belief that was perhaps reinforced by flying the aircraft with another pilot who had previous experience of the type. He also said that the gear lever on G-IMAB was not biased to the right.

The pilot stated that he verified that the safety latch was in place during his pre-flight checks and he thought that the bumpy runway may have resulted in it jumping out of position. If the gear lever then moved sideways out of the gate, he considered the forces would have been sufficient for the landing gear to retract.

Initial aircraft examination and requirement for annual checks

An initial check by an LAA inspector found wear in the landing gear mechanism, but no obvious cause for the uncommanded landing gear retraction. At the time of writing, the aircraft was awaiting a more detailed inspection prior to repair.

The LAA Type Acceptance Data Sheet refers to Flight Safety Bulletin FSB004, which was produced after the Popular Flying Association carried out a review following a number of undercarriage collapses on Europa and Europa XS aircraft. The bulletin describes mandatory annual checks on retractable monowheel aircraft, including the need for retraction checks and specific requirements relating to the main undercarriage, tailwheel and outriggers.

BULLETIN ADDENDUM

The original AAIB report stated that the aircraft had been repaired after a previous landing gear collapse but a previous owner, who had been associated with the aircraft for several years advised, that this was not correct therefore the following correction has been made.

The first paragraph of the '*Pilot's assessment of the cause*' section of the report has been replaced. The original text is stated below:

> **Pilot's assessment of the cause**
>
> The pilot had acquired G-IMAB a few months prior to the accident and his operating experience of the Europa XS was limited to this airframe. The aircraft had been repaired after a previous landing gear collapse before he bought it and when describing the gear lever operation, he noted that "there appeared to be an undue amount of pressure required to engage the down position". Given his limited experience of the aircraft type, he considered this to be normal; a belief that was perhaps reinforced by flying the aircraft with another pilot who had previous experience of the type. He also said that the gear lever on G-IMAB was not biased to the right.

The original AAIB report also stated that '*An initial check by an LAA inspector found wear in the landing gear mechanism, but no obvious cause for the uncommanded landing gear retraction. At the time of writing, the aircraft was awaiting a more detailed inspection prior to repair.*' This inspection has been completed and the LAA inspector reports that no anomalies were found with the landing gear system. The aircraft has been repaired and an optional spring to assist the operation of the landing gear safety latch has been installed.

The online version of this report was amended on 10 February 2022. Full details of the addendum can be found in the March 2022 Bulletin.

ACCIDENT

Aircraft Type and Registration:	Falco F8L Series 3 (Modified), G-PDGG	
No & Type of Engines:	1 Lycoming O-320-A3A piston engine	
Year of Manufacture:	1959 (Serial no: 208)	
Date & Time (UTC):	24 September 2018 at 1430 hrs	
Location:	Meppershall Airfield, Bedfordshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Propeller, crankshaft and nose landing gear broken, engine bearer bent and damage to rear fuselage	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	60 years	
Commander's Flying Experience:	1,148 hours (of which 10 were on type) Last 90 days - 26 hours Last 28 days - 13 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The pilot approached Runway 24 with full flap selected. During the landing roll, application of the brakes caused the aircraft to veer right and towards a hedge. The pilot had to release the brakes to correct the aircraft's direction. The same thing happened when the brakes were reapplied. As a result, he was unable to stop the aircraft overrunning the runway.

The pilot was uninjured but unable to exit the aircraft unaided because the rearwards sliding canopy was jammed from the accident.

The brakes on this aircraft were operated by a single, heel operated, pedal which applied both wheel brakes together. An engineer, experienced on type, found that only the right brake was operating normally. The left brake was not adjusted correctly and therefore did not apply any braking to its wheel.

The pilot commented that, in future, when he visits a new private airfield he will "carry out a missed approach and overfly at low level", to assess its geography and layout before landing.

He also recommended that owners of similar aircraft, without a canopy jettison system, have a properly stowed escape assist device available to allow the canopy to be broken for emergency egress, should it become jammed.

Photograph with permission

Figure 1

ACCIDENT

Aircraft Type and Registration:	Grob G115E Tutor, G-BYUU	
No & Type of Engines:	1 Lycoming AEIO-360-B1F piston engine	
Year of Manufacture:	1999 (Serial no: 82105/E)	
Date & Time (UTC):	2 October 2018 at 1115 hrs	
Location:	RAF Wittering, Cambridgeshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Engine failure	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	74 years	
Commander's Flying Experience:	8,100 hours (of which 100 were on type) Last 90 days - 37 hours Last 28 days - 3 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The pilot noted an uncommanded reduction in engine speed when returning to Wittering after a successful air test following an engine change. The engine initially recovered but, when the speed reduced again, the pilot made a PAN call. A further loss of power meant that he was unable to maintain height and he transmitted a MAYDAY and prepared to land in a field. The engine stopped prior to the landing, which was accomplished without damaging the aircraft.

Examination found that the engine oil sump drain cap was missing (Figure 1). Loss of the cap resulted in an oil leak and engine seizure.

There is no requirement for the oil cap to be wire locked on the Grob 115E, which is equipped with a modified (inverted) engine oil system to cater for aerobatic manoeuvres. The maintenance organisation considered that the most likely scenario is that the drain cap was not correctly secured after the engine was installed.

The maintenance organisation is reviewing their procedures and, as part of their continuous airworthiness management, is liaising with the manufacturer about an alternative cap that can be wire locked. In the interim, they have introduced an independent check to ensure that the cap is correctly refitted.

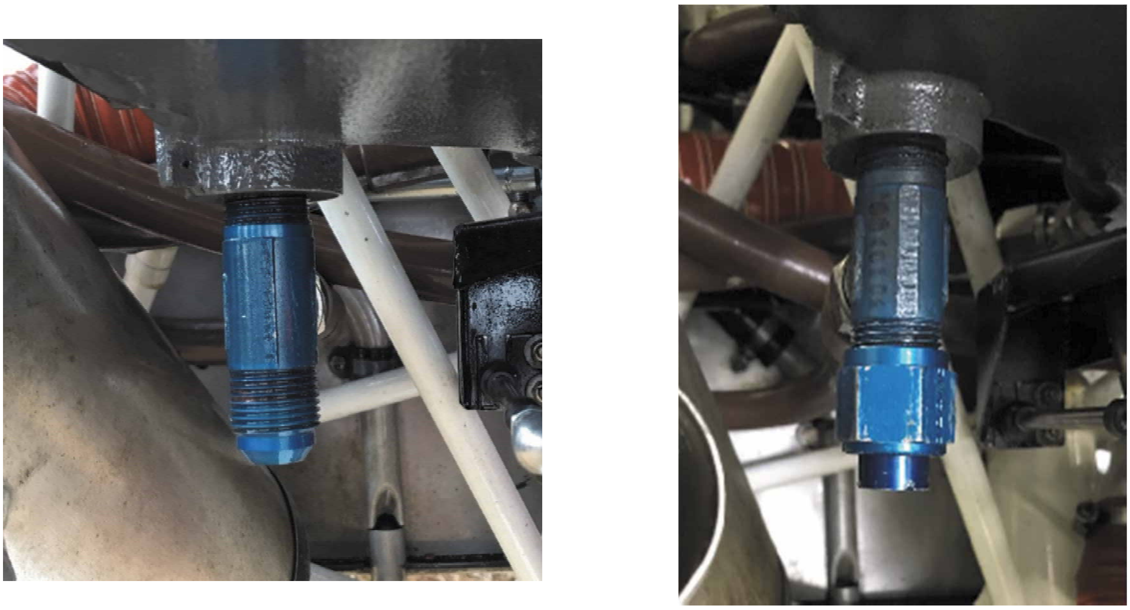

Figure 1

Grob 115E engine oil sump drain
(Left image shows cap missing; right image shows cap installed)

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-180 Cherokee, G-BAJR
No & Type of Engines:	1 Lycoming O-360-A4A piston engine
Year of Manufacture:	1972 (Serial no: 28-7305008)
Date & Time (UTC):	4 September 2018 at 1215 hrs
Location:	Whitesands Beach, Pembrokeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Nose landing gear and propeller damaged; salt water ingress due to partial submersion in seawater
Commander's Licence:	Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	339 hours (of which 265 were on type) Last 90 days - 33 hours Last 28 days - 17 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Shortly after reaching cruising level, the pilot noticed a vibration and the engine began to run roughly. Selecting full throttle and carburettor heat did not resolve the loss of power and the aircraft was unable to maintain level flight. The pilot then focussed on making a forced landing. His intention was to land on a beach, but due to the presence of people, the pilot instead landed along the water's edge. The aircraft landed in shallow water on its main landing gear, but the nose gear broke off when it contacted the water. The pilot was uninjured and able to vacate the aircraft unaided. A subsequent examination of the engine did not conclusively determine the cause of the failure.

AAIB Comment

During his recent biennial flight with an examiner the pilot had received coaching on conducting forced landings. This emphasised "flying the aircraft" to ensure a loss of control did not occur. This is good advice as a number of recent fatal accidents investigated by the AAIB have been due to a loss of control following a partial loss of engine power.

The CAA have recently published guidance on '*Managing partial loss of engine power*' on its Skywise website, SW2018/162[1].

Footnote

1 http://skywise.caa.co.uk/managing-partial-loss-of-engine-power/ [accessed November 2018].

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-180 Cherokee, G-LFSG	
No & Type of Engines:	1 Lycoming O-360-A4A piston engine	
Year of Manufacture:	1970 (Serial no: 28-5799)	
Date & Time (UTC):	26 October 2018 at 1120 hrs	
Location:	Eshott Airfield, Northumberland	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Left wing damaged	
Commander's Licence:	Student	
Commander's Age:	19 years	
Commander's Flying Experience:	32 hours (of which 3 were on type) Last 90 days - 8 hours Last 28 days - 4 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and information supplied by the flying school	

Synopsis

The early solo student touched down long, with slightly excessive speed. Firm braking then caused the aircraft to skid off the runway and strike a fence post.

History of the flight

The flying school at Eshott reported that the student had recently transferred from another training provider. He had then flown a number of times at Eshott and was considered to be familiar with the circuit patterns and procedures there. On the day before the accident, he had carried out a dual training detail before going solo. The instructor had assessed the student to be "quite capable and reasonably competent in consideration of his age and experience and that he was of a standard for solo flying".

The training detail on the day was to be a completion of student solo circuit time, including overhead joins. This followed a comprehensive briefing and general discussion.

The school assessed the weather conditions and deemed them acceptable for this exercise. Although the wind was forecast to increase later in the afternoon, conditions at the time of the flight were judged suitable for a student with this level of experience. The wind, according to an observation made immediately after the accident, was from 300° at 8 kt and the asphalt surface was subsequently reported as being dry.

The student reported that during the final approach (on Runway 26), he experienced some buffeting. He judged that he was slightly to the left of the centreline and slightly fast (75 to 77 kt). He touched down later than normal and “in a panic to stop” he “slammed” the footbrakes, which veered the aircraft to the left, causing it to depart the runway. The left wing struck a fence post and the aircraft rotated through 180°, coming to rest on the grass Runway 01/19, approximately 30 m from the post, facing approximately east. The pilot radioed the airfield frequency for assistance and a school staff member arrived within 30 seconds. The pilot shut the aircraft down and vacated.

The total runway length available was 550 m. Subsequent examination of the Runway 26/08 surface showed a series of fairly long skid marks positioned approximately half-way along the available length; these were attributed to G-LFSG.

On subsequent debrief with the school, the student reported that he had felt some turbulence on the first approach, but he considered it more severe during the second approach and therefore chose to make a full-stop landing.

The student reported that the event had taught him the importance of discontinuing the approach and carrying out a go-around if he was not happy with any of the flight parameters.

AAIB comment

The 550 m length available on Runway 26 at Eshott is shorter than runways typically used for ab-initio training. Landing on such a runway could be considered as challenging for an early soloist.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-181 Cherokee Archer II, G-USSY
No & Type of Engines:	1 Lycoming O-360-A4M piston engine
Year of Manufacture:	1982 (Serial no: 28-8290011)
Date & Time (UTC):	13 June 2018 at 1148 hrs
Location:	Skegness Water Leisure Park, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - None
Nature of Damage:	Beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	79 years
Commander's Flying Experience:	387 hours (of which 347 were on type) Last 90 days - 7 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

When overhead Skegness, the pilot could not see the ground markings for his chosen runway so elected to land on the shorter, east-facing runway. There appeared to be some confusion over the designations of the runways, and the pilot reported that the wind at his departure airfield had been westerly. Due to the first landing attempt being 'long', the aircraft went around but struck a hedge whilst doing so. The pilot reported some difficulty in controlling the aircraft but managed to re-position for a landing on the same runway. That landing culminated in the aircraft overrunning the end of the runway and striking the same hedge. Since the accident, Skegness Airfield has emphasised the runway orientation information on its website.

History of the flight

The pilot reported that he planned to fly with a passenger from Leicester to Skegness for a day trip with a friend. He telephoned Skegness Airfield before departure to gain prior permission to land there and was told that there was no air to ground radio operating that day. Having been there before, he decided to make the flight. Prevailing winds meant that a westerly facing runway was appropriate for departing Leicester.

The pilot originally planned to land on the longer of the two grass strips at Skegness, which is oriented 030° and 210°. On arrival, the pilot reported that there was no windsock and, despite performing two level circuits at 1,000 ft agl, neither occupant of the aircraft could see the ground markings for the chosen runway. Therefore, he elected to use the shorter, east-west orientated, strip – which he could see.

The pilot originally reported the designation of his chosen landing runway as being ‘03’, but stated afterwards that it was in fact ‘11’.

He performed a left-hand circuit for Runway 11 at 1,000 ft agl and turned on to final approach at 700 ft agl. Towards the end of the approach, he realised that he was going to land far down the runway so he performed a go-around. During that manoeuvre, the aircraft clipped a hedge situated after the departure end of the runway, and some foliage became attached to the airframe.

The pilot reported that he struggled to maintain control and prevent the aircraft from stalling. He turned the aircraft right “with difficulty” to avoid a large caravan park ahead and entered a non-standard right hand circuit over a clear ground area, again for Runway 11. He stated that the aircraft would only “stay in the air” with full power selected. The rudder and elevator appeared to operate normally, but the ailerons were operating “strangely”.

Due to the high power setting, G-USSY touched down at an airspeed of around 90 KIAS. The brakes seemed to have little effect. Approaching the end of the runway, the pilot shutdown the engine and told the passenger to ‘brace’.

In order to avoid some trees situated within the same hedge as was struck previously, the pilot slewed the aircraft to the right. The aircraft came to rest in the hedge. This blocked the doors, and the occupants remained inside the aircraft for approximately 15 minutes until other people arrived at the aircraft and could open the luggage hatch.

Runway designation

The pilot reflected that the choice of runway was a factor in the accident, and that the winds appeared to be more westerly than he had originally thought. Prior to the flight, he accessed runway information on the Skegness Airfield website, which describes them as follows:

> *‘Runways 03/21 799m x 23m*
> *11/29 650m x 23m*
> *<u>All circuits inland</u> i.e. 03/11 LH - 21/29 RH’*

Conclusion

The description of the runways and the circuit directions may have contributed to some confusion by the pilot over the runway designations. Since the accident Skegness Airfield stated that it intends to alter its website to emphasise the runway designations.

ACCIDENT

Aircraft Type and Registration:	Robinson R44 Raven II, G-FLYX	
No & Type of Engines:	1 Lycoming IO-540-AE1A5 piston engine	
Year of Manufacture:	2007 (Serial no: 11669)	
Date & Time (UTC):	2 November 2018 at 1458 hrs	
Location:	Denham Aerodrome, Buckinghamshire	
Type of Flight:	Training	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - 2 (Minor)	Passengers - N/A
Nature of Damage:	Substantial	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	66 years	
Commander's Flying Experience:	2,643 hours (of which 1,400 were on type) Last 90 days - 130 hours Last 28 days - 35 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

A student pilot, who was training towards his PPL(H), was practising his takeoff and landing techniques with an instructor. The instructor stated that after completing several takeoffs and landings to a good standard, the student repositioned the helicopter to the beginning of grass Runway 12 and landed across the white arrow marking the start of the runway.

The instructor stated that this landing was a bit rushed, especially considering the uneven nature of the surface, and the student immediately began to lift off to attempt the landing again. However, as the helicopter lifted, it began to rotate to the right which the instructor attempted to counter with the application of left pedal and by lowering the collective. The helicopter then rolled to the left and the front of the left skid contacted the ground before breaking off. The helicopter continued to roll further to the left, with the rotor blades striking the ground, before coming to rest on its left side with the engine still running.

The student vacated the aircraft using the right door and assisted the instructor out of the helicopter after the instructor had first shut down the engine. Both occupants sustained minor cuts from the broken windscreen.

The instructor stated that he had previously emphasised to the student the need for a gentle two-stage lift into a hover and that he may have been "lulled into a false sense of security" by the student's good performance at the beginning of the lesson.

ACCIDENT

Aircraft Type and Registration:	Sportstar Max, G-TMAX	
No & Type of Engines:	1 Rotax 912 ULS2 piston engine	
Year of Manufacture:	2010 (Serial no: 2010 1305)	
Date & Time (UTC):	29 August 2018 at 1140 hrs	
Location:	Wycombe Air Park, Buckinghamshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to the firewall, nosewheel, cowling and propeller	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	37 years	
Commander's Flying Experience:	225 hours (of which 26 were on type) Last 90 days - 1 hour Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The aircraft landed, in crosswind conditions, on the nosewheel causing damage to the nosewheel, firewall, cowling and propeller. The pilot attributed the accident to lack of recency and reflected that he should have gone around when the aircraft did not land as expected.

History of the flight

The pilot was returning from a local general handling flight to land on Runway 24 at Wycombe Air Park. The surface wind was varying between 330° and 340° at 10 kt giving a crosswind from the right and slight tailwind for Runway 24. Visibility was good with scattered cloud at 3,500 ft and temperature 21°C. The pilot described the approach and initial landing as unremarkable, but after the initial touchdown the aircraft did not appear to 'settle' as he expected. The pilot tried to force the aircraft to settle onto the runway, causing oscillations in pitch as the landing continued. Approximately two thirds along the runway the aircraft 'ballooned' then landed firmly on the nosewheel. The pilot was initially unaware of any damage and was able to taxi back to the normal parking position. Subsequent inspection found damage to the firewall, nosewheel, cowling and propeller.

Analysis

After the accident the pilot believed that the additional groundspeed due to the lack of headwind caused the aircraft to not settle as he anticipated. He reflected that an early decision to go around would have avoided the accident.

The pilot had only flown for 36 minutes in the last 90 days and he thought that his lack of recency may have contributed to the accident.

ACCIDENT

Aircraft Type and Registration:	Flight Design CTSW, G-KUPP
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2006 (Serial no: 8227)
Date & Time (UTC):	19 July 2018 at 1140 hrs
Location:	Redhill Aerodrome, Surrey
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Fire damage to cockpit instrument console
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	65 years
Commander's Flying Experience:	4,870 hours (of which 2,069 were on type) Last 90 days - 47 hours Last 28 days - 24 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

An electrical fire in the instrument console developed shortly after takeoff and the pilot returned to land on the active runway. An electrical short circuit with the composite instrument console, resulting in a resin fire, was traced to a damaged wire. The wiring had been previously modified and a Service Bulletin has been released to reduce the risk of electrical and fuel fires.

History of the flight

The aircraft took off from Runway 08R at Redhill Aerodrome, on the second training flight of the day at 1138 hrs. The northerly wind was 3 kt and the pilot in command was in the right seat. As the aircraft climbed through 500 ft the pilot noticed an electrical burning smell and smoke coming from the instrument console. He declared a MAYDAY, immediately turned the aircraft left and could feel heat coming from the central instrument console onto his left leg. The pilot continued a tight left-hand circuit to land back on Runway 08R and selected 40° of flap. With the smoke making it difficult to the read the ASI on final approach, the pilot landed the aircraft about halfway along the runway. The airport RFFS met the aircraft as it stopped and used carbon dioxide fire extinguishers to put the fire out. The total flight time was less than two minutes. It was noted by the pilot, after exiting the aircraft, that the flaps were in the takeoff configuration (15°).

Aircraft examination

The aircraft was recovered to a repair organisation for examination and the instrument console was disassembled. There was evidence that the console had been modified previously to fit new avionics equipment and the charge indicator lamp had been moved. The original location was the upper right of the panel, but it had been moved to the lower central section (Figure 1). The repair organisation's assessment was that the standard of wiring was very poor. Wires were over length, had insufficient support, there was a risk of entrapment or chafing and improper terminals had been used.

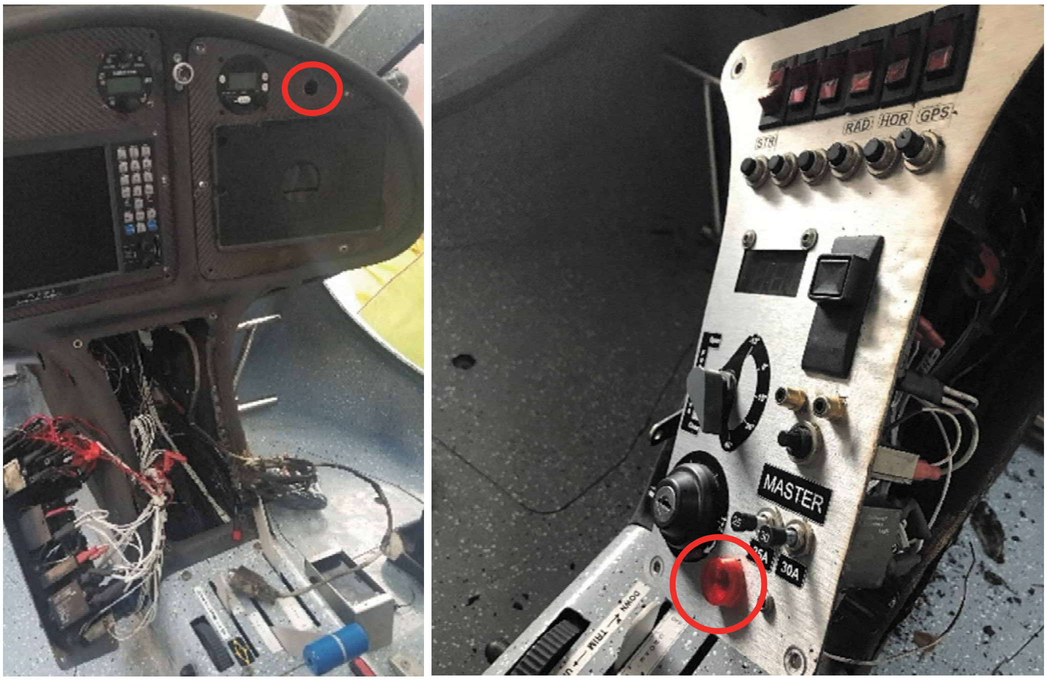

Figure 1
Instrument console

The charge indicator lamp is connected to the voltage regulator through a 22AWG (0.64 mm) wire which is nominally sized for current up to 3 amps. Should the lamp supply wire short to earth, the current could be up to 50 amps; the full regulator output of 20 amps and up to 30 amps from the battery. The wire to this lamp had burned through and several adjacent wires showed evidence of heat damage. The structure of the instrument console is a woven carbon / resin composite which showed evidence of fire damage. The damage showed that in some places, the resin had been totally consumed and only the carbon mat remained (Figure 2).

Figure 2
Fire damage to the instrument console

Located in the rear of the instrumnt console (Figure 3) was the engine fuel supply pipe, and the fuel filter, from the wing fuel tanks to the engine.

Figure 3
Fuel supply and filter location (Instrument console removed)

Analysis

The repair organisation assessed that the modification to the charge warning lamp, without shortening the wires, was a causal factor in initiating the fire. The length of wire for the modified position was significantly less compared to the original location. The insulation on this excess wire was damaged and this resulted in a short circuit to the structure of the composite instrument console. The cause of the insulation damage could not be determined but could have been from chafing or pinching in a panel joint. The composite material is electrically resistive and the current of up to 50 amps generated sufficient heat for the resin to ignite and produce smoke as it burned.

The UK type approval holder (also the repair organisation) has subsequently issued Service Bulletin 150 for Flight Design CTSL, CTSW and CT2K aircraft. The Service Bulletin recommends a 1 amp fuse to be fitted to the charge warning lamp supply wire and to:

> *'ensure the wiring is tidy with tight connections and is well secured and protected. Be sure the wiring cannot be trapped in panel joints and has adequate strain relief. Ensure it cannot short against anything including control runs, at all extremes of movement.'*

Further, it states that any fuel filter inside the instrument console must be of a fire-resistant type.

Conclusion

Due to a modification to the charge warning lamp in the instrument console, an over-length wire was damaged and short circuited to the composite structure. The heat generated from the short circuit resulted in the resin igniting shortly after takeoff. The pilot managed to land the aircraft on the active runway despite reduced visibility and system failures.

Safety Actions

Following the accident, the following Safety Action was taken:

> The UK type approval organisation has issued a Service Bulletin No 150 to modify Flight Design CTSL, CTSW and CT2K aircraft, to reduce the risk of electrical and fuel fires.

ACCIDENT

Aircraft Type and Registration:	Flight Design CTSW, G-KEVK
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2009 (Serial no: 8483)
Date & Time (UTC):	15 September 2018 at 1742 hrs
Location:	4.5 miles north of Sywell Aerodrome
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Aircraft damaged beyond repair
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	541 hours (of which 345 were on type) Last 90 days - 14 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

After completing a local flight, the occupants of G-KEVK were positioning the aircraft for a return to Sywell Airfield. Approximately 5 nm from Sywell, the engine 'coughed' and then stopped. The pilot flying positioned the aircraft for a forced landing in a stubble field. After landing the nosewheel struck a tractor furrow and the nose landing gear collapsed. The aircraft came to rest upside down in the field. Neither occupant was injured.

The cause of the engine failure could not be positively determined although it was suspected that it was caused by issues with the fuel supply. It was possible that there was water in the fuel which the pilots were unable to check, or that air was drawn into the fuel system due to a low fuel level and the design of the system.

History of the flight

G-KEVK was prepared for a local flight from Sywell Airfield, Northamptonshire. Before departure the fuel tanks were checked to ensure that the fuel was more than sufficient for the planned short flight plus contingencies. After departing from Sywell, the two occupants, both qualified pilots on the aircraft type, decided to proceed to Denethorpe Airfield to carry out some circuit practise. Having completed four circuits at Denethorpe, the aircraft departed to the west to do some local sightseeing. Having flown over Market Harborough, the occupants decided that it was time to return to Sywell and began a left turn to position the aircraft for its approach to the airfield.

As they approached approximately 5 nm from the airfield, the pilots heard the engine ‘cough’ and then stop. The pilot who was flying the aircraft at the time began to scan for a suitable field. He observed that most of the fields appeared newly ploughed but that there was a long field that looked to have a stubble surface although it was not into wind. The pilot considered that there was little or no other choice than to accept a downwind landing into this field as he did not have the height to position the aircraft for an into-wind landing. As a result, the touchdown was at a higher groundspeed than the pilot would have liked. The aircraft type is not fitted with suspension and has disc brakes on its main wheels. The pilot was beginning to apply the brakes gently to avoid locking the wheels when the nose dropped suddenly and the aircraft lurched forward, coming to rest upside down as show in Figure 1.

Figure 1
The final position of the aircraft

Accident site

The aircraft landed in a field of stubble which contained numerous tractor furrows. The CTSW undercarriage is not constructed for rough terrain and photographs of the accident site suggested that the nosewheel struck a tractor furrow before the aircraft speed had been reduced significantly. This caused the collapse of the nose landing gear and pitched the aircraft onto its roof. Both occupants were able to vacate the aircraft unaided and neither suffered any injuries.

In preparation for the aircraft recovery both wings were drained of fuel. It was discovered that one wing was empty of fuel whilst the other contained a significant amount. There was no sign of a leak. Once the aircraft was recovered to an engineering facility, the remains of the propeller were removed, and the engine was connected to a new source of fuel and started. It started immediately and showed no signs of damage.

Aircraft information

The Flight Design CTSW is a high wing, tricycle undercarriage microlight aircraft. The aircraft is of composite construction, primarily made of carbon fibre. Each wing has an integral fuel tank with a capacity of 65 litres (62 litres useable) and fuel is gravity fed. The fuel tanks are interconnected and in normal operations the fuel should feed equally from each tank. However, slight geometric differences or flying with a sideslip can result in one tank feeding faster than the other.

Service Bulletin SB131[1] was released by the manufacturer after a CTSW ran out of fuel with apparently 5 litres of fuel remaining in one tank with the other tank empty[2]. Tests showed that when 5 litres remained in one tank with the other tank empty, it was possible to uncover the fuel feed pipe if the aircraft was flown with sideslip, putting the wing containing fuel on the low side. Uncovering the fuel feed pipe would draw air into the system causing the engine to stop.

Neither pilot was aware of the contents of SB131 which was issued in 2012. Service Bulletins are available to aircraft owners and users through the Type Certificate holder in the country of registration. It is the responsibility of the aircraft owner or operator to seek out information from the Type Certificate holder. These Service Bulletins should be included in the Pilots Operating Handbook for the aircraft so that they are available to all the pilots who fly the aircraft. Many of the Type Certificate holders work closely with owners and the aircraft sporting associations to try and maximise the visibility of bulletins.

The fuel tanks in the CTSW contain no water drain points and there is no requirement to check for the presence of water in the fuel.

G-KEVK was fitted with a Ballistic Recovery System (BRS) which was not used. The pilots did consider using the BRS but, given the wind direction and possible landing areas underneath them, decided that the field landing was the safer option. The pilots flew together frequently and would regularly practise engine failures.

Weight and balance

The maximum weight of a microlight aircraft is governed by regulations set by the CAA. This limits the weight of a two-seat aeroplane to 450 kg which is increased to 472.5 kg if the aircraft is fitted with an airframe-mounted emergency parachute system. G-KEVK was designed with a maximum takeoff weight of 600 kg, which was then limited by the class regulations currently in force.

One of the pilots had completed a weight and balance calculation to ensure the aircraft was below the 472.5 kg maximum weight on takeoff from Sywell. The pilots planned to fly a short flight due to the limited fuel load available to comply with the maximum weight. Subsequent checks of the calculations by the pilots discovered that no account had been

Footnote

1 Service Bulletin Number SB 131 Issue 1, Issued by P&M Aviation, 18 Jun 2012.
2 AAIB report EW/C2009/08/02, G-VINH from AAIB Bulletin 8/2010.

taken of the extra safety equipment on the aircraft. This extra equipment meant the aircraft was actually over its weight limit of 472.5 kg but this had no effect on the subsequent events and the pilot reported no issues with the aircraft performance.

The regulation maximum weight of microlights is currently under review by the CAA in consultation with the aviation sporting associations and other industry stakeholders. Both pilots stated that raising the maximum weight to that for which the aircraft was designed would allow them to carry more fuel without being concerned about the current regulation maximum weight which they consider to be very limiting.

Analysis

The cause of the engine failure could not be positively determined. However, the aircraft engine was run successfully after the aircraft was recovered and a fuel source was attached. This indicated that the engine had not suffered any kind of internal fault and it was likely that the cause of the stoppage was a lack of fuel supply.

It is possible that water in the fuel caused the engine to stop suddenly. There was no requirement in the checklist to check for water in the fuel nor any method by which pilots could check.

It is also possible that one of the wing tanks was empty of fuel which, combined with some sideslip or the turn back to the airfield, caused the fuel feed pipe in the other tank to become uncovered and air to be drawn into the fuel system. This would have stopped the engine but neither pilot was aware of the Service Bulletin detailing this possibility.

The flying pilot positioned the aircraft for a forced landing in a suitable field but was not at a height at which he could manoeuvre to approach the landing into wind. The extra speed of the downwind landing combined with the nose striking a tractor furrow before the speed had decreased pitched the aircraft onto its roof. Neither occupant was injured.

Conclusion

The aircraft engine failed as the pilots prepared for their return to Sywell. The failure was probably due to a fuel supply issue. They were able to complete a forced landing in a field, but the aircraft nose wheel caught in a tractor furrow and the aircraft was pitched onto its roof.

Neither pilot was aware of a Service Bulletin regarding the fuel supply which had been issued in 2012.

ACCIDENT

Aircraft Type and Registration:	Ikarus C42 FB100 Bravo, G-CHWN
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2013 (Serial no: 1302-7240)
Date & Time (UTC):	20 October 2018 at 1434 hrs
Location:	Sywell Aerodrome, Northamptonshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to the left landing gear leg, left door and surrounding structure
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	220 hours (of which 15 were on type) Last 90 days - 16 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries made by the AAIB

The owner had recently purchased G-CHWN, his first fixed-wing microlight, having previously flown flex-wing types and was flying it back to his home airfield at Sywell from Dunkeswell Aerodrome. On arrival at Sywell, he stated that the weather was sunny with scattered clouds and good visibility, a light wind which favoured a landing on Runway 21R, and a temperature of 10°C.

After a stable approach, he landed slightly to the left of the runway centreline and attempted to steer back towards the centre of the runway. However, he mistakenly applied left rudder pedal, which would have been the correct steering sense for a flex-wing microlight, but incorrect for a fixed-wing type. The microlight left the paved runway surface, struck a runway edge light, and subsequently the left landing gear leg collapsed under braking.

The pilot, who was not injured, attributed the accident to his unfamiliarity on fixed-wing microlights and the reversed sense of operation of the steering system when compared to flex-wing types on which he had more experience.

ACCIDENT

Aircraft Type and Registration:	Pipistrel Alpha Trainer, F-JDGZ
No & Type of Engines:	1 ROTAX 912 UL
Year of Manufacture:	2018
Date & Time (UTC):	11 July 2018 at 1815 hrs
Location:	Clench Common Airfield, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Bent nose gear strut, cracked engine cowling, scratched propeller and wing
Commander's Licence:	National Private Pilot's Licence (Microlight)
Commander's Age:	58 years
Commander's Flying Experience:	305 hours (of which 22 were on type) Last 90 days - 13 hours Last 28 days - 10 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was on the final leg of a delivery trip from the manufacturer in Slovenia. The owner, who was operating as pilot in command (PIC), was seated in the left seat and had flown two prior legs that day. The pilot in the right seat had flown as PIC on other legs on previous days of the trip. This pilot was also qualified as an instructor.

The PIC overflew the airfield, determined that there was minimal wind and elected to land on Runway 26, a 450 m grass strip. During the landing he bounced and elected to go around. Control was taken by the pilot in the right seat and a second approach commenced. The aircraft touched down approximately one third of the way down the runway. Upon applying the brakes, the pilot flying determined that the braking effect would not slow them sufficiently and decided to go around. He opened the throttle and, once airborne, initiated a slight right turn to avoid some trees on the climb out. He noticed that the climb performance was not as expected and, realising that the airbrakes were extended, called "Retract Retract" to the PIC, who had the controls for the electrically-driven airbrakes[1] directly in front of him. Instead of operating the airbrake control, the PIC retracted the flaps. The ensuing loss of lift caused the aircraft to sink into a corn field at the end of the runway. It struck a wire fence and came to rest in a field.

Footnote

[1] The airbrakes can be set to AUTO for automatic deployment when the flaps are set to the second stage, RETR. for manual retraction and EXT. for manual extension.

ACCIDENT

Aircraft Type and Registration:	RAF 2000 GTX-SE, G-CCUH
No & Type of Engines:	1 Subaru EJ22 piston engine
Year of Manufacture:	2004 (Serial no: PFA G/13-1356)
Date & Time (UTC):	9 July 2018 at 14:52 hrs
Location:	Goodwood Aerodrome, Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - None
Nature of Damage:	Aircraft damaged beyond repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	603 hours (of which 475 were on type) Last 90 days - 14 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was returning to Goodwood after landing at another aerodrome. As he approached Runway 24, he noticed that his landing was going to be on or just before a patch of worn grass. Although this patch was flat and suitable for the landing, he decided to add power to ensure the aircraft landed beyond it. The addition of power increased the speed of the aircraft, which then touched down faster than the pilot had intended. He attempted to slow the aircraft by aft movement of the stick but the aircraft became light on its wheels. This combined with some steering applied for the crosswind from the left combined to make the aircraft swerve and it started to fall onto its side. The rotor and propeller then both contacted the ground, causing the aircraft move violently before coming to rest on its left side. The pilot was seriously injured and the aircraft was damaged beyond repair.

Although the pilot was able to release his harness and turn off the ignition he was unable to vacate the aircraft unaided due to his injuries and had to await the assistance of the emergency services.

The pilot commented that spending some time flying with an instructor might have been beneficial to all aspects of his flying.

ACCIDENT

Aircraft Type and Registration:	Rotorsport UK Cavalon, G-CKYV
No & Type of Engines:	1 Rotax 914-UL piston engine
Year of Manufacture:	2018 (Serial no: RSUK/CVLN/026)
Date & Time (UTC):	9 August 2018 at 1306 hrs
Location:	Wolverhampton Halfpenny Green Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	701 hours (of which 13 were on type) Last 90 days - 95 hours Last 28 days - 24 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The rotor was being pre-rotated in preparation for departure. The pilot recalled seeing 200 rpm but shortly thereafter noticed the rotor rpm indication had dropped to zero. Concerned that the rotors might now be rotating below 200 rpm he decided to attempt to increase the rotor rpm by commencing a takeoff roll. At approximately 30 kt the cyclic control moved violently and was wrenched from the pilot's grasp. The aircraft pitched up, yawed left and rolled left before falling upright and sliding along the runway.

It is likely that the aircraft encountered a blade sailing[1] event as the airspeed increased and the rapid movement of the rotor disc forced the controls from the pilots grasp.

History of the flight

The pilot was delivering the aircraft to a new owner. As is usual, he engaged the pre rotator before departure to accelerate the rotor to a suitable rpm for takeoff, and he recalled seeing 200 rpm, which was normal. Shortly thereafter, he noticed that the rotor indication had dropped to zero and, concerned that the rotors might now be rotating at less than 200 rpm, decided to attempt to increase the rotor rpm by commencing a takeoff roll with less than full power. At approximately 30 kt the cyclic control moved violently and was wrenched from his grasp. The aircraft pitched up, yawed left and rolled left before falling

Footnote

[1] See later section: *Blade sailing.*

upright and sliding along the runway. The pilot was assisted from the aircraft by the Fire Service and suffered only minor injuries.

Figure 1
Aircraft on the runway

Pro-rotation

The pre-rotator system uses a clutch from the engine to accelerate the rotor prior to takeoff and reduce the required takeoff distance. For a normal takeoff, the clutch is disengaged leaving the rotor unpowered, but the cyclic control is initially held fully aft to maximise the airflow through the rotor and maintain the rpm. When he noticed the rotor rpm at zero, the pilot decided to attempt to increase it by running the aircraft forward along the runway. Increasing the flow of air through the rotor disc will increase the rotor rpm.

Blade sailing

A condition known as ‘blade sailing’ can occur at low rotor rpm in strong wind conditions. In this case the increasing airspeed would create the wind. With the aircraft facing into wind, the advancing blade experiences an increase in lift and will flap up excessively due to the low centrifugal force, reaching a maximum height to the front of the aircraft. As the blade progresses on the retreating side, it experiences a sudden loss of lift and will flap down rapidly, flex and reach its lowest position to the rear of the aircraft, over the tail. There is a danger that the blade may strike the tail. In this case, the pilot recognised the danger of the blades striking the tail and did not move the cyclic fully aft as he accelerated the aircraft. His intention was to try and move the cyclic aft in stages as the aircraft gained speed to generate sufficient rotor rpm for flight.

At low rotor rpm, blade sailing can cause the rotor disc to move violently. It is probable that G-CKYV encountered a blade sailing event as the airspeed increased and the rapid movement of the rotor disc forced the controls from the pilots grasp. Though he reduced power, he was unable to effectively counter the motion of the aircraft.

The pilot recognised that his determination to take off distracted him from the obvious course of aborting due to the rotor rpm indicator issue.

ACCIDENT

Aircraft Type and Registration:	Aeryon Skyranger R60, (UAS) SR9112798
No & Type of Engines:	4 Electric - engines
Year of Manufacture:	(Serial no: SR9112798)
Date & Time (UTC):	18 January 2018 at 0330 hrs
Location:	Brixton, London
Type of Flight:	Aerial Work
Persons on Board:	Crew - N/A Passengers - N/A
Injuries:	Crew - N/A Passengers - N/A
Nature of Damage:	Unmanned aircraft destroyed
Commander's Licence:	CAA Permission
Commander's Age:	33 years
Commander's Flying Experience:	n/k hours (of which n/k were on type)[1] Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further information provided by the operator and manufacturer

Synopsis

After takeoff the unmanned aircraft (UA) experienced winds exceeding the manufacturer's stated limitations and was unable to hold its position position. A culmination of the subsequent position warning and automatic attempt to return "home" and land triggered a software error, commanding the UA to land while not over its home position. As the UA descended there was a loss of link with the ground control unit and the UA collided with a tree. The loss of signal was probably caused by the loss of radio line of sight between the UA and ground control unit when it drifted in the high wind over a five-storey building.

History of the flight

The UA was being operated in a built-up area at night, with appropriate authorization from the CAA. It was carrying a camera and was being operated by a pilot and observer. Prior to the flight, an inspection of the area was carried out to identify suitable takeoff and landing sites and to check for any local hazards. A check of the UAS was also completed with no faults identified.

Footnote

[1] The actual hours have not been determined but the pilot was reported to be inexperienced, both on UAS and on type.

Flight settings were loaded into the ground control unit, with a programmed maximum operating height of 121 m. The pilot stated he then lifted the UA into a 1.5m hover to complete calibration and safety checks, which all proved satisfactory. The UA was then climbed towards its planned operational height, but as it reached a height of about 50m it started to drift and the ground control unit displayed a 'Strong Winds [N10]' message[2]. The ground control unit also displayed two options for the pilot: 'Home and Land' and 'Ignore'. The pilot did not select either option. The UA, unable to hold position, then drifted out of sight over an adjacent five-storey building, generating a 'Position Control Warning'.

The pilot realised the UA was not following the intended flight track and changed position in an attempt to see the UA again, but without success. The ground control unit then indicated a loss of control signal. The UA camera image was lost and the control screen switched to the home screen, with no apparent connection indicated with the UA. The UA did not return to the pre-programmed home position (the takeoff point) and a search of the local area revealed the UA had impacted the ground about 30 m from the take-off site, breaking into several pieces.

Recorded information

Flight data stored on the UA's internal storage card could not be recovered due to damage sustained to the card in the impact. The flight logs recorded on the ground control unit, and video recorded to the video storage card, were however recovered. These indicated that after the control link was lost, the UA went through a number of direction and height changes before descending and impacting a tree top at a height of approximately 15 m, then falling to the ground.

UAS software information

The UAS comprised a Skyranger R60 quadcopter, controlled by a Panasonic Toughpad FZ-G1 ground control unit with an integrated Aeryon joystick controller. The system was loaded with software Version 3.6.14.54767 but on 23 December 2016 the manufacturer became aware it contained an error. The error only became evident when a 'non-fatal' message[3] was generated and the UA became unable to hold position. As a result of the pilot not selecting either the 'Home and Land' or 'Ignore' options after the strong wind message, the UAS had automatically entered the 'return home' mode. The error however resulted in the UA considering it was over its home position, regardless of its actual location, and landing. A software fix was completed on 6 June 2017, but this was not made available until the manufacturer's software Version 3.7 was released on 8 January 2018. The manufacturer was aware of only one other incidence of the error occurring operationally and believed the conditions required to trigger it were sufficiently rare that the delay would not pose an undue risk to operators.

Footnote

[2] Message displays in winds in excess of 45km/hr.
[3] Prompts to the pilot to either alter or terminate the flight when the UA encounters certain conditions, such as strong winds.

Operators had to either subscribe to an online system to receive software updates or receive these through the relevant reseller. The reseller of the UAS involved in the accident was no longer representing the manufacturer when the software update was released. In addition, the operator of the UAS involved in the accident was not its owner. The operator reported that it did not have access to the manufacturer's online service, although the manufacturer stated that the operator had an access account at the time of the accident. Nevertheless, the operator was not aware of the issue with the software, nor that there was an update available, and as a consequence Version 3.7 had not been installed.

Aircraft performance

The UAS operator's manual states that it can operate in sustained wind speeds of up to 65 km/hr (35 kt) and gusts of 90 km/hr (48 kt).

Meteorology

Forecasts for London City, Heathrow and Gatwick Airports indicated the risk of strong south-westerly winds at the time of the intended UAS flight, along with a risk of rain. The nearest airfield to Brixton that had a valid TAF at the time of the incident was London City and the TAF issued at 0306 hrs gave a risk of winds blowing from the west at 25-30 kt with gusts of 40-50 kt from 0300 hrs until 0800 hrs.

Actual conditions gave wind speeds generally increasing through the morning in the London area. London City produced METARs at the time of the incident, and at 0320 hrs the wind was from 250° at 30 kt mean with gusts of 47 kt. At Heathrow, the second closest airfield to Brixton, at 0320 hrs the wind was from 260° at 31 kt with gusts of 45 kt. Finally, at Gatwick at 0320 hrs the wind was from 240° at 17 kt with gusts of 29 kt.

The pilot and observer used the Gatwick TAF and a weather app to obtain wind speeds in planning the flight. Both provided only forecast data. The app-predicted wind speed at the time of the flight was 42 km/hr (22 kt) with gusts of 77 km/hr (41 kt) at ground level.

The UAS also recorded the wind speed experienced by the UA. This indicated that sustained wind speeds in excess of 65 km/hr were experienced approximately 75 seconds into the flight for about 20 seconds.

Personnel

Both the pilot and observer had received training on the Skyranger R60 and been issued with the appropriate permission by a CAA National Qualified Entity. They were however relatively inexperienced at operating UAS at the time of the accident.

Analysis

The pilot and observer were aware of the difficult weather conditions at the time of operation, but the sources of weather information they were relying on indicated the conditions were within the capability of the UAS. These sources provided, however, only forecast conditions and the actual conditions were somewhat different. In particular, it was not apparent to the operator that the app they were using was providing forecast, rather than the actual, conditions at the time. Had they reviewed the actual wind conditions reported by Heathrow and London City Airports they would have realised the conditions were marginal for the UAS to be operating.

The data recovered from the UA indicate that after takeoff, when the UA left the shelter of the surrounding buildings, it experienced wind speeds above its design limit and was unable to hold position.

Whilst it has not been possible to eliminate a technical failure, due to the damage sustained by the UA in the impact, the most probable cause of the loss of link between the UA and the ground station just after the wind warning occurred was the fact it drifted out of radio line of sight. Whilst the low height at which the UA was blown over the building contributed to the attenuation of the radio signal, the siting of the ground station and the height and proximity of the building would still have provided a potential issue in maintaining a strong signal between the ground station and UA had it achieved its proposed operating height.

Having lost its ability to hold position, with no command made by the pilot in response, the UA should have attempted to return to its home position, which in the strong winds would have proved difficult. The combination of the wind and position warnings, with the return home function triggered, caused the software error to make the UA attempt to land immediately, rather than to return to the home position in order to do so. The UA descending contributed to the loss of signal, after which the UA was committed to try and land, resulting in the collision with the tree and the subsequent impact with the ground. Had the UA remained in visual line of sight, not only should it have been obvious to the pilot what the UA was doing, but he should have had the ability to take over manually to try and return the UA to the home position or find an alternative safe place to land.

The manufacturer had taken six months to provide a software fix to the problem and a further six months to release it. The delay in doing so was due to the consideration by the manufacturer that the failure was unlikely to occur, and by inference was not critical to the safe operation of the UAS. The delay was further compounded by the fact the operator was not aware of the software problem or the fact that an update existed. As the UAS was not required to be certified, due to its low weight, there was no oversight of these aspects by the relevant authorities.

Safety actions

As a result of the accident, the operator carried out a comprehensive review of their procedures as well as liaising with the manufacturer on the technical aspects of the accident. As a result, the operator has introduced a number of safety actions. These include:

- Ensuring software checks and updates are integrated into the maintenance procedures.

- Ensuring at least one member of the operating team is experienced in operating the system and introducing a mentoring scheme to provide opportunities to increase experience levels with appropriate oversight.
- Providing information on the most appropriate sources of weather information to be used in planning and operating flights and ensuring these take into account actual, as well as forecast, weather conditions.
- Providing pilots and observers with training on weather effects experienced in a built-up environment, especially related to wind.
- Introducing reduced wind limits on the operation of UAS to allow a safety factor, mitigating the risk of exceeding the limits. These will also be varied to take account of each pilot's experience.
- Revised training on the assessment of ground station transmitter siting to minimise the likelihood of signal loss.
- Review of incident and accident reporting procedures.

Comment

This accident demonstrates some of the issues associated with this emerging technology. New operators with little, or no, previous aviation experience are still developing procedures whilst operating small UAS which do not require certification due to their relatively low weight. The combination presents a challenge which operators, manufacturers and regulators will continually need to monitor and develop to ensure the safe operation of this expanding area of aviation.

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).

BULLETIN CORRECTION

Aircraft Type and Registration:	BAE Systems (Operations) Ltd ATP, SE-MHF
Date & Time (UTC):	14 December 2017 at 0606 hrs
Location:	On approach to East Midlands Airport
Information Source:	AAIB Field Investigation

AAIB Bulletin No 12/2018, page 9 refers:

Prior to publication the information below was received from the aircraft manufacturer. The report has been amended as set out below.

Table 1, *Methods for autopilot disengagement*, has been amended to reflect the following information:

1. The location of the AP System 1-2 select switch is on the centre console, not the forward instrument panel.
1. Trimming the aircraft in pitch using the trim wheel on the centre console will not disengage the autopilot.
1. Pulling the AP No.1 flight controller circuit breaker on the left side distribution panel will disengage the autopilot.

The aircraft's Communications Control System distributes all audible warnings to the cockpit speakers rather than to a specific GPWS speaker. The text following Table 1 has therefore been amended to state: '*At the same time, a continuous audio 'cavalry charge' multiple tone is provided to each pilot's headset and the cockpit speakers if they are selected ON'.*

Table 1 and the following paragraph now read:

There are multiple methods by which an autopilot can be disengaged, shown in Table 1:

Action	Location
Activation of autopilot disconnect button	Pilot control wheels
Activation of either electric trim switch	Pilot control wheels
Activation of either Go around button	Power levers
Operation of AP System 1-2 select switch	Centre console
Circuit breakers AP No.1 flight controller and No.2 flight controller	Left and Right side distribution panel respectively

Table 1

Methods for autopilot disengagement

When an autopilot disengages automatically, the AP/YD annunciations on the autopilot controller are removed and the AP1/AP2 indications on the PFDs are replaced with a red

AP/FD[1] indication. At the same time, a continuous audio 'cavalry charge' multiple tone is provided to each pilot's headset and the cockpit speakers if they are selected ON. The tone can be cancelled by pressing either of the AP disengage switches.

The online version of the report was amended prior to publication on 13 December 2018.

Footnote

1 Autopilot/Flight Director.

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
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)
FDR	Flight Data Recorder
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)
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
TGT	Turbine Gas Temperature
TODA	Takeoff Distance Available
UAS	Unmanned Aircraft System
UHF	Ultra High Frequency
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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