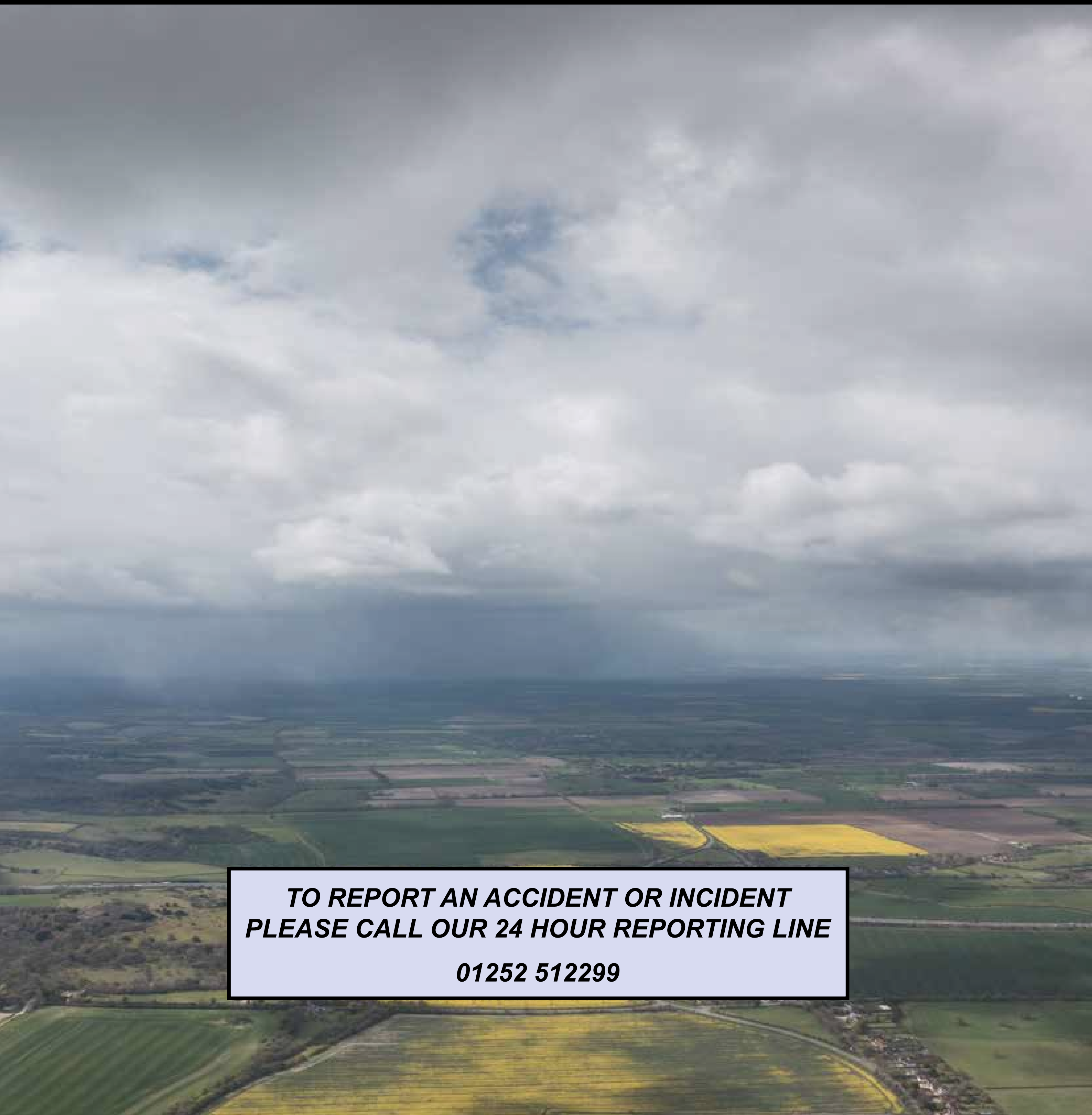
AAIB Bulletin 4/2017



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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).

Air Accident Report No: 1/2017

This report was published on 3 March 2017 and is available in full on the AAIB Website www.aaib.gov.uk

Report on the accident to Hawker Hunter T7, G-BXFI near Shoreham Airport on 22 August 2015

Registered Owner and Operator:	Canfield Hunter Ltd
Aircraft Type:	Hawker Hunter T7
Nationality:	British
Registration:	G-BXFI
Place of accident:	A27, Shoreham Bypass, at the junction with Old Shoreham Road, North of Shoreham Airport
Date and Time:	22 August 2015 at 1222 hrs (Times in this report are UTC[1] unless stated otherwise)

Introduction

The accident was reported to the Air Accidents Investigation Branch by Shoreham Air Traffic Control.

In exercise of his powers, the Chief Inspector of Air Accidents ordered an investigation to be carried out in accordance with the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996 and the European Regulations EU996/2010 on the investigation and prevention of accidents and incidents in civil aviation. The sole objective of the investigation under these Regulations is the prevention of accidents and incidents and not the apportioning of blame or liability.

The AAIB dispatched a team of investigators and support staff to the accident scene to commence an investigation immediately.

Summary

At 1222 UTC (1322 BST) on 22 August 2015, Hawker Hunter G-BXFI crashed on to the A27, Shoreham Bypass, while performing at the Shoreham Airshow, fatally injuring eleven road users and bystanders. A further 13 people, including the pilot, sustained other injuries.

Footnote

[1] Coordinated Universal Time.

The AAIB investigation considered the circumstances in which the aircraft came to be in a position from which it was not possible to complete its intended manoeuvre, and the reasons for the severity of the outcome.

The AAIB recognises that as well as being enjoyed by large numbers of spectators and participants, flying displays are also considered to provide important economic and educational benefits[2].

A safe flying display relies on the training and experience of the participating pilots, the airworthiness of the aircraft, and the planning and risk management of the event. Regulations, guidance and oversight provide the framework for these activities.

The aircraft was carrying out a manoeuvre involving both a pitching and rolling component, which commenced from a height lower than the pilot's authorised minimum for aerobatics, at an airspeed below his stated minimum, and proceeded with less than maximum thrust. This resulted in the aircraft achieving a height at the top of the manoeuvre less than the minimum required to complete it safely, at a speed that was slower than normal.

Although it was possible to abort the manoeuvre safely at this point, it appeared the pilot did not recognise that the aircraft was too low to complete the downward half of the manoeuvre. An analysis of human performance identified several credible explanations for this, including: not reading the altimeter due to workload, distraction or visual limitations such as contrast or glare; misreading the altimeter due to its presentation of height information; or incorrectly recalling the minimum height required at the apex.

The investigation found that the guidance concerning the minimum height at which aerobatic manoeuvres may be commenced is not applied consistently and may be unclear.

There was evidence that other pilots do not always check or perceive correctly that the required height has been achieved at the apex of manoeuvres.

Training and assessment procedures in place at the time of the accident did not prepare the pilot fully for the conduct of relevant escape manoeuvres in the Hunter.

The manoeuvre was continued and the aircraft struck the ground on the northern side of the westbound carriageway of the A27 close to the central reservation with a ground track at a slight angle to the direction of the road. When it struck the ground it broke into four main sections. Fuel and fuel vapour released from the fuel tanks ignited. In its path were vehicles that were stationary at, or in the vicinity of, the traffic lights at the junction with the Old Shoreham Road, and pedestrians standing by the junction.

The pilot did not attempt to jettison the aircraft's canopy or activate his ejection seat. However, disruption of the aircraft due to the impact activated the canopy jettison process and caused the ejection seat firing mechanism to initiate. The seat firing sequence was not

Footnote

[2] Response of the Royal Aeronautical Society to the CAA air display charges consultation, 29 February 2016.

completed due to damage sustained by its firing mechanism during the impact. The seat was released from the aircraft and the pilot was released from the seat as a result of partial operation of the sequencing mechanism. Some of the pyrotechnic cartridges remained live and were a hazard to first responders until they were made safe.

The investigation found that the aircraft appeared to be operating normally and responding to pilot control inputs until it impacted the ground. Defects in the altimeter system would have resulted in the height indicated to the pilot being lower than the actual aircraft height at the apex of the manoeuvre.

Information included in a previous AAIB report indicated that there had been several cases involving the type of engine fitted to this aircraft where an un-commanded reduction in engine speed had occurred and subsequent engineering investigation did not establish a clear cause. This investigation was unable to determine whether a reduction in engine speed recorded during the accident manoeuvre was commanded by the pilot.

The aircraft's engine was subject to a Mandatory Permit Directive (MPD) which imposed a calendar life on the engine type, and provided an option to extend that life using an Alternative Means of Compliance (AMOC). Proposals for an engine life extension using an AMOC inspection programme had to be approved by the regulator. Related tasks were being conducted by the maintenance organisation, but the regulator had not approved the operator or its maintenance organisation to use an AMOC to this MPD.

The investigation found that defects and exceedences of the aircraft's operational limits had not been reported to the maintenance organisation, and mandatory requirements of its Airworthiness Approval Note had not been met. During prolonged periods of inactivity the aircraft's engine had not been preserved in accordance with the approved maintenance schedule. The investigation identified a degraded diaphragm in the engine fuel control system, which could no longer be considered airworthy. However, the engine manufacturer concluded it would not have affected the normal operation of the engine.

The aircraft had been issued with a Permit to Fly and its Certificate of Validity was in date, but the issues identified in this investigation indicated that the aircraft was no longer in compliance with the requirements of its Permit to Fly.

The investigation found that the parties involved in the planning, conduct and regulatory oversight of the flying display did not have formal safety management systems in place to identify and manage the hazards and risks. There was a lack of clarity about who owned which risk and who was responsible for the safety of the flying display, the aircraft, and the public outside the display site who were not under the control of the show organisers.

The regulator believed the organisers of flying displays owned the risk. Conversely, the organiser believed that the regulator would not have issued a Permission for the display if it had not been satisfied with the safety of the event. The aircraft operator's pilots believed the organiser had gained approval for overflight of congested areas, which was otherwise prohibited for that aircraft, and the display organiser believed that it was the responsibility of the operator or the pilot to fly the aircraft's display in a manner appropriate to the constraints of the display site.

No organisation or individual considered all the hazards associated with the aircraft's display, what could go wrong, who might be affected and what could be done to mitigate the risks to a level that was both tolerable and as low as reasonably practicable.

Controls intended to protect the public from the hazards of displaying aircraft were ineffective.

The investigation identified the following causal factors in the accident:

- The aircraft did not achieve sufficient height at the apex of the accident manoeuvre to complete it before impacting the ground because the combination of low entry speed and low engine thrust in the upward half of the manoeuvre was insufficient.
- An escape manoeuvre was not carried out, despite the aircraft not achieving the required minimum apex height.

The following contributory factors were identified:

- The pilot either did not perceive that an escape manoeuvre was necessary, or did not realise that one was possible at the speed achieved at the apex of the manoeuvre.
- The pilot had not received formal training to escape from the accident manoeuvre in a Hunter and had not had his competence to do so assessed.
- The pilot had not practised the technique for escaping from the accident manoeuvre in a Hunter, and did not know the minimum speed from which an escape manoeuvre could be carried out successfully.
- A change of ground track during the manoeuvre positioned the aircraft further east than planned producing an exit track along the A27 dual carriageway.
- The manoeuvre took place above an area occupied by the public over which the organisers of the flying display had no control.
- The severity of the outcome was due to the absence of provisions to mitigate the effects of an aircraft crashing in an area outside the control of the organisers of the flying display.

The AAIB has published three Special Bulletins (SB) highlighting areas of concern that required timely consideration.

SB 3/2015, published on 4 September 2015, 13 days after the accident, reported initial information about the occurrence.

SB 4/2015, published on 21 December 2015, dealt with the safety of first responders to the accident scene, the maintenance of ejection seats in historic ex-military aircraft and issues regarding the maintenance of ex-military aircraft on the UK civil register. Seven Safety Recommendations were made.

SB 1/2016, published on 10 March 2016, considered the risk management of flying displays, minimum display heights and separation distances, regulatory oversight and piloting standards. It contained a further 14 Safety Recommendations, and was published to inform the air display community ahead of the 2016 air display season.

A further 11 Safety Recommendations are made in this report.

Findings

Operational aspects

1. The pilot was licensed and authorised in accordance with the requirements existing at the time of the accident to operate the Hawker Hunter at flying displays.
2. It was the pilot's fifth aerobatic display in a Hunter during the 2015 season and the only public display he carried out that day. He met the recency requirements specified in CAP 403.
3. The accident occurred during a manoeuvre involving pitching and rolling components, intended to be a 'bent loop', at the apex of which the aircraft was inverted.
4. Flight trials indicated that the apex height for a looping manoeuvre with a 90° track change on the upward vertical was 300 to 400 ft less than for a straight loop with all other parameters constant.
5. The accident manoeuvre started and finished outside the aerodrome boundary, over an area not controlled by the organisers of the flying display.
6. A general permission granted by the CAA provided an exemption from the Standardised European Rules of the Air, permitting flight below 500 feet up to 1 km from the display gathering.
7. The pilot's display authorisation for the Hunter stipulated a minimum height for executing aerobatics of 500 ft.
8. The manoeuvre started approximately 900 m from the display line at a height of 185 ±25ft agl.
9. The pilot's declared minimum entry speed for the manoeuvre was 350 KIAS. The aircraft entered the manoeuvre at approximately 310 KIAS.

10. Engine speed varied during the upward first half of the manoeuvre. This was contrary to the pilot's declared technique of using full thrust.

11. The manoeuvre could have been abandoned during its upward first half if an un-commanded reduction in thrust had occurred and been detected.

12. There was no evidence of a pre-existing mechanical defect that would have prevented the engine from responding to pilot throttle inputs. However, the fuel pump governor diaphragm showed significant signs of ageing and chemical attack such that it could no longer be considered airworthy.

13. Information included in a previous AAIB report (EW/C98/6/1) indicated that there had been a number of cases involving the Avon Mk 122 engine where engine speed had dropped and subsequent engineering investigation had not established a clear cause. Therefore, an uncommanded reduction in thrust during the accident manoeuvre could not be ruled out.

14. In tests, the left altimeter under-read by approximately 100 feet. It also exhibited lag and stickiness in its operation both during testing and on a previous flight. Overall, these defects would have resulted in the altitude indicated to the pilot being lower than the actual aircraft altitude at the apex of the accident manoeuvre.

15. The right altimeter had a latent defect which meant it was no longer providing a synchronising signal to the left altimeter.

16. No other technical defects were identified that were relevant to the accident.

17. The minimum height loss during the downward half of a looping manoeuvre in the Hawker Hunter is between 2,600 and 2,950 feet (including 100 ft for instrument reading error), when flown at the values of aircraft mass and density altitude relevant to the accident.

18. The pilot stated that he required a minimum height of 3,500 ft at the apex of the manoeuvre to ensure that he completed it 500 ft or more above the ground (as required by his display authorisation).

19. The aircraft achieved an apex height of approximately 2,700 ft.

20. The airspeed at the apex of the accident manoeuvre was 105±2 KIAS, which was at the lower end of the pilot's declared airspeed range of 100 to 150 KIAS.

21. The aircraft was lower than required at the apex because it entered the manoeuvre below the target airspeed, because less than maximum thrust was applied during its upward half, and because any rolling element initiated before the aircraft reached the upward vertical would have further reduced apex height.

22. The entry height of the manoeuvre was consistent with the 200ft minimum height on the pilot's DA for a Jet Provost; the apex height and speeds on the accident manoeuvre were consistent with those flown in the Jet Provost the previous weekend.

23. The pilot stated that he would abandon a 'bent loop' manoeuvre if the minimum entry speed, or the minimum gate height at the apex, were not achieved. He did not abandon the accident manoeuvre when these minimums were not achieved.

24. It is possible that the pilot misread or misinterpreted speed and height indications during the manoeuvre, or recalled those for a different aircraft type.

25. The pilot had not previously rolled the Hawker Hunter at the low airspeed encountered at the apex, and was not sure that a roll could be achieved at that speed.

26. Flying an escape manoeuvre is not the same as flying planned manoeuvres such as a half Cuban 8.

27. Flight trials indicated that a rolling escape manoeuvre was possible up to four seconds after the aircraft passed the apex of the accident manoeuvre.

28. The pilot had not practised flying escape manoeuvres in the Hunter.

29. The operator's Operational Control Manual did not contain information about performing aerobatic manoeuvres and associated escape manoeuvres.

30. The previous two renewals of the pilot's display authorisation were not performed on the Hawker Hunter.

31. The g experienced by the pilot during the manoeuvre was probably not a factor in the accident.

32. The aircraft struck the carriageway of the A27, Shoreham Bypass, in a wings level, nose-high attitude at a speed of approximately 225 kt.

33. The aircraft collided with bystanders, road users and vehicles at the junction of the A27 and Old Shoreham Road, in an area outside the control of the flying display organisers. Eleven people were fatally injured and 13 others, including the pilot, were injured as a result of the accident.

Organisation of the flying display

34. The organiser of the flying display had obtained the permission of the CAA required by Article 162 of the Air Navigation Order (ANO).

35. The CAA, pursuant to Article 162, had permitted the Flying Display Director (FDD) to act as the FDD for the 2015 Shoreham Airshow, having

assessed him as 'fit and competent', but had no written policy or procedure for making that determination.

36. The FDD believed that the risk assessment for the flying display was compliant with CAP 403. However, the risk assessment was not suitable and sufficient to manage the risks to the public.

37. The risk assessment did not consider which aircraft would be displaying, where they would operate and to whom they would present a hazard.

38. The FDD did not know the intended sequence of manoeuvres to be flown by the accident pilot, and the edition of CAP 403 in force at the time did not indicate that he should.

39. The risk assessment and risk management guidance provided to display organisers in CAP 403 requires improvement.

40. The risk assessment relied upon compliance with Rule 5 of the Rules of the Air (that no aircraft should fly closer than 500 ft to any person, vehicle, vessel or structure) to mitigate the hazard presented by aircraft displaying over areas outside the control of the organisers.

41. The FDD was not aware that, under a permission granted by the CAA, the aircraft was exempt from this rule when within 1,000 metres of a gathering of persons assembled to witness the event.

42. The CAA did not require to see or approve risk assessments before issuing a permission to hold a flying display in accordance with Article 162 of the ANO.

43. The CAA recommended in CAP 632 that operators of Permit to Fly ex-military aircraft adopt a safety management system (SMS). It did not require them to have one.

44. The operator of the aircraft did not have an SMS or a documented alternative.

45. The General Aviation Unit of the CAA did not have an SMS.

46. The planned display of G-BXFI at the 2015 Shoreham Airshow was similar to that in 2014, in which the location of the aircraft's manoeuvres did not comply with its Permit to Fly.

47. The operator did not have a process to ensure that the manner in which the aircraft was operated during flying displays would comply with the conditions of its Permit to Fly.

48. The CAA did not require persons outside the area controlled by the organisers of the flying display to be protected from the hazards associated with it.

49. The CAA granted the organisers of the 2015 Shoreham Airshow permission to hold a flying display. However, the CAA considers that the principle reason for rejecting an application is safety, and that the proximity of congested areas and heavily used major roads must be taken into account in determining the viability of the site of a flying display. The A27 is a heavily used major road, carrying approximately 58,500 vehicles per day.

50. The organisers of the 2015 Shoreham Airshow recognised that the junction of the A27 with the Old Shoreham Road was a popular gathering point for secondary crowds.

51. Measures taken by the organisers probably reduced the size of the crowd that gathered at the A27 junction, however, there were a number of people standing at the junction of the A27 and Old Shoreham Road during the flying display.

52. Approximately 40% of the land area within 2 km of Shoreham Airport meets the definition of a 'congested area' given in the ANO.

53. The Flying Control Committee had no means of accurately determining the height and speed of displaying aircraft and had to rely on its judgement and experience to monitor their performance.

54. The rescue and firefighting resources in place responded promptly to the accident.

55. The CAA had no means of determining the safety of flying displays other than by attending them. It attended 7% of the flying displays it approved in 2015 and 2.8% of those it approved in 2014.

56. The CAA had not established an acceptable level of safety performance for display flying.

Engineering aspects

Matters related to the accident sequence

57. The pilot did not command an ejection.

58. The aircraft was probably outside the operational envelope of the ejection system during the downward portion of the accident manoeuvre.

59. Activation of the canopy jettison system and the ejection seat was initiated by damage to the cockpit and seat structure sustained during impact.

60. The ejection sequence did not complete due to damage sustained to the ejection seat gun during the impact.

61. The pilot and ejection seat were released from the cockpit during the later stages of the impact sequence and the ejection seat automated release features acted to release the pilot from the seat before it came to rest.

62. Some pyrotechnic cartridges in each of the ejection seats remained live after the aircraft came to rest.

63. Information about the dangers of the ejection seats and other hazards associated with G-BXFI was not available to the organisers of the flying display and therefore could not be passed on to the first responders.

Maintenance and airworthiness

64. The ejection seat manufacturer's recommended installed cartridge life was two years with a maximum total (shelf) life of six years. This recommendation was included as a limitation in the aircraft's AAN, which formed the basis for its certification. The maintenance organisation had adopted a six-year installation life for ejection seat cartridges. This extension to the installed life had not been documented in accordance with the maintenance organisation's procedures, nor had it been approved by the CAA.

65. At the time of the accident, the two-year installed cartridge life had been exceeded by more than 4½ years and the six-year total life had been exceeded by more than a year.

66. The CAA was not aware of the extension to the ejection seat cartridge lives.

67. The CAA did not have a documented procedure for approving extensions to ejection seat cartridge lives but stated that applications for extensions would be considered on a case-by-case basis, and would only be granted for a short period upon proof that new cartridges were on order.

68. The maintenance organisation had new cartridges available, which had not been fitted to the ejection seats in the aircraft.

69. CAP 632 requires the pilot escape systems of swept-wing jet aircraft, such as the Hawker Hunter, to be 'fully serviceable'. The use of time-expired ejection seat cartridges meant that the ejection seats fitted to G-BXFI did not meet this requirement.

70. The practice of using time-expired ejection seat cartridges in civil-operated ex-military aircraft was not confined to G-BXFI or its maintenance organisation.

71. The engine fitted to G-BXFI was not preserved during periods of inactivity as required by the aircraft's approved maintenance program.

72. Neither the operator nor the maintenance organisation had an approved Alternative Means of Compliance with the Mandatory Permit Directive related to engine life (MPD 2001-001).

73. The maintenance organisation did not have access to the previous operator's AMOC. It based scheduled maintenance tasks on entries in the aircraft maintenance records associated with MPD 2001-001.

74. The maintenance organisation submitted a proposal for an AMOC to MPD 2001-001 to the CAA which in turn requested this be resubmitted to include additional tasks detailed in CAP 562 Leaflet 70-80. However, no further application to the CAA was made by the maintenance organisation.

75. The serial number of the right altimeter did not match that recorded in the technical records.

76. Engine rpm exceedences occurring during a test flight in 2011 were not reported or investigated.

77. There was no formal or documented monitoring of engine performance, either during engine ground runs or in flight, which would enable engine performance deterioration to be identified.

78. Video evidence showed that the g-meter fitted to the aircraft was defective during the accident flight and in September 2014. No related defects had been reported or recorded, and the maintenance organisation stated that it was not aware of any.

79. The AAN and Permit to Fly required the fatigue state of the aircraft to be recorded after each day's flight. The maintenance organisation read and recorded the fatigue state once each year; between these readings, monitoring of high fatigue inducing events relied on the pilots reporting high loads seen on the g-meter.

80. The aircraft was being operated with the aileron trim position indicator inoperative.

81. The aircraft had been operated with the flaps extended at speeds exceeding the limit for doing so. This had not been reported in the aircraft technical log.

82. The maintenance organisation issued a Certificate of Validity to the Permit to Fly. At the time of the accident the aircraft did not meet airworthiness requirements or the conditions of its Permit to Fly.

83. CAA oversight of the maintenance organisation and the operator did not identify the deficiencies with the aircraft's airworthiness.

84. The maintenance organisation did not have an established safety management system and was not required to have one.

85. The diaphragm of the fuel pump governor had degraded due to the combined effects of age and chemical attack. The engine manufacturer concluded that it would not have prevented the engine from operating

normally but considered that it had exceeded its known predictable functional capability and its continued integrity would be severely affected.

86. MPD 2001-001 was published to mitigate the effects of ageing on the Rolls-Royce Avon series of engines, including the engine fuel systems.

87. The AMOC approved for a previous operator of the aircraft did not include routine inspections of the condition of engine fuel systems. This inspection regime, continued by the current maintenance organisation, did not identify the degradation of the fuel pump governor diaphragm.

88. The aircraft was fitted with underwing drop tanks made from phenolic asbestos. This hazard had not been identified.

Causal factors

- The aircraft did not achieve sufficient height at the apex of the accident manoeuvre to complete it before impacting the ground, because the combination of low entry speed and low engine thrust in the upward half of the manoeuvre was insufficient.
- An escape manoeuvre was not carried out, despite the aircraft not achieving the required minimum apex height.

Contributory factors

- The pilot either did not perceive that an escape manoeuvre was necessary, or did not realise that one was possible at the speed achieved at the apex of the manoeuvre.
- The pilot had not received formal training to escape from the accident manoeuvre in a Hunter and had not had his competence to do so assessed.
- The pilot had not practised the technique for escaping from the accident manoeuvre in a Hunter, and did not know the minimum speed from which an escape manoeuvre could be carried out successfully.
- A change of ground track during the manoeuvre positioned the aircraft further east than planned producing an exit track along the A27 dual carriageway.
- The manoeuvre took place above an area occupied by the public over which the organisers of the flying display had no control.
- The severity of the outcome was due to the absence of provisions to mitigate the effects of an aircraft crashing in an area outside the control of the organisers of the flying display.

Safety Recommendations

The following Safety Recommendations were made in Special Bulletin S4/2015 on 21 December 2015. The CAA responded to each in FACTOR F1/2016, published on 8 April 2016.

Safety Recommendation 2015-041

It is recommended that the Civil Aviation Authority require operators of ex-military aircraft fitted with ejection seats or other pyrotechnic devices operating in the United Kingdom, to ensure that hazard information is readily available which includes contact details of a competent organisation or person able to make the devices safe following an accident.

The CAA responded as follows:

'The CAA accepts this recommendation. To ensure that hazard information is readily available for aircraft participating in flying displays, the CAA will amend the certificate supplied to the Flight Display Director by a pilot participating in a flying display to identify the pyrotechnic devices fitted to the aircraft and the contact details of a competent organisation or person able to make the devices safe (or advise on doing so) following an accident. The revised form will be published before the end of April 2016 as part of an amendment to CAP 403.

The CAA is currently reviewing how best to ensure that the same information is readily available for aircraft not participating in flying displays. This review will be completed before the end of June 2016.'

The AAIB has categorised the response to this Safety Recommendation as *'Adequate – closed'.*

Safety Recommendation 2015-042

It is recommended that the Civil Aviation Authority review the guidance in CAP 632 with respect to ejection seats and the means by which operators of ex-military aircraft equipped with them comply with this guidance. This review should include:

- The benefits and hazards of aircrew escape systems in civilian-operated aircraft
- The use of time-expired components
- The availability of approved spares
- The seat manufacturer's guidance on deactivating its historic products
- Adoption of a dedicated Maintenance Approval for persons or organisations competent to perform ejection seat maintenance.

The CAA responded as follows:

> *'The CAA accepts this recommendation and is undertaking a review of ejection seat safety as part of the Air Display Review. This review includes consideration of each of the specific points highlighted by this recommendation and will be completed before the end of December 2016.'*

The AAIB has categorised the response to this Safety Recommendation as '*Adequate – closed*'.

> **Safety Recommendation 2015-43**
>
> It is recommended that the Civil Aviation Authority establish a process for the effective dissemination of ex-military jet aircraft experience and type-specific knowledge to individual maintenance organisations.

The CAA responded as follows:

> *'The CAA accepts this recommendation. By December 2016, the CAA will establish and promote a process for the more effective dissemination of ex-military jet aircraft experience and type-specific knowledge between individual maintenance organisations.'*

The AAIB has categorised the response to Safety Recommendation 2015-043 as '*Adequate – closed*'.

> **Safety Recommendation 2015-44**
>
> It is recommended that the Civil Aviation Authority define a minimum amendment standard for the technical publications for each ex-military jet aircraft type operated on the United Kingdom civil register.

Following the publication of FACTOR F1/2016 Issue 2 the CAA's response is as follows:

> *'Working in conjunction with industry, the CAA will establish a minimum amendment standard for the technical publications for each individual ex-military jet aircraft operated on the UK civil register. The established standard will be recorded in the Airworthiness Approval Note (AAN) for each aircraft.*
>
> *The CAA will complete this work by December 2018.'*

The AAIB has categorised the CAA response to Safety Recommendation 201544 as '*Adequate – closed*'.

> **Safety Recommendation 2015-45**
>
> It is recommended that the Civil Aviation Authority require that an ex-military jet aircraft's maintenance programme be transferred with the aircraft when it moves to another maintenance organisation to ensure continuity of the aircraft's maintenance.

Following the publication of FACTOR F1/2016 Issue 2, the CAA's response is as follows:

> *'The CAA is developing a proposal for consultation with industry to introduce a new requirement into BCAR Section A to require a maintenance programme to be transferred with an ex-military jet aircraft if it moves to a new maintenance/continuing airworthiness management organisation, or new owner/operator.*
>
> *Subject to the outcome of the process of industry consultation, the CAA intends to implement this requirement by April 2018.'*

The AAIB has categorised the response to Safety Recommendation 2015-45 as '*Adequate – closed*'.

> **Safety Recommendation 2015-046**
>
> It is recommended that the Civil Aviation Authority review the effectiveness of all approved Alternative Means of Compliance to Mandatory Permit Directive 2001-001.

Following the publication of FACTOR F1/2016 Issue 2, the CAA's response is as follows:

> *'The CAA will require ex-military jet aircraft maintenance organisations and/or continuing airworthiness management organisations to conduct a review of their approved Alternative Means Of Compliance (AMOC) to MPD2001-001. Following such a review, each of these affected organisations must make application for a new AMOC in accordance with a new MPD to be issued which will supersede MPD2001-001.*
>
> *The review process will be completed by April 2018.'*

The AAIB has categorised the response to Safety Recommendation 2015-46 as '*Adequate – closed*'.

> **Safety Recommendation 2015-047**
>
> It is recommended that the Civil Aviation Authority review its procedures to ensure that a '*Permit to Fly-Certificate of Validity*' is valid when it is issued.

Following the publication of FACTOR F1/2016 Issue 2, the CAA's response is as follows:

> *'Responsibility for ensuring that a 'Permit to Fly-Certificate of Validity' is valid when issued sits with the approved maintenance organisation and not the CAA. An organisation approved by the CAA to conduct an airworthiness review on such aircraft is granted the privilege, under its approval, to declare to the CAA that a particular aircraft complies with the requirements of BCAR Section A Chapter A3-7, which includes completing a physical survey of the aircraft and a documented review of its records to determine its airworthiness status. The CAA is not required to validate the work carried out under this approval before a Certificate of Validity is issued. Instead, an organisation's compliance*

with these requirements, including the adequacy of declarations, is audited as part of CAA's continued oversight activity.

Therefore, in order to deliver the intent of this safety recommendation, the CAA will review both the design and implementation of its oversight activity in respect of approved maintenance organisations and the process by which documents such as Permit to Fly Certificates of Validity are issued by approved organisations.

By April 2018, the CAA will conclude this review, and, should any changes be necessary, identify the date by which they will be implemented.'

The AAIB has categorised the response to Safety Recommendation 2015-47 as '*Adequate – closed*'.

The following Safety Recommendations were issued in Special Bulletin S1/2016 on 10 March 2016. The CAA responded to each in FACTOR F4/2016, published on 9 June 2016.

Safety Recommendation 2016-031

It is recommended that the Civil Aviation Authority review and publish guidance that is suitable and sufficient to enable the organisers of flying displays to manage the associated risks, including the conduct of risk assessments.

Following the publication of FACTOR F4/2016 Issue 2 the CAA's response is as follows:

'The CAA will review the findings contained in the HSL reports on the management of risk, in conjunction with the conclusions of its post-implementation review of UK Civil Air Displays. The CAA will complete this review and publish any updated guidance by April 2017.'

The AAIB has categorised the response to Safety Recommendation 2016-31 as '*Adequate – closed'.*

Safety Recommendation 2016-032

It is recommended that the Civil Aviation Authority specify the safety management and other competencies that the organiser of a flying display must demonstrate before obtaining a Permission under Article 162 of the Air Navigation Order.

In FACTOR F4/2016, published on 9 June 2016 the CAA made the following response to Safety Recommendation 2016-032:

> *'The CAA accepts this recommendation.*
>
> *The CAA will specify the safety management and other competencies that the organiser of a flying display must demonstrate before obtaining a Permission under Article 162 of the Air Navigation Order. This will be completed by the end of March 2017.'*

The AAIB has categorised the response to Safety Recommendation 2016-31 as '*Adequate – closed*'.

> **Safety Recommendation 2016-033**
>
> It is recommended that the Civil Aviation Authority introduces a process to ensure that the organisers of flying displays have conducted suitable and sufficient risk assessments before a Permission to hold such a display is granted under Article 162 of the Air Navigation Order.

The CAA responded in FACTOR F4/2016 as follows:

> *'The CAA accepts this recommendation that organisers of flying displays must conduct suitable and sufficient risk assessments.*
>
> *It remains the responsibility of organisers of flying displays to conduct suitable and sufficient risk assessments. The CAA has introduced a new risk assessment process for display applications together with a new risk assessment template and a revised display application form. These are designed to make it clearer to organisers of flying displays the nature of the risk assessment that must be completed. The revised process was published alongside the guidance 'Flying displays and special events: A guide to safety and administrative arrangements' in March 2016.'*

Following the publication of FACTOR F4/2016 Issue 2 the CAA's response to the Safety Recommendation is as follows:

> *The CAA has already introduced enhanced risk assessment guidance to assist event organisers when conducting such risk assessments. The CAA cannot carry out its own risk assessments in respect of every application for a display (and so cannot "ensure" that suitable and sufficient risk assessments have been carried out) and has introduced a process so that, when considering an application for a Permission to hold a display under Article 86 of the Air Navigation Order 2016 (previously Article 162 of the Air Navigation Order 2009), the CAA considers whether the application aligns with the CAA's guidance.*
>
> *The CAA intends also to review the findings of the HSL reports in conjunction with the conclusions of the CAA's own postimplementation review of UK Civil Air Displays in order to consider whether any updated guidance on the management of risk is necessary (see FACTOR response to Safety Recommendation 2016-031 above).*

> *The CAA will clarify the responsibilities of organisers / FDDs in this respect during this review and complete and publish any updated guidance by April 2017.*
>
> *For the 2017/2018 seasons the CAA will review each risk assessment submitted with an application for a display against the specified criteria notified in CAP 403. Where those criteria are not met, the CAA will request further information from the applicant or, where necessary, not grant a permission for that display.'*

The AAIB has categorised the response to Safety Recommendation 2016-31 as '*Adequate – closed'*.

> **Safety Recommendation 2016-034**
>
> It is recommended that the Civil Aviation Authority specify the information that the commander of an aircraft intending to participate in a flying display must provide the organiser, including the sequence of manoeuvres and the ground area over which the pilot intends to perform them, and require that this is done in sufficient time to enable the organiser to conduct and document an effective risk assessment.

The CAA responded in FACTOR F4/2016 as follows:

> *'The CAA understands the intent here is to define the area of ground over which the commander of an aircraft will be permitted to display that aircraft. This can be done in a number of ways. The CAA does not accept that it should specify information in the manner set out in the recommendation. The CAA has concluded that the FDD's risk assessment should be informed by and take account of both the manoeuvres to be flown and the area of ground over which they will be flown.*
>
> *The CAA now requires pilots to confirm to the FDD well in advance of the display briefing that their air display conforms to the air display permission granted by the CAA. If the series of linked manoeuvres or the area of ground over which the aircraft will fly is outside the areas already risk assessed by the FDD, the FDD will be able to take this into account in their risk assessment and document it accordingly.*
>
> *It remains the responsibility of the organisers of flying displays to follow this guidance and conduct risk assessments that are suitable and sufficient to manage the risks associated with the air displays that they are organising.'*

Following the publication of FACTOR F4/2016 Issue 2 the CAA's response to the Safety Recommendation is as follows:

> *'The risk assessment conducted by the FDD is required to be informed by and take account of both the manoeuvres intended to be flown and the area of ground over which they will be flown.*
>
> *The CAA has amended CAP 403 Appendix B "Certificate to be supplied to the event organiser by a pilot participating in a flying display", to specify the information that the commander of the aircraft intending to participate in a flying display must provide to an organiser in advance of a display, including the manoeuvres intended to be flown. Appendix B must be supplied in sufficient time to enable the event organiser to conduct a risk assessment for the display. The risk assessment (to be submitted with the application for a Permission) must also take account of the ground area over which the display will be performed, which in turn will enable the CAA to specify the boundaries of a flying display within which any permission applies.*
>
> *The CAA has introduced a requirement, in CAP 403 for any pilot intending to fly aerobatic manoeuvres to notify the FDD of the series of the linked manoeuvres that they intend to perform at least one day prior to a display. If the information is not provided, the FDD must not allow the pilot to fly in the display. This information, together with the prior notification of a defined area within which the permission applies, will support the implementation of an effective risk assessment.*
>
> *CAP 403 was amended in June 2016.Completed.'*

The AAIB has categorised the response to Safety Recommendation 2016-31 as 'Partially adequate – closed'.

> **Safety Recommendation 2016-035**
>
> It is recommended that the Civil Aviation Authority require operators of Permit to Fly aircraft participating in a flying display to confirm to the organiser of that flying display that the intended sequence of manoeuvres complies with the conditions placed on their aircraft's Permit to Fly.

The CAA responded as follows:

> *'The CAA accepts this recommendation. The CAA now requires operators of Permit to Fly aircraft participating in a flying display to confirm to the organiser of that flying display that the intended sequence of manoeuvres complies with the conditions placed on their aircraft's Permit to Fly.*
>
> *As set out in the March 2016 edition of the CAA's guidance "Flying displays and special events: A guide to safety and administrative arrangements", all pilots participating in a flying display must supply the FDD of the air display with a*

certificate confirming that the display that they intend to perform complies with the conditions placed on the aircraft's Certificate of Airworthiness and Permit to Fly. A template for the certificate is at Appendix B of the guidance.'

The AAIB has categorised the response to Safety Recommendation 2016-035 as *'Adequate – closed'.*

Safety Recommendation 2016-036

It is recommended that the Civil Aviation Authority remove the general exemptions to flight at minimum heights issued for Flying Displays, Air Races and Contests outlined in Official Record Series 4-1124 and specify the boundaries of a flying display within which any Permission applies.

Following the publication of FACTOR F4/2016 Issue 2 the CAA's response is as follows:

'The CAA has removed the general exemption to flight at minimum heights issued for civil air displays, air races and contests, outlined in Official Record Series 4-1124.

Display Permissions granted by CAA under Article 86 of the Air Navigation Order 2016 now specify the boundaries of a flying display within which the permission applies.'

The AAIB has categorised the response to Safety Recommendation 2016-036 as *'Adequate – closed'.*

Safety Recommendation 2016-037

It is recommended that the Civil Aviation Authority require that displaying aircraft are separated from the public by a sufficient distance to minimise the risk of injury to the public in the event of an accident to the displaying aircraft.

The CAA responded as follows:

'The CAA understands that this recommendation relates to members of the public attending a flying display.

The CAA accepts this recommendation.

The MAA has commissioned an independent study into crowd separation distances. This research is ongoing and should report in 2017. As the MAA research is ongoing, the CAA decided in its review of UK civil air displays that, as an interim measure, where current MAA crowd separation distances are higher it would align with them. The increased distances were announced in April this year in the final report of the CAA's Review of UK Civil Air Displays. The CAA will confirm crowd separation distances after the independent study commissioned by the MAA into crowd separation distances reports in 2017.'

The CAA subsequently updated its response to this and Safety Recommendation 2016-038 as shown below.

Safety Recommendation 2016-038

It is recommended that the Civil Aviation Authority specify the minimum separation distances between secondary crowd areas and displaying aircraft before issuing a Permission under Article 162 of the Air Navigation Order.

FACTOR F4/2016, issued on 9 June 2016, recorded that the CAA did not accept this recommendation. Following discussions with the AAIB the CAA, FACTOR F4/2016 Issue 2 provided an updated, combined, response to Safety Recommendations 2016-037 and 2016-038, as follows:

'The CAA will conduct a review, within six months of publication by the MAA of a study by Frazer-Nash, to consider whether any changes are required to the minimum distance that display aircraft are to be separated from the public (primary and secondary crowds) to effectively minimise the risk of injury to the public in the event of an accident to the displaying aircraft. In the event that this study does not deliver a clear output or is terminated, for any reason, the CAA will consider what additional work will be needed to resolve this Recommendation. Subject to the findings of the study and the outcome of the review, the CAA shall make any necessary revisions to the application process for Permissions granted under Article 86 of the Air Navigation Order 2016.'

The AAIB categorised this response as *'Adequate – closed'.*

Safety Recommendation 2016-039

It is recommended that the Civil Aviation Authority require the organisers of flying displays to designate a volume of airspace for aerobatics and ensure that there are no non-essential personnel, or occupied structures, vehicles or vessels beneath it.

The CAA responded as follows:

'The CAA does not accept this recommendation.

The CAA expects the organisers of flying displays and in collaboration with FDDs to identify and then mitigate or manage all the risks to the public arising from their air display. It is for the organiser of the display and the FDD to decide what course of action is necessary and how they will implement it. Furthermore the pilot is responsible for performing their display in accordance with the Permission granted under Article 162 of the Air Navigation Order and their own display authorisation.'

The AAIB has categorised the response to Safety Recommendation 2016-039 as *'Superseded – closed'.*

Safety Recommendation 2016-040

It is recommended that the Civil Aviation Authority require Display Authorisation Evaluators to have no conflicts of interest in relation to the candidates they evaluate.

The CAA responded as follows:

'The CAA does not accept this recommendation as it is impractical to achieve in the relatively small air display community and maintain a working display evaluation system.

The CAA believes that it is better to identify any potential conflicts of interest, such as personal or commercial connections, and manage them. In its Action Report of its Review of UK Civil Air Displays, published in January 2016, the CAA strengthened the display authorisation process by requiring, after the first two years, a pilot holding a display authorisation to be revalidated by a different DAE, selected by the CAA. The CAA believes this will reduce the risks of conflicts of interest.'

The AAIB has categorised the response to Safety Recommendation 2016-040 as *'Partially adequate – closed'.*

Safety Recommendation 2016-041

It is recommended that the Civil Aviation Authority require a Display Authorisation to be renewed for each class or type of aircraft the holder intends to operate during the validity of that renewal.

Following the publication of FACTOR F4/2016 Issue 2 the CAA's response is as follows:

'The CAA will review the list of different categories of aircraft relevant to pilot Display Authorisation renewal and assess the impact of operating differences between each category. The CAA will expand this work to include a study of the potential for inappropriate transfer of behaviours between aircraft types. The CAA will consider introducing any relevant findings into the ongoing training and assessment requirements for display pilots, including the requirements for Display Authorisation renewal.

The CAA will conclude this review and publish its findings by April 2018.'

The AAIB has categorised the response to Safety Recommendation 2016-041 as *'Adequate – closed'.*

Safety Recommendation 2016-042

It is recommended that the Civil Aviation Authority publish a list of occurrences at flying displays, such as 'stop calls', that should be reported to it, and seek to have this list included in documentation relevant to Regulation (EU No 376/2014.

The CAA responded as follows:

'The CAA does not accept this recommendation.

The CAA is developing a positive reporting culture - a Just Culture – for the air display community. Within the air display sector the CAA believes that this is the most effective way to identify and address potential safety issues before they lead to accidents.

In support of this, from April this year the CAA required all event organisers and FDDs to submit, within seven days, a post-air display report to the CAA. This report must include what went well at the display, as well as information on any lapses or breaches from the required standards. Pilots must also report any aspect of their display that could have caused a significant safety risk. The CAA will record all this information. Key information will be shared with the civil air display community through briefings, the pre- and post-season seminars that the CAA jointly hosts with BADA[3] and the MAA, and the annual seminar that the CAA organises for DAEs.'

The AAIB has categorised the response to Safety Recommendation 2016-042 as *'Partially adequate – closed'.*

Safety Recommendation 2016-043

It is recommended that the Civil Aviation Authority introduce a process to immediately suspend the Display Authorisation of a pilot whose competence is in doubt, pending investigation of the occurrence and if appropriate re-evaluation by a Display Authorisation Evaluator who was not involved in its issue or renewal.

The CAA responded as follows:

'The CAA accepts this recommendation.

In its final report of its Review of UK Civil Air Displays, published in April 2016, the CAA announced that where a stop is called because an FDD, or member of the Flight Control Committee, has reason to doubt the fitness or competence of a pilot that pilot will be subject to a provisional suspension of their display authorisation pending an investigation by the CAA of the circumstances leading

Footnote

3 British Air Display Association.

to the stop being called. In its investigation, the CAA will determine whether the suspension of the display authorisation should be withdrawn or further regulatory enforcement action taken against the pilot concerned.'

The AAIB has categorised the response to Safety Recommendation 2016-043 as *'Adequate – closed'.*

Safety Recommendation 2016-044

It is recommended that the Civil Aviation Authority establish and publish target safety indicators for United Kingdom civil display flying.

Following the publication of FACTOR F4/2016 Issue 2, the CAA's response is as follows:

'The CAA will undertake a study to identify and publish meaningful safety indicators for civil display flying.

The CAA will conclude this study and publish safety indicators by September 2017.'

The AAIB has categorised the response to Safety Recommendation 2016-044 as '*Adequate – closed'.*

The following new Safety Recommendations are made in this report:

Safety Recommendation 2017-001

It is recommended that the Civil Aviation Authority amend CAP 403 to clarify the point at which an aerobatic manoeuvre is considered to have been entered and the minimum height at which any part of it may be flown.

Safety Recommendation 2017-002

It is recommended that the Civil Aviation Authority require pilots intending to conduct aerobatics at flying displays to be trained in performing relevant escape manoeuvres and require that their knowledge and ability to perform such manoeuvres should be assessed as part of the display authorisation process.

Safety Recommendation 2017-003

It is recommended that the Civil Aviation Authority review the grouping of aircraft types in display authorisations to account for handling and performance differences it considers significant.

Safety Recommendation 2017-004

It is recommended that the Civil Aviation Authority remind operators, whose activities are subject to the guidance published in Civil Aviation Publication 632, of the need to maintain detailed training records for pilots and check their compliance during inspections it carries out.

Safety Recommendation 2017-005

It is recommended that the Civil Aviation Authority specify that the flight demonstration requirement of a display authorisation evaluation, other than to assess formation following, cannot be satisfied by the pilot following another aircraft during the evaluation.

Safety Recommendation 2017-006

It is recommended that the Civil Aviation Authority undertake a study of error paths that lead to flying display accidents and integrate its findings into the human factors training it requires the holders of display authorisations to undertake.

Safety Recommendation 2017-007

It is recommended that the Civil Aviation Authority review the arrangements for safety regulation and oversight of intermediate and complex ex-military aircraft operated in accordance with Civil Aviation Publication 632, to ensure that they are consistent and appropriate.

Safety Recommendation 2017-008

It is recommended that the Civil Aviation Authority consider implementing the changes outlined in Health and Safety Laboratory report MSU/2016/13 'Review of the risk assessment sections of CAP 403'.

Safety Recommendation 2017-009

It is recommended that the Civil Aviation Authority require operators of aircraft used for flying displays to identify, and where practicable remove, any hazardous materials.

Safety Recommendation 2017-010

It is recommended that the Civil Aviation Authority prohibit the use of phenolic asbestos drop tanks on civil registered aircraft.

Safety Recommendation 2017-011

It is recommended that the Department for Transport commission, and report the findings of, an independent review of the governance of flying display activity in the United Kingdom, to determine the form of governance that will achieve the level of safety it requires.

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:	Piper L18C Super Cub, G-AXLZ
No & Type of Engines:	1 Continental Motors Corp C90-8F piston engine
Year of Manufacture:	1952 (Serial no: 18-2052)
Date & Time (UTC):	18 July 2016 at 1007 hrs
Location:	Shoreham Airport, West Sussex
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - None
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	19,162 hours (of which 30 were on type) Last 90 days - 38 hours Last 28 days - 22 hours
Information Source:	AAIB Field Investigation

Synopsis

During takeoff the aircraft encountered a wake vortex system from a helicopter which had hover-taxied across the runway approximately two minutes earlier. The pilot was unable to correct the roll, induced by the vortex system, before the aircraft struck the ground.

History of the flight

The flight had been planned as a training flight from Shoreham. After completing the pre-flight briefing and checks, the flying instructor, with the broadcast wind information as "variable at 03 kt", decided to take off from Runway 24, the longest of Shoreham's grass runways. The flying instructor was to carry out the takeoff. No abnormalities were identified during the pre-takeoff power checks and, after lining up on Runway 24, the pilot received clearance for takeoff and the updated wind conditions of "150 at 07 kt".

The pilot stated that the takeoff was initially normal, with the aircraft accelerating as usual, but reported that the runway surface was very uneven and "bouncy". The aircraft became airborne before reaching its normal takeoff speed; the pilot did not recall the actual speed. Its left wing dropped and this was corrected by the pilot. The aircraft remained level for a brief period. The right wing then dropped but, despite the use of full corrective aileron, the pilot was unable to prevent the right wing from striking the ground. The aircraft's fuselage then struck the ground and the aircraft rotated 180° before coming to rest. The pilot and passenger received minor injuries. The aircraft was destroyed.

Approximately two minutes prior G-AXLZ's takeoff a Robinson 44 helicopter had hover-taxied from the northern side of Runway 24 to the fuel installation on the south of Runway 24.

Aircraft operation on grass runways

When operating from uneven or bumpy grass surfaces aircraft can become airborne at lower than the normal takeoff speed. In these cases, if the aircraft has sufficient airspeed, it may be possible for the pilot to correct any tendency for 'wing drop' by using the ailerons. However, the use of aileron to correct roll at airspeeds close to the aircraft's stall speed can induce a stall of the 'high' wing. For example: the use of aileron to correct a left wing down roll will cause the right wing to descend. The downward movement of the right wing increases its relative angle of attack to the airflow which, at speeds close to the stall speed, can result in the right wing stalling.

Wake vortex

All aircraft generate vortices at their wing tips as a consequence of generating lift. The strength and duration of these vortices is generally a function of the weight, size and speed of the aircraft. In stable air conditions the wake vortex produced by an aircraft will tend to move downwind. The rate of dissipation of a wake vortex is dependent on the local wind speed; in high wind conditions wake vortices dissipate rapidly but in low wind conditions the wake vortex can remain active for a prolonged period.

The CAA commissioned a study by the University of Liverpool[1] to investigate the specific effects of helicopter wake encounters which was published on 17 March 2015. The introduction to the study (Chapter 1, page 1) states:

> *'There are clear definitions of the separation time or distance for the wake encounter between fixed-wing aircraft. However, for the wake encounter between helicopter wake and an encountering light aircraft, the separation distance is not clearly defined and lacks of details. There is, however, some guidance for helicopter wake encounters, for example, the three-rotor-diameter separation distance described the CAP 493, Manual of Traffic Services. Serious and fatal accidents have happened in the UK when a light aircraft has been caught in a helicopter wake and the pilots have subsequently lost control. The wake generated by a helicopter is different to that of a fixed-wing aircraft. The helicopter wake vortices maybe more intense with different wake structure, duration and decay. The wake vortices are also dependant on the type of the helicopter (weight, size, configuration) and its operating conditions (altitude, speed). Helicopter wake encounter accidents have often happened around airports where helicopters are in hover or hover taxiing and the light aircraft is either landing or departing. Both the helicopter and aircraft are at low altitudes and low speeds and hence this type of wake encounter scenario has its own*

Footnote

[1] Helicopter Wake Encounter Study, Version 1.0, University of Liverpool, March 17 2015. https://www.liverpool.ac.uk/media/livacuk/flightscience/projects/cfd/wakeencounter/caa_helicopter_report.pdf

> *distinct features. When a helicopter is flying at low altitude, ground effect can distort its wake vortices, while the low forward speed causes a large wake skew angle.'*

The CAA have published a number of Aeronautical Information Circulars (AIC) providing guidance and advice relating to Wake Turbulence for ATC personnel. The current AIC, P001/2015, was published on 22 January 2015 and states:

> *'5.2 When hovering, or whilst air taxiing, a helicopter directs a forceful blast of air downwards that then rolls outwards in all directions. This can create problems on the apron, in parking areas and to light aircraft movement on taxiways and runways. In particular there is a risk of damage to fixed-wing control runs and surfaces caused by helicopter downwash driving unlocked control surfaces forcibly against their stops. The risk of damage from this form of turbulence and from wake turbulence encounters may be reduced if the guidelines below are followed:*
>
> *(a) wherever possible and/or practicable segregate helicopter movements from fixed wing movements;*
>
> *(b) whenever possible, ground taxi rather than air taxi;*
>
> *Note: Ground taxiing uses less fuel than air taxiing and minimises air turbulence. Hovering helicopter downwash turbulence, when produced in ground effect, has an increased horizontal flow; this increases proportionally with larger and heavier helicopters.*
>
> *(c) if it is necessary to air taxi, ensure that as wide a clearance as possible is maintained from other aircraft or loose ground equipment;*
>
> *(d) when air taxiing, avoid flying over parked aircraft or vehicles;*
>
> *(e) when helicopters and fixed wing aircraft must use common areas such as aprons, it is recommended that helicopters follow standard taxi routes in those areas. This will facilitate any following aircraft to visualise avoidance areas or areas of increased likelihood of wake turbulence encounter……..*
>
> *5.6 Controllers and pilots should consider wake vortices generated when helicopters hover taxi across active runways and apply the appropriate wake turbulence separation minima. Caution should be exercised when a helicopter or fixed-wing aircraft of lower weight category is cleared to land on a runway immediately after a helicopter of higher weight category has taken off from that runway's threshold. Additionally it should be borne in mind that the downwash and associated turbulence generated by a hovering helicopter can drift a substantial distance downwind and may therefore affect an adjacent runway.*
>
> *5.7 In cruise flight, light fixed-wing aircraft should allow a substantial horizontal distance when passing behind and below helicopters.'*

In addition the CAA provide guidance of pilots regarding wake vortex in CAA Safety Sense leaflet 15c. This states:

> *'HELICOPTERS*
>
> *a) The AIC specifies minimum spacing between light aircraft and large helicopters. However, it is considered that any helicopter in forward flight generates more intense vortices than a fixed-wing aircraft of a similar weight. For example, the S76 is characterised as 'light', so no minimum spacing is recommended for another 'light' aircraft, but such a light aircraft has been turned over by an S76 vortex. When following a helicopter, pilots of light aircraft should consider allowing a greater spacing than they would behind a fixed-wing aircraft of similar size, especially if the helicopter has been hovering.*
>
> *b) Helicopters with rotors turning create a blast of air outwards in all directions, the strongest effect being downwind. This effect is not so significant when the helicopter with rotors turning is on the ground. It is most severe during hovering and hover taxiing, when the rotors are generating enough lift to support the full weight of the helicopter, and this creates the greatest downwash, out to a distance of approximately three times the rotor diameter.'*

Analysis

Given the pilot's report regarding the nature of the runway surface, it is considered probable that the uneven surface resulted in his aircraft becoming airborne before reaching its normal takeoff speed. The fact that the pilot was able to correct the initial wing drop and return the aircraft to wings level showed that the aircraft's speed, whist lower than normal, was sufficient to allow roll control using the ailerons.

The light wind conditions prevalent during the takeoff would have prevented the rapid decay of the wake vortex produced by the hover-taxiing helicopter which had crossed the runway prior to G-AXLZ's takeoff. These conditions would also have caused the vortex system to progress across and along Runway 24. The presence of a wake vortex system over the runway could introduce significant aerodynamic effects on the PA18 during its takeoff. The inability of the pilot to correct the subsequent wing drop is consistent with the aircraft having been subject to such effects.

Conclusion

In view of the facts established during the investigation, it is considered that the most probable cause of the accident was a wake vortex encounter at low airspeed which resulted in an uncontrollable wing drop and subsequent contact with the ground.

ACCIDENT

Aircraft Type and Registration:	Rotorsport UK MT-03, G-MEPU
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2006 (Serial no: RSUK/MT-03/007)
Date & Time (UTC):	28 July 2016 at 1015 hrs
Location:	Turweston Aerodrome, Buckinghamshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Pilot under training (see text)
Commander's Age:	79 years
Commander's Flying Experience:	1,650 hours (of which 41 were on type) Last 90 days - 35 hours Last 28 days - 8 hours
Information Source:	AAIB Field Investigation

Synopsis

The gyroplane was seen to depart from controlled flight as it performed a go-around manoeuvre at Turweston Aerodrome. The accident occurred in benign conditions and no evidence of pre-existing failures or defects was found. A post-mortem examination showed that the pilot had been suffering from a serious and undiagnosed cardiac condition which could have incapacitated him and led to the accident.

History of the flight

The pilot was an experienced fixed-wing private pilot who was nearing the end of a course of instruction to qualify him for issue of a gyroplane pilot's licence. He had completed 41 hours of gyroplane flight instruction and was due to take his General Flight Test (GFT) the following week. On the day of the accident, he intended to fly approximately 90 minutes of solo flight in final preparation for the GFT; this was to be spread over at least two flights under the supervision of his instructor. After that, he was to join his instructor for a discussion about the test itself.

The pilot's instructor arrived at the aerodrome at about 0800 hrs on the day of the accident and met with the pilot, who was already carrying out the daily checks on G-MEPU. They completed the checks together, before discussing the pilot's preparations for the flight. This discussion included relevant safety notices and the weather forecast, which showed favourable conditions for the morning with some rain showers in the afternoon.

The pilot flew G-MEPU on a local flight, taking off at 0910 hrs and landing at 0950 hrs. The flight consisted of general handling in the local area and one approach and landing. Afterwards, the pilot spoke to his instructor and others. During this time he appeared to be his normal self and said nothing that would indicate that the aircraft was not fully serviceable or that he was in any way unwell or had any concerns about his next flight. He did speak to his instructor about refining his landing technique, and it was agreed that he might usefully fly some low approaches and go-arounds[1] on his next flight. Otherwise, the instructor's briefing for the second flight was unchanged from the first.

The pilot took off in G-MEPU again at 1003 hrs and flew to the north of the airfield for a short while before returning to join the circuit. Runway 27 was in use, a tarmac runway 1,256 m long with a declared length of 1,000 m between thresholds. The weather was fine, with a surface wind from 220° at 12 kt. The temperature at that time was 18°C. The pilot's return was sooner than his instructor expected but he was not surprised, given the pilot's expressed desire to practise landings.

The pilot made normal radio calls to the Turweston Flight Information Service Officer during the flight. On re-joining the circuit, he called his intention to perform a low approach and go-around. He was seen to fly what appeared to be a normal powered approach and, just above the runway, initiated the go-around and transmitted "GOING AROUND". The gyroplane was seen to accelerate at a low height until it reached a climbing speed and started to climb away. This manoeuvre was watched by the instructor, who said that it appeared normal.

At a height estimated in the region of 100 ft and without warning, the gyroplane was seen to roll quickly to one side and to dive to the ground, striking the Asphalt runway surface about 580 m from the Runway 27 threshold. There was no emergency radio call from the pilot and nothing was seen to detach from the aircraft in flight. The pilot did not survive the accident.

Eyewitness accounts

Eyewitnesses were consistent in their accounts that the gyroplane was in essentially normal flight and that it suddenly and quickly rolled to one side before descending steeply in a nose down attitude. The direction of initial roll was not uniformly reported, but the witness closest to the scene and to one side of it thought that it had been to the left. There were some descriptions of the aircraft continuing to rotate in some manner until it struck the runway, although the time period concerned had been very short.

One witness to the early stage of the go-around (but not the accident itself) who was also positioned to one side of the aircraft's flight path, described a noticeable pitching or 'porpoising' motion as the aircraft crossed his field of view in the early stages of the go-around. A similarly reported pitching motion was reported by a witness who saw the gyroplane during one of its earlier take-offs. The instructor, who witnessed the same

Footnote

[1] A manoeuvre in which the pilot flies a normal approach to the runway but discontinues the landing and climbs away again. The pilot was practised in this manoeuvre, which was commonly used during training.

stages of flight from a different viewpoint, did not recall any significant pitch variations and thought any such variations would have been temporary and could have occurred as the gyroplane transitioned through phases of flight during which the pilot was trimming the gyroplane in pitch.

Post-accident response

All or part of the accident sequence was witnessed by aerodrome personnel in the control cabin. The 'crash alarm' was sounded, which alerted emergency response personnel nearby. The aerodrome's dedicated response vehicle was dispatched immediately to the accident site, which was about 400 m away.

On arrival at the accident site, it was evident that the pilot had not survived. There was no fire, but a considerable amount of fuel was leaking from the tanks, so a layer of firefighting foam was put down. The civil emergency services were called as part of the initial emergency response plan and they duly attended.

The pilot had been wearing a flying helmet, but this had detached during the accident sequence and was lying nearby. Examination showed that the helmet had detached due to failure of its restraining strap, and its proximity to the wreckage suggested that the failure had occurred relatively late in the accident sequence.

Aircraft examination

Examination of the wreckage revealed that the aircraft had struck the runway in a steep descent with considerable rotational energy in the main rotor blades, both of which had separated following in-plane bending during the initial impact. Limited damage had been inflicted to the propeller. Impact with the surface had destroyed the fuselage forward of the front occupant position, fragmenting most of the instruments and pneumatic system components mounted in the nose area. Distortion had resulted in jamming of the control system but all those components not destroyed by the impact remained connected and exhibited no evidence of pre-impact failure. Examination of the engine did not reveal any evidence of failure and both carburettor float chambers were found to be nearly full of fuel.

Since the propeller on the type is mounted aft in an un-exposed position, propeller blades did not come into contact with the ground until late in the accident sequence, after the aircraft had become almost inverted. Separation of the main rotor blades during initial impact precluded them from entering the arc of the propeller. Thus the limited damage to the propeller blades almost certainly happened late in the impact sequence and was not indicative of the amount of engine power being delivered at the time of the impact.

Pilot information

The 79 year old pilot had qualified for his fixed-wing Private Pilot's Licence in 1999. His training and all his subsequent flying had been conducted from Turweston. For about the last 10 years, he had owned and flown a PA-28-180 fixed wing aircraft. The pilot was a popular and well regarded club member who was described as meticulous in his approach to flying and not an individual who would deliberately take risks or attempt to fly beyond his own limits or that of his aircraft.

The pilot had flown a total of 1,650 hours, which included 41 hours gyroplane training that commenced on 25 April 2016. This flying had been spread over a total of 45 flights in G-MEPU, 10 of which (9.5 hrs) had been solo. His last flight, a solo, had been made two days before the accident.

The pilot had made satisfactory progress through his course, and had demonstrated an attitude and approach to his training which reflected his considerable fixed-wing experience. Although the pilot himself had raised some concern about his landing technique prior to the accident flight, his instructor considered any issues he was having to be minor and consistent with his relative lack of experience in gyroplane flying. He was considered ready to undertake the GFT.

Medical and pathological information

The pilot's family and colleagues considered him to be very fit and active. He appeared to be in good overall health and was not suffering from any known condition or illness which may have affected his ability to safely pilot the gyroplane. There was nothing remarkable in the pilot's history in the days immediately before the accident. He had slept normally the night before and had breakfasted that morning.

On 2 February 2016, the pilot had been examined by an Aeromedical Examiner for a Class Two medical certificate. This was duly issued and was valid until 20 February 2017. The examination included an electrocardiogram (ECG).

A post-mortem examination concluded that the pilot had died from a combination of injuries sustained in the accident. However, the examination also revealed severe and extensive coronary artery atherosclerosis, to an extent of severity that it could have been given as a cause of sudden death in the absence of any accident. The pathologist performing the post-mortem reported that it was *'very likely that a sudden cardiac event, possibly causing unconsciousness, precipitated the accident'*.

Analysis

The accident occurred without prior indication that anything was amiss. The pilot appeared to be well, had reached a level of competence whereby he was ready to be tested for his licence, and had expressed no misgivings about the aircraft or the conditions of the day.

The accident occurred during a routine manoeuvre with which the pilot was familiar and which he had demonstrated his competence to carry out during his previous training. The pilot had already flown the most critical stage of the manoeuvre, being the transition from the approach phase to the climb-out phase, and this had appeared unremarkable to his instructor.

The aircraft was not being flown in a regime of flight which ordinarily would be regarded as close to the limit of its capabilities, nor in unsuitable or marginal weather conditions.

The progression of the flight was as expected and the pilot had made a routine radio call seconds before the accident. The option to land the aircraft was available to the pilot even after initiating the go-around (an emergency landing ahead on the relatively long, tarmac runway should have been within the pilot's capabilities, even taking into account the surprise factor of an unexpected event occurring at that stage). Consequently, the accident sequence either unfolded very rapidly or the precursors to it were not apparent as such beforehand.

The physical examination of the gyroplane structure, its systems and engine revealed no evidence of pre-impact failures or defects. There was ample fuel in the aircraft tanks and related engine components.

The aerodrome response to the accident was in accordance with the local crash procedures, which appear to have been properly executed. However, the forces involved in the accident were such that the pilot did not survive the initial impact and no changes to local procedures could have affected the fatal outcome.

Although the post-mortem examination concluded that the pilot died as a result of multiple injuries sustained in the accident, the discovery of severe and extensive coronary artery atherosclerosis is significant as it provides a credible case for a pilot incapacitation. Indeed, the pathologist performing the examination thought that the severity of the pilot's condition could itself have been given as a cause for sudden death, stating that it was *'very likely that a sudden cardiac event, possibly causing unconsciousness, precipitated the accident'*.

Conclusion

The investigation considered the post-mortem evidence and the opinion of the pathologist, along with the lack of any evidence of other causal factors. It was concluded that the accident was most probably the result of a sudden medical incapacitation of the pilot, in which his capacity to pilot the aircraft safely was either removed or severely degraded.

ACCIDENT

Aircraft Type and Registration:	Schleicher ASW 27-18E (ASG 29E) glider, G-VLCC
No & Type of Engines:	1 Solo Type 2350 two-stroke engine
Year of Manufacture:	2007 (Serial no: 29511)
Date & Time (UTC):	21 July 2016 at 1043 hrs
Location:	Moundsmere, near Basingstoke, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Glider destroyed
Commander's Licence:	British Gliding Association Gliding Certificate
Commander's Age:	60 years
Commander's Flying Experience:	1,800 hours gliding (of which 3 were on type) Last 90 days - 16 hours Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

Following a launch by aerotow, there was a period of soaring flight before the pilot apparently started the glider's sustainer engine for practice, as pre-planned. Shortly afterwards the glider was seen descending steeply toward the ground, which it struck at a speed in excess of 100 kt. There was no evidence of any technical failure.

The pilot was an experienced glider pilot and seemed fit and well before the flight. However, it is possible that the pilot was incapacitated during the latter stages of flight and the pathologist could not rule out the possibility that she might have lost consciousness, as a result of a cardiac problem owing to a family history and reports of heart palpitations about two weeks prior to the flight.

History of the flight

At 0830 hrs on the day of the accident the pilot attended a briefing to gliding club members concerning the day's flying conditions and a suggested gliding task. Club members wishing to participate in the task were to cross a start line, close to Lasham Airfield, fly a route of approximately 300 km and return to Lasham. The pilot's intention was to launch by aerotow and to soar in the vicinity of Lasham, until she was ready to start the task. Once at a safe altitude, she planned to practise starting the glider's sustainer engine, to run it for a short time and then to stow it before the cross-country task.

The glider, an ASG 29E, had been stored in its trailer since its owner flew it four days previously. Three people assisted the pilot to attach the glider's main wing sections to the fuselage and then she completed rigging the machine herself, including the loading of water ballast from four 25 litre containers into the tanks in each wing.

By 1000 hrs the pilot was sitting in the glider, queuing for an aerotow in the launch 'grid', when an acquaintance spoke to her. She was having difficulty integrating her Naviter Oudie tablet device[1] with the glider's flight computer but the acquaintance later said that the pilot appeared to be her usual "energetic and bubbly" self. Her husband, whose own glider was positioned further back in the queue, stated afterwards that his wife told him before takeoff that she was unconcerned by the issue with the Oudie.

When it was the pilot's turn for an aerotow she was assisted by two gliding club members. She was wearing a parachute and one of the members helped her with her harness. This member owns and flies an ASG 29E and, acting as ''wingtip runner", he lifted the right wing of the glider in readiness for the launch. He felt the water ballast moving as he levelled the wings and assessed there was between 80 and 100 litres of water in the wing tanks. While assisting the pilot he judged by her speech and demeanour that she was "relaxed and well."

At the pilot's request, the other club member attached the tow rope and issued radio instructions for the tug to take up the slack on the tow cable and then to commence takeoff. The wingtip runner ran forward with the glider and kept the wings level for as long as he could. He did not observe which flap setting the pilot had selected, but he did observe that the pilot appeared to have full aileron control and the wings remained level after he let go. From his experience of this glider type, he would have expected a lack of aileron control at low speed and one wing to drop if the flaps were not at '*setting 2*' at the start of the takeoff.

This was the tug pilot's sixth glider tow of the morning and he experienced no difficulties with the tug aircraft. Weather conditions were favourable; visibility was good, there was a light north-westerly wind and, at nearby RAF Odiham, the only recorded cloud below 10,000 ft agl was a scattered layer at 3,600 ft agl. The Met Office later stated the wind direction was from 250º to 260º at 1,000 ft agl veering to 280º to 290º by 4,000 ft agl, and that up to this altitude the wind speeds were less than 10 kt. The start of the aerotow was logged at 1020 hrs and the tug pilot reported the ground run and takeoff were normal.

At approximately 500 ft agl the tug pilot saw in his rear-view mirror that the glider was moving from side to side and up and down, in a manner he assessed as unusual, given the height. The tug pilot continued climbing, at an estimated airspeed of 70 to 75 kt, and made one gentle turn toward the northwest. He was surprised to see the glider continuing to move around, predominantly from side to side, but the glider pilot did not initiate any radio communication to ask for an adjustment of the tow speed or to indicate she was experiencing a problem.

Footnote

[1] See *Recorded information* for further detail.

At approximately 1,500 ft agl, the tug pilot sensed an area of good thermal activity and was surprised the glider pilot did not release the tow. Then, passing 1,800 ft agl, the tug pilot could not see the glider in his mirror and thought it may have released, although he had not felt an appropriate reaction from the tug. He therefore continued to climb and, shortly afterwards, saw the glider in his mirror, moving quickly up from below his line of sight to a relatively high position. The glider pilot then released the tow at approximately 2,000 ft agl, a normal aerotow release height in the UK, and turned left, while the tug pilot turned right and descended, without seeing the glider again.

A number of other gliders were already airborne and were thermalling to the northwest of Lasham. A pilot in one of these gliders was listening on a common radio frequency used by many of the pilots after launch. At approximately 1035 hrs he heard the pilot of G-VLCC replying to a radio call from her husband, who was flying in his own glider. Her brief response sounded characteristic of her and the other pilot later assessed she was not experiencing any difficulty when she spoke.

A few minutes later, the pilot's husband called her again and she indicated to him she was "climbing up nicely". His impression was that everything was fine in his wife's glider and a further pilot who overheard this exchange, and who knew the pilot of the ASG 29E well, also thought she sounded normal. Nobody reported hearing her speak on the radio again.

Two witnesses on the ground appear to have seen the glider as the accident occurred. One man was in a garden two miles west of Lasham when he saw a glider approximately one mile from his position, above the accident site. Its nose was pointing steeply down and it seemed to be "spiralling downwards". He thought it rotated three or four times before his view was obscured, by which time the glider was sufficiently close to the ground for him to fear it had crashed. He set off with a relative to check nearby fields and to see if they could assist the pilot.

A second witness, approximately 1.25 nm north of the first witness, was standing at the edge of a woodland clearing. At approximately 1045 hrs he heard the noise of an engine and looked up to see a glider, apparently intact, which he assessed was flying low and approximately in a southerly direction. There was a "whooshing" sound as the glider passed by and the witness also heard a noise that suggested an engine was stuttering. The witness' view of the glider was quickly obscured by trees and a few seconds later he heard a "bang", which led him to believe it had hit the ground.

A loud noise, which sounded like an engine running up and dying away two or three times was heard by four people at a farm. One of them, who was driving a farm vehicle, described hearing the high-pitched "screaming" of an engine above the noise of his own machine, and then a loud crashing sound. Three of these witnesses went to investigate and they found wreckage of the glider in a field, approximately 300 metres from the farm. One person called the emergency services while the other two approached the glider but could not help the pilot, who had suffered fatal injuries.

Recorded information

Several pieces of avionics were recovered from the accident site, including a Naviter Oudie navigation tablet device and an LXNAV LX8080 flight computer with integrated FLARM[2], which would have recorded a log of the flight into memory. These were, however, damaged to the extent that no data could be recovered from their memory.

Some of the UHF broadcasts from the FLARM were detected and recorded by a ground-based receiver near the airfield. The recording was then automatically uploaded to a server operated by the Open Glider Network (OGN)[3]. Upon request, the AAIB was provided with a copy of the recording which contained the time (to the nearest second), position (latitude and longitude), GPS height, vertical speed (climb rate) and turn rate for each of the detected FLARM broadcasts from G-VLCC.

Figure 1 shows the track of the glider beginning on the ground at Lasham at 0953 hrs (airborne at 1020 hrs) to about 550 ft above the accident site at 1043:20 hrs, 4.5 km west of the airfield. The flight time from tug release was about 21 minutes. The recorded height, vertical speed and turn rate for these points is presented as a time history at Figure 2 and includes a calculation of ground track angle based on the angle between its present position point and the previous point.

The figures show that, following the tug release at just under 2,400 ft amsl (about 1,900 ft aal), G-VLCC turned to the left, to the north of the release point, where it commenced a climb to 3,270 ft, gaining about 810 ft [A]. The glider then tracked west then east, descending to 2,910 ft. It then climbed again to 3,370 ft [B] before descending to 3,200 ft. The final climb was to 3,920 ft amsl [C].

G-VLCC then descended at between 400 and 500 ft/min, initially tracking west, in a gentle (about 1°/s) turn to the left. After about 90 seconds (now tracking south and descending through 3,250 ft) the turn tightened, taking the glider onto an easterly track, then tightened further to about 4°/s onto a north-north-westerly track where it levelled off at 3,050 ft for about 25 seconds. From the top of the final climb to this point the glider's path over the ground was 3 nm, which it covered in 167 seconds giving an average groundspeed of 65 kt. The FLARM ground-receiver then lost contact for 35 seconds; however, the straight-line distance travelled during this period was 0.55 nm which indicates an average groundspeed slightly greater than 57 kt.

Footnote

2 FLARM is a collision avoidance system for General Aviation, light aircraft, and UAVs that alerts the pilot to both traffic and potential collisions with aircraft that also have FLARM installed. FLARM obtains its position and altitude readings from an internal GPS and a barometric sensor and broadcasts, every second, a prediction of its position about two seconds ahead. Broadcasts are with radio signals in the UHF band.

3 The Open Glider Network (OGN) is a project run by enthusiasts with the aim of creating and maintaining a unified tracking platform for gliders and other GA aircraft with FLARM.

Figure 1

Flight track of G-VLCC with area of climbing marked at A, B & C and the last 35 seconds of recordings in light blue (Figure 3). The distribution of points varies as not all of the FLARM broadcasts were detected by the ground-receiver

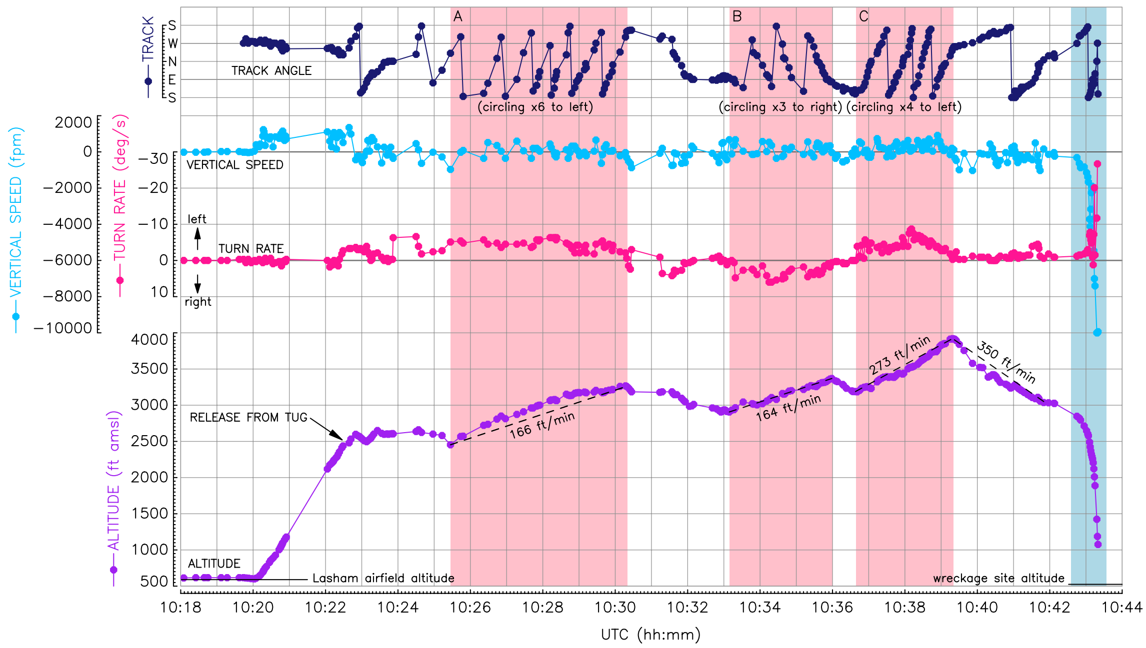

Figure 2

FLARM flight data with the last 35 seconds of recordings highlighted in light blue (Figure 3) – the highlighted areas in pink indicate when G-VLCC was climbing

Figure 3 shows the FLARM flight data once contact was regained, with G-VLCC at 2,850 ft on a south-westerly track, gently descending and turning, through to the end of the recording 35 seconds later. Groundspeed (calculated from distance travelled and time taken between points) is also presented, together with a parameter labelled '3D' groundspeed that incorporates the component of vertical speed.

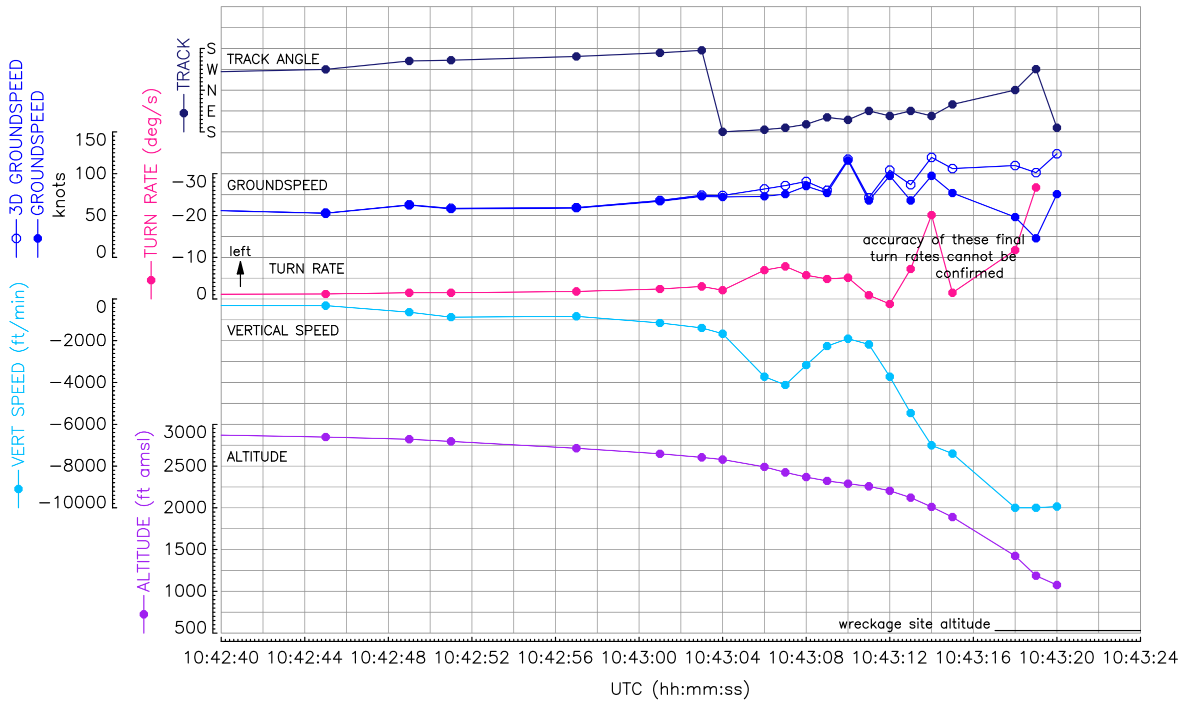

Figure 3

FLARM flight data – last 35 seconds of recordings

G-VLCC continued to turn and descend, reaching a descent rate of 1,660 fpm after 19 seconds and this rapidly increased to 4,000 fpm over the next 3 seconds. There was a similar marked increase in the turn rate during this period. Over the next 3 seconds the descent rate reduced to 2,000 fpm; however, within another 4 seconds it had increased to over 7,000 fpm, with the glider now about 1,500 ft above the ground. The calculated groundspeed throughout the last 35 seconds was always greater than 50 kt and for the last 18 seconds it was greater than 70 kt.

Ground-receiver contact was then lost for a couple of seconds before regaining contact for three last points to be recorded. The last point positioned the glider about 550 ft agl, near the accident site and the groundspeed and vertical speed combined indicate the glider hit the ground with a speed in excess of 100 kt.

11 April 2015 flight in G-VLCC by the pilot

A copy of the downloaded log files from the LX8080 for the two previous flights by the pilot was provided by the owner of the glider, so that the Engine Noise Level (ENL) data could be examined, to establish whether the sustainer engine had been used on either of these flights. With the exception of the pilot's first flight in G-VLCC on 11 April 2015, there was no evidence that the engine may have been used. The flight data for the 11 April 2015 flight (Figure 4) shows that significant noise was detected twice when the glider was airborne – the first lasting 100 seconds and the second 60 seconds. However, when analysing the phase of flight (position and altitude), climb rate and speeds immediately prior to and during these periods of high ENL values, only the first was consistent with use of the engine. It is therefore probable that the engine was used in the first period (100 seconds) and it is only a possibility for the second.

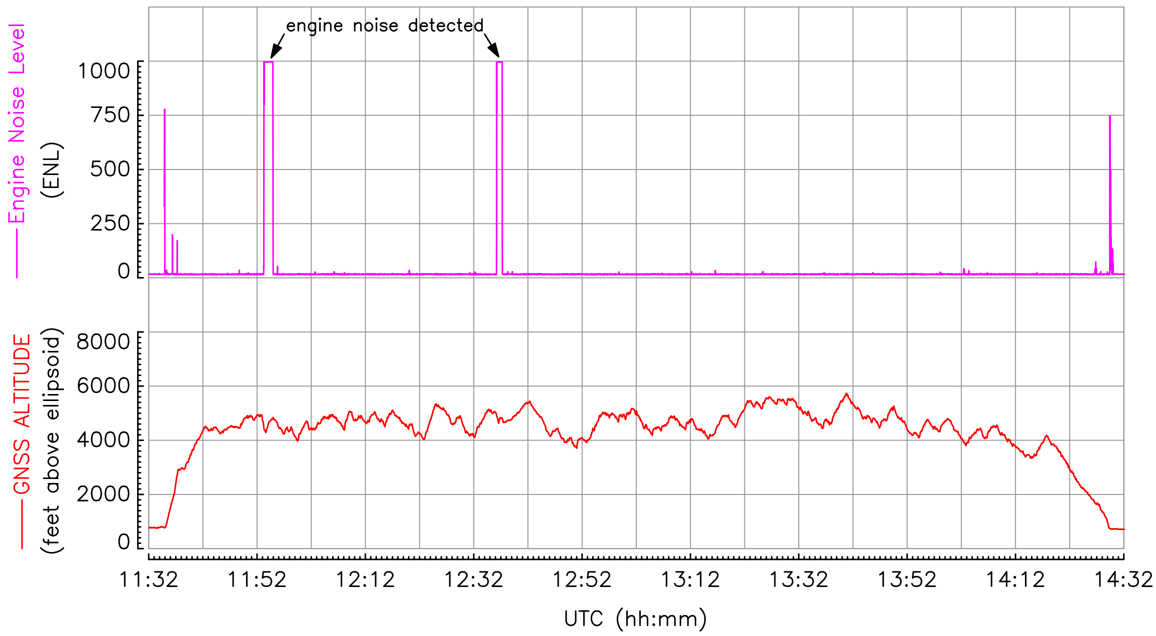

Figure 4

Data from flight on 11 April 2015 showing when noise from the engine may have been detected

Glider description

ASG 29E is the product name for the ASW 27-18E, which is a single-seat self-sustaining powered glider, designed and manufactured by Alexander Schleicher GmbH & Co. The glider is a derivative of the ASW 27 with a T-tail, retractable sprung landing gear and a water ballast system (Figure 5). Interchangeable outer wing sections allow participation in 15 m and 18 m competition classes.

Image courtesy of Alexander Schleicher GmbH & Co

Figure 5

General view of an ASG 29E with the engine deployed

Maintenance and glider history

G-VLCC was manufactured in 2007 and had a valid Airworthiness Review Certificate (ARC). When the ARC was issued in March 2016 the glider had accrued 637 flight hours and 192 flight cycles. It was fitted with an optional water ballast tank in the fin but the tank had been damaged and could not be used. At the time of the accident the glider was configured with an 18 m wingspan.

System descriptions

Flying controls

The elevator, flaps, aileron and airbrake controls connect automatically when the glider is rigged. With the exception of the rudder, the controls are actuated using a combination of push rods and levers. The rudder is operated by steel control cables.

Pitch and roll are controlled using a conventional control column and there is a basic mechanical trim facility for pitch. The rudder is controlled using rudder pedals that can be adjusted to suit the pilot.

Flaps

Two trailing edge flaps, which also function as ailerons, cover the entire span of each wing. The flaps are controlled using a lever in the cockpit and the seven positions and recommended phase of flight are defined within the flight manual (Table 1).

Flap setting	L	6	5	4	3	2	1
Flap deflection	47º / 12º	24º / 22º	20º / 19º	12º / 11º	5º	0º	-2.5º
Description	Landing	Thermalling	Thermalling	Neutral	Gliding	Gliding	Gliding

Table 1

Flap settings as presented in the flight manual
(flap deflection is tabulated as inboard flap angle / outboard flap angle)

Airbrakes

Each wing has a triple-blade airbrake that extends from the upper surface and is controlled using a lever in the cockpit. The flight manual states that the airbrakes increase the sink rate and stall speed and have a small effect on trim.

Water ballast

The nose sections of the inner wings contain integral water ballast tanks and each wing can hold approximately 85 litres. A 5 litre ballast tank in the vertical fin can be installed as an option to counteract the nose-heavy moment of the wing ballast.

Carrying water ballast is a disadvantage when climbing in rising air (thermalling) but the increased weight allows the glider to fly at a higher airspeed for a given glide angle. Carriage of ballast is, therefore, advantageous during cross-country competitions in good soaring weather and 100 litres of ballast was typical for this glider in the prevailing conditions.

Sustainer engine

The glider is equipped with a Solo 2350 two-stroke, two-cylinder sustainer engine driving a two-blade, fixed-pitch, composite propeller. The engine is capable of delivering up to 24 horsepower and is normally stowed inside the fuselage behind the cockpit. The engine is extended by an electrically-driven screwjack and starting is reliant on the airflow to rotate the propeller. Engine status is displayed on a cockpit instrument that also performs engine control and monitoring functions.

The engine is controlled using a lever that protrudes from a detented slot on the cockpit left side console (Figure 6). There are five positions and the lever is connected to an engine control unit by means of a mechanical linkage. The control unit is mounted behind a removable panel in the left side of the engine compartment and consists of a sliding assembly that operates electrical microswitches to 'sequence' the engine.

A fuel tank located just behind the pilot contains 10.5 litres of fuel, which is sufficient for approximately one hour of powered flight. The fuel shutoff valve is operated by a lever in the cockpit (Figure 6) and, if inadvertently left closed, is automatically opened by the action of moving the engine control lever to the ignition position.

Figure 6

Fuel shutoff and engine control levers

Engine operation

There are five detented lever positions for the engine control (Figure 7).

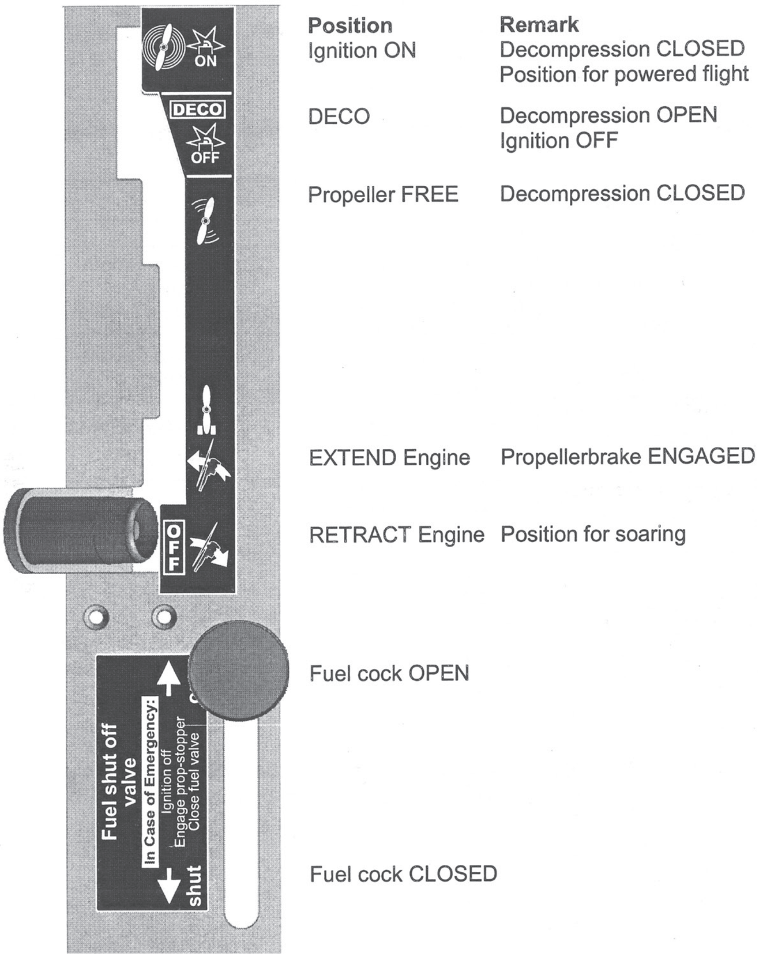

Figure 7

Engine control lever positions

The engine is extended into the airflow by moving the control lever forward to the EXTEND position. The flight manual recommends this is accomplished at an airspeed of less than 76 kt and an experienced ASG 29E pilot stated he would aim to do this at approximately 50 kt, with the flaps at setting 5. A green light illuminates on the cockpit instrument when the engine is extended fully. If the engine does not extend fully, a red light flashes, accompanied by an audio alert and an error message on the cockpit instrument display.

Advancing the control lever to the DECO position withdraws a propeller stop and opens the decompression valves, allowing the propeller to windmill. The flight manual states the glider should be accelerated to 65 kt before pushing the control lever fully forward to IGNITION ON, closing the decompression valves and starting the engine. The experienced ASG 29E pilot stated he would aim to accelerate to 75-80 kt, selecting the flap to setting 3. When the engine has started, engine speed will increase above 4,400 rpm and the airspeed should be reduced to 51 kt, at which the glider will climb steadily unless in sinking air.

The glider does not have a throttle control and engine speed is dependent on the airspeed. Engine speed is monitored and the status is displayed on the cockpit instrument. A green light signifies 4,400 to 5,200 rpm and a yellow light signifies 5,200 to 5,400 rpm. Depending upon airspeed, it is possible to exceed the maximum engine speed of 5,400 rpm and if this occurs, a red light illuminates and the ignition is switched off automatically until the over-speed is no longer present. Pilots familiar with the ASG 29E commented that the engine sound under such conditions is distinctive as the ignition cuts in and out; a flight test report in Sailplane & Gliding magazine dated August 2007 described it as '*splutter*'. The experienced pilot (quoted previously) described it as a "surging effect" and noted that it would not happen if the airspeed was less than approximately 60 kt. He pointed out that, because it is a fixed-pitch propeller, the rpm is very dependent on airspeed.

The flight manual states that the time taken to extend and start the engine is approximately 40 seconds. Height loss is '***usually** about: 100 – 200 m (330 – 660 ft)*'.

The engine is stopped by moving the control lever aft to the DECO position and reducing airspeed. When the propeller has slowed, the engine lever is moved to the propeller free position, which closes the decompression valves. The propeller stop is engaged by moving the control lever to the EXTEND position and the engine is retracted by moving the lever fully aft to the RETRACT position.

Accident site

The accident site was in a corn field approximately 2 nm west of Lasham airfield. The accident followed a period of dry and warm weather that had created a very hard surface to the field. The glider was severely disrupted in the ground impact and the fuselage forward of the wings was fragmented through the site, which was approximately 30 metres wide. The tongue-and-fork joint between the wings was secure but the wing structure had broken up exposing the internal flying control rods, which were heavily distorted. Both airbrakes were found extended and the engine had detached from the fuselage. The tail boom had broken into multiple pieces but the fin, rudder and right horizontal stabiliser remained as an assembly.

The extremities and major components of the glider were identified at the site, indicating that it was structurally intact prior to the impact. The majority of the external white surfaces had a mottled brown dusty coating that was consistent with the wreckage being enveloped in a cloud of dust and water when the water ballast tanks ruptured on impact.

Clear indentations in the soil, approximately 5 cm in depth had been made by the left winglet and left wing outboard leading edge. The general disposition of the wreckage was consistent with the glider having crashed at high speed in a steep nose-down attitude with the nose approximately 30° from vertical.

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

Detailed examination of the wreckage

Flying controls

Damage on the left wing appeared to have been caused by interference with the airbrakes as they extended and fouled the adjacent distorted structure. It was, therefore, concluded that the airbrakes extended as the glider broke apart.

The positions of the remaining flying control surfaces at the time of the accident could not be determined. There was no evidence of a pre-accident flying control system failure but it was not possible from the wreckage alone to eliminate the possibility of a control restriction or jam.

Engine

Damage sustained by the engine and its associated components was consistent with it being in the extended position when the impact occurred. The propeller blades had detached from the hub and chordwise scoring and leading edge damage indicated that the propeller was rotating at impact.

The fuel shutoff valve selector lever was found in the OPEN position but the operating linkage had detached from the valve. The shutoff valve itself was fully open.

The engine control lever had come out of its detented slot and it was not possible to determine the position of the lever at the time of the impact, either from the engine or the control unit. The engine control unit remained in place and comparison with a reference unit showed its position was consistent with the control lever being in the PROPELLER FREE position. The possibility that the control unit had been disturbed during the impact could not be discounted and the installation is such that the sliding mechanism would probably be displaced aft when the forward fuselage broke apart.

The extent of the damage precluded testing of the engine but strip examination revealed no evidence of any pre-accident damage or undue deterioration. The owner of the glider reported that the engine had been started without difficulty on the two flights prior to the accident.

Landing gear

The condition of the landing gear indicated that it was retracted at impact.

Canopy

The canopy release mechanisms were identified and the locking pins were fully engaged. There was no evidence that the pilot was in the process of jettisoning the canopy.

Weight and balance

G-VLCC had an empty mass of 344.6 kg and a maximum permitted takeoff mass of 600 kg in the 18 m configuration. The estimated takeoff weight for the accident flight was 534 kg, giving an estimated wing loading of 50.9 kg/m^2. The centre of gravity was calculated to be 275 mm aft of the datum, almost midway between the forward and aft limits as prescribed in the flight manual.

Handling

The ASG 29E, and the ASG 29 with no engine, have become very popular over the last 10 years and many examples are operated in the UK. The manufacturer indicates there are approximately 190 ASG 29E gliders in use worldwide and approximately 110 ASG 29 gliders.

Sailplane & Gliding magazine published flight test reports on the ASG 29 (June 2006) and the ASG 29E (August 2007) which state '*Control was direct and stable: with comfortably low, unambiguous forces…*' and '*…easy to fly, making it ideal for club use*'. The 2007 report says starting the engine is '*really easy*' and the glider is described as having high performance while being '*reliable and safe'*.

Aerotow

The flight manual suggests that pilots should begin their takeoff using flap setting 2, to achieve best lateral control. The flap setting should then be increased steadily to setting 5 during the ground run, with setting 4 or 5 used when airborne. The manual also notes that setting 4 can be maintained throughout the whole aerotow and indicates that 70 kt would have been the ideal airspeed for G-VLCC in this phase of the flight.

During Sailplane & Gliding magazine's 2006 assessment, setting 4 was used for the ground run and the tow and the test pilot reported:

> *'At a towing speed of 110 km/h (59 kt) the tug was clearly visible above the instrument panel. For even better visibility on slower tows, the flaps could be set to 5, which lowers the nose. I also checked the behaviour on tow with the flaps set to 6 or even L, and found no significant tendency to 'go out of control' and over climb the tug even at high towing speeds.'*

A reference card found in the glider suggested that setting 2 or 4 could be used for the ground run and setting 4 or 5 on the aerotow.

Airspeed

The ASG 29E's normal operating airspeed range (marked in green on the airspeed indicator) is from 56 to 113 kt and the best-rate-of-climb speed, when powered by the sustainer engine and at maximum weight without water ballast, is 51 kt.

A table in the flight manual offers stall speeds for different flap settings and weights. For a glider weighing 530 kg, the table indicates a minimum stall speed of approximately 42 kt at flap setting 5 (which might increase to 45 kt at an angle of bank of 30º), with or without the engine extended.

Use of the sustainer engine

The sustainer engine is fitted to allow continued flight when there is insufficient lift to allow the glider to soar and the flight manual suggests that the minimum safe height before extending and starting the engine is 1,300 ft. It advises pilots to familiarise themselves with starting procedures '*within safe reach of an airfield*' and recommends running the engine for a short time before commencing a cross-country flight, to ensure that it is operating correctly and that the fuel lines are filled. The minimum speed for extending and starting the engine is 45 kt and the maximum speed with the engine extended is 76 kt.

A few weeks before the accident, the glider's owner suggested to the pilot and her husband[4] that all three of them should routinely practise engine starts at a safe altitude. The accident occurred during the pilot's first flight following this discussion and she had informed her husband that she would run the engine for a short time that morning when she was in a safe position. He saw her looking at the engine procedures checklist in the flight manual prior to the flight.

Manoeuvres

The flight manual states the ASG 29E is not approved for aerobatic manoeuvres and intentional spins or spiral dives are not permitted. During certification tests with the engine extended the glider recovered from a spin after two turns without any pilot input. It was also shown that recovery was possible from a spin that turned into a spiral dive with the engine windmilling, without exceeding its design manoeuvring speed or the maximum positive manoeuvring load factor of +5.3g. The flight manual lists the actions to be taken to recover from a spiral dive:- '*release stick*', '*reduce bank angle with aileron and rudder against the direction of turn*', '*gently pull out of the dive*'. The manufacturer stated that these actions will lead to an immediate recovery.

Footnote

[4] The pilot's husband was also a glider pilot, current on the LS8 and the accident glider.

Gliding procedures

Licensing and gliding club procedures

The pilot of G-VLCC was in possession of a valid British Gliding Association (BGA) certificate. The UK Air Navigation Order (ANO) does not require a glider pilot to possess a flight crew licence and pilots may operate a glider in the UK if they possess BGA certification.

The BGA does not regulate a glider pilot's recency and gliding clubs issue local guidance on levels of recency deemed appropriate for their site. At Lasham, pilots with more than 100 hours total flying experience and who fly '*30-40 hours per year or more'* are advised to have a '*check flight*' with an instructor only if more than three months have elapsed since their last flight.

Pilot information

Medical requirements

A pilot is deemed medically fit to fly a glider solo if they possess a current motor vehicle driving licence and are flying as a BGA gliding certificate holder, rather than with a flight crew licence. The pilot of G-VLCC was in possession of a current driving licence and there were no indications from her medical record that she was unfit to hold this licence. Previously, in order to compete in international gliding competitions, the pilot held an EASA Class 2 medical certificate but its validity expired on 30 April 2014.

Medical history

Nine days before the accident, the pilot had indicated to a friend that she had difficulty sleeping a few nights earlier because of "palpitations and thought she was having a heart attack". There was no evidence the pilot talked to anyone else, including her husband, about her sensation of palpitations nor did she consult a medical professional.

Two days before the accident, while on another business trip, the pilot stayed overnight with close friends from the gliding community. They recalled that she seemed her normal "effervescent" self. However, while discussing her forthcoming retirement, she said that she would probably not do any more gliding when she retired because she was "too tired". The friends were surprised by this remark but the pilot did not elaborate further.

Witnesses who interacted with the pilot on the morning of the accident thought she seemed fit and in good spirits. One of these witnesses described her as an "energetic, bubbly lady" and noted that morning "she was her usual self and appeared very well". Her husband stated that the previous evening she had been quite relaxed, that they had spent the night in their caravan at the airfield and that she seemed typically "lively" on the morning of the flight.

Family history

Both the pilot's natural mother and her maternal grandmother suffered cardiac illness when aged over 60. The pilot's mother reported having a heart attack when she was aged 65, with further complications, and her brother, the pilot's uncle, suffered serious cardiac illness which began with a heart attack at the age of 43.

Post-mortem examination

The histopathologist who carried out a post-mortem examination stated that his findings were consistent with the glider suffering a high-velocity impact in a nose-down attitude. He observed no evidence of pre-existing natural disease that could have contributed to death but he was constrained by the extent of the injuries following the accident and it was not possible to analyse the pathology of the pilot's cardiac system. After learning about the related family history and the pilot's report of an abnormal heart rhythm, the pathologist observed that this could explain a sudden loss of consciousness but could offer no corroborative physical evidence for this.

Experience

The pilot started hang gliding in 1979 and became an accomplished hang glider pilot before obtaining her BGA certificate in 1997. She had flown in excess of 1,800 hours in gliders, had represented her country in international competitions and had gained an array of gliding certificates, diplomas and records[5]. Other, experienced, glider pilots praised her piloting skills and stated she was "sensible", "cautious" and demonstrated "exemplary airmanship". Her husband also stressed that she was a focussed and well-disciplined pilot, who was not easily distracted.

Over the last few years the pilot mostly flew in a Rolladen-Schneider LS8, a single-seat glider without a sustainer engine. No log book entries were made after August 2013 but there were loose notes relating to some flights during 2014. From the start of that year, all the pilot's flying was from Lasham and the Gliding Club's launch record, along with glider log data, provided information of flights made after the last log book entry. Nearly all of these flights were in an LS8 but one, on 22 February 2014, involved a refresher flight with an instructor in a two-seat glider and this was completed satisfactorily.

On 11 April 2015 the pilot flew the accident glider for the first time, on a flight that lasted 2 hours 55 minutes. Her only other flight in it was on 3 April 2016 and this lasted 29 minutes but, in the 12 months prior to the accident, she also flew 12 times in an LS8, the last flight being made on 15 May 2016. Her estimated total flight time over this last year was 36 hours.

Footnote

5 British gliding records are listed by category and glider class at https://members.gliding.co.uk/competitions/british-gliding-records/

Manufacturer's comments

Aerotow

The glider manufacturer commented that if flap setting 4 had been used and the glider towed at 70-75 kt, the pilot should not have had difficulty maintaining the tow position. Even if another flap setting had been used, the pilot might have had to concentrate more on holding position and this should not have posed any particular problem. The manufacturer considered that, barring a control difficulty, the only plausible explanation for the glider's movement was that the pilot lost concentration while focussing on some other task, such as changing a setting on a flight computer.

Given the pilot was seen before takeoff to experience some difficulty integrating her tablet device with the on-board equipment, she may have had further difficulties as the aerotow progressed. There may, equally, have been another unknown source of distraction in the cockpit.

Descent with engine deployed

The manufacturer stated that a deployed engine 'acts as a large airbrake' and limits the airspeed in descent. It was the manufacturer's opinion that the engine noises heard by the witnesses on the ground probably reflected an engine speed accelerating above 5,400 rpm, due to high airspeed, and the ignition cutting out until the engine speed reduced below 5,400 rpm. At high airspeed the engine would have accelerated again and the process would have repeated.

Analysis

Engineering

Ground marks and the disposition of the wreckage showed that the glider struck the ground in a steep nose-down attitude with the nose approximately 30° from vertical. The glider was structurally intact before the impact occurred.

The engine was in the deployed condition and damage to the propeller showed it was rotating. Witness reports of a "screaming" engine which was running up and dying away two or three times are most likely explained by the automatic over-speed protection temporarily switching off the ignition. This would suggest that the engine was running prior to the accident.

With the exception of the airbrakes, which were stowed, it was not possible to establish the position of the flying control surfaces. Detailed examination showed no evidence of a pre-accident flying control system failure but it was not possible to eliminate the possibility of a control restriction or jam.

There was no evidence that the pilot was in the process of jettisoning the canopy.

Flight preparation

On the day of the flight the pilot appeared to have made her preparations in her usual, thorough manner and the only apparent difficulty she had was in programming the tablet device she used in the cockpit. The glider was loaded to less than its maximum takeoff mass, the centre of gravity was close to the middle of the allowed range and it was evident the pilot planned to deploy and run the sustainer engine for a short time at a safe altitude. This was in accordance with the manufacturer's recommendations.

The pilot had only flown the Schleicher ASG 29E twice before but she was an experienced pilot who should not have had difficulty flying this glider with its benign handling characteristics. Her last flight with an instructor took place two years and five months previously but, with her level of experience, neither the BGA nor her gliding club requires such a pilot to have regular check flights.

Aerotow

The wingtip runner and the tug pilot both said the takeoff appeared normal. However, despite the tug being flown at a suitable speed, the glider apparently moved around from side to side and up and down after passing 500 ft. Given the pilot's high level of experience, she should not have had any problem maintaining a steady position on this tow and she did not indicate on the radio that she had encountered a problem. As no technical defect was later found, it is possible that the pilot was distracted by something which caused her to lose concentration when flying the glider.

Soaring

The recorded data indicates that for 16 minutes after launch the pilot soared the glider within a few miles of Lasham in readiness for starting the cross-country task. During this time she was heard speaking on the radio and gave no indication that she was encountering any difficulty; if there had a been a problem she could have returned safely to Lasham at any point.

Final descent

The highest altitude 3,920 ft amsl (approximately 3,400 ft above ground level and coincident with the lowest reported cloud) was recorded at 1039:15 hrs, while still close to Lasham. The glider appears to have then descended at an average rate of descent of 350 ft/min for approximately 2.5 minutes before flying almost level at 3,050 ft amsl for some 25 seconds. It is possible the engine was deployed and started during this descent but there is no indication of the glider climbing as would be expected following a successful engine start.

There are a number of stages to the engine starting procedure and the glider's owner said he found it stressful doing this when at low level. It is uncertain whether the pilot had started this engine previously but, given her level of experience and the evidence from the Sailplane & Gliding magazine, it should not have been particularly challenging to achieve this pre-planned task when 3,000 ft above the ground and within easy gliding distance of the airfield.

Based on a wind speed of no more than 10 kt and the available groundspeed data, there is no evidence the glider was flown at or below the stall speed before the FLARM signal was temporarily lost.

In the 35 seconds for which the FLARM signal was lost, the glider was generally flying into wind and the average groundspeed of 57 kt, suggests an airspeed of between 57 and 67 kt, greater than the stall speed. If the engine had not been started earlier in the descent, then it might have been started at this stage, with the glider still more than 2,500 ft above the ground. It is also possible that having deployed the engine, the pilot experienced difficulty starting it because the data does not reflect a gentle climb consistent with powered flight.

During the last 35 seconds of recorded flight the glider descended approximately 2,500 ft and turned left from a heading that was initially south-westerly, maintaining an average groundspeed greater than 50 kt. The groundspeed and the rate of turn increased quickly in the last 8 seconds or so, suggesting the glider entered a spiral dive shortly before it struck the ground at a speed in excess of 100kt. This is close to the maximum speed the manufacturer expects to be achieved, in a dive, with the engine deployed.

An eyewitness, positioned approximately one mile from the accident site, believed the glider made three or four spiral turns in the last few seconds of flight but this could not be substantiated from the available data. The data does indicate that in the last few seconds of flight the glider entered a spiral dive prior to impact.

From the noises heard by several witnesses it is considered likely that the engine was running while the glider was diving for the last few seconds of flight, with the apparent running up and down most likely caused by the automatic over-speed protection temporarily switching off the ignition.

Possible incapacitation

In this accident, investigation showed no evidence of a technical malfunction, the pilot was very experienced and was operating in a benign environment. It appears possible that she lost control of the glider due to incapacitation while starting, or after starting, the sustainer engine. If she had experienced a technical problem, such as a jammed control column, it is likely she would have made a distress call on the radio or attempted to open the canopy in order to parachute free from the glider.

There is evidence the pilot believed she experienced an abnormal heart rhythm about 13 days before the accident and the familial history of such illness adds to this possibility. There is no evidence to indicate the pilot suffered cardiac illness earlier in this flight but it is likely that she was incapacitated in some way during the latter stages of flight and the pathologist could not rule out the possibility that she might have lost consciousness as a result of a cardiac problem.

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-EZWX
No & Type of Engines:	2 CFM56-5B4/3 turbofan engines
Year of Manufacture:	2014 (Serial no: 6192)
Date & Time (UTC):	27 July 2016 at 0729 hrs
Location:	In-flight from Heraklion, Greece, to London Gatwick
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 177
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to trimmable horizontal stabiliser (THS) mini reduction gear
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	17,000 hours (of which 6,000 were on type) Last 90 days - 217 hours Last 28 days - 82 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

During cruise at FL340 an Electronic Centralised Aircraft Monitor (ECAM) message STAB JAM appeared, there was a pitch excursion, the autopilot disengaged and the control law degraded to Alternate Law. The flight crew carried out the ECAM actions and the aircraft continued to its destination without further incident. The failure was probably due to water ingress into the trimmable horizontal stabiliser (THS) command transducer which migrated into the mini reduction gear, froze and damaged the gear.

History of the flight

Whilst the aircraft was in cruise, there was an oscillation in pitch and in normal acceleration during which a fault was detected in the stabiliser system. The flight crew were alerted to the fault when the autopilot disengaged and the Master Caution annunciated with ECAM message STAB JAM. The co-pilot took control of the aircraft while the commander carried out the ECAM actions. The checklist required the flight crew to check that the manual trim was available and to move the stabiliser trim until the elevator was in the neutral position. The commander stated that they moved the stabiliser trim wheel a little but the co-pilot stated that he felt that the aircraft was largely in trim and so they decided not to move the stabiliser significantly after that.

As a result of the fault the control law degraded into ‘Alternate Law’, which provided reduced levels of protection and the use of the autopilot was lost. However, ‘load factor demand law’ was maintained as were load factor protection and low/high speed stability functions. During the time when the flight crew were performing the checklist items, the aircraft started a gradual climb 100 feet from its assigned altitude; however, the flight crew were able to bring the aircraft back to the assigned altitude with minor control stick inputs. The flight crew descended below RVSM[1] airspace and continued the flight to Gatwick with the autopilot disengaged. When the landing gear was lowered during the approach the control law changed to ‘Direct Law’, as designed, and an uneventful landing was carried out.

After arrival, maintenance actions were carried out and the trimmable horizontal stabiliser actuator (THSA) was removed for further examination to determine why the fault occurred.

Recorded information

The flight data recorder (FDR) data showed that from about 1401:50 UTC to 1402:10 the aircraft experienced oscillations in pitch and in normal acceleration before the aircraft returned to steady flight (Figure 1).

The maximum normal acceleration achieved was 1.37 g and the minimum acceleration was 0.65 g over a 4-second period. It was during these oscillations that the elevator aileron computer (ELAC) parameters showed that a handover from ELAC 2 to ELAC 1 had occurred in quick succession at 1402:06. The autopilot disengaged two seconds later.

The oscillation in pitch was caused by an oscillation in the stabiliser position, for which the elevator automatically tried to compensate. The stabiliser then settled in a positon that was about 0.6° more nose-down than before the upset, while the elevator settled at a position about 2° more nose-up.

The ECAM actions called for the flight crew to trim the stabiliser manually until the elevator was indicating zero degrees, the neutral position. The stabiliser moved about 70 seconds after the upset which was probably the manual stabiliser input by the flight crew, although the stabiliser was not moved sufficiently to bring the elevator to zero degrees. The fact that the stabiliser is seen to move in response to the manual input indicates that it was not physically jammed.

Stabiliser system description

The horizontal stabiliser is controlled by the THSA and it can be trimmed either electrically or manually with a trim wheel in the cockpit via the THSA. The electrical trim is, by default, controlled by ELAC 2 and if ELAC 2 detects that the system is not responding to its commands it will hand over control to ELAC 1. If both ELAC 2 and 1 detect that the stabiliser is not following their commands then control of the stabiliser will be handed over to spoiler elevator computer 2 (SEC 2) followed by SEC 1 if the same fault is detected by each respective SEC.

Footnote

1 RVSM airspace is upper level airspace with Reduced Vertical Separation Minima.

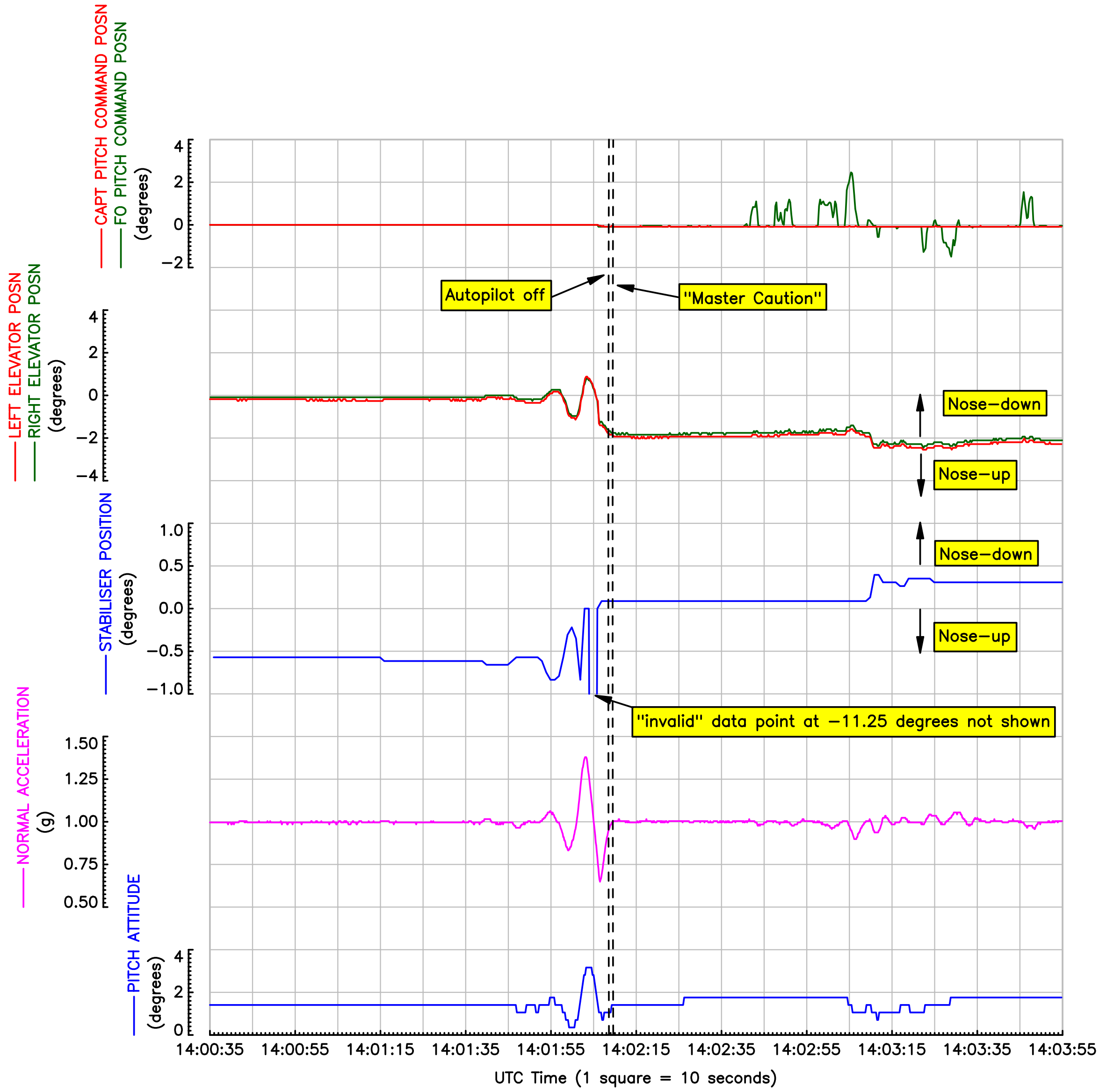

Figure 1

Salient FDR parameters at the time of the stabiliser malfunction

The ELAC sends commands to the THSA via the pitch trim actuator (PTA) which contains three electric motors, which control the two hydraulic motors that drive the stabiliser ball screwjack. An override mechanism downstream of the PTA allows the manual trim wheel in the cockpit to override any inputs from the PTA to the hydraulic motors. The commanded stabiliser position is measured by the COM transducer which contains three RVDTs[2]. A mini reduction gear assembly mechanically transmits the commanded stabiliser position to the COM transducer. A separate MON transducer measures the position of the stabilizer ball screwjack. The ELACs monitor both the COM and MON transducers and if there is a discrepancy the 'STAB JAM' message will be annunciated and stabiliser movement will cease.

Footnote

2 An RVDT is a Rotary Variable Differential Transformer which is used to measure a rotating position.

THSA component examination

The THSA was sent to the component manufacturer for examination. They discovered that the mini reduction gear assembly was not driving the COM transducer, so the COM transducer could not sense the commanded stabiliser position. About 2 ml of water was found inside the mini reduction gear liner/cavity, which was an unusual finding (Figure 2).

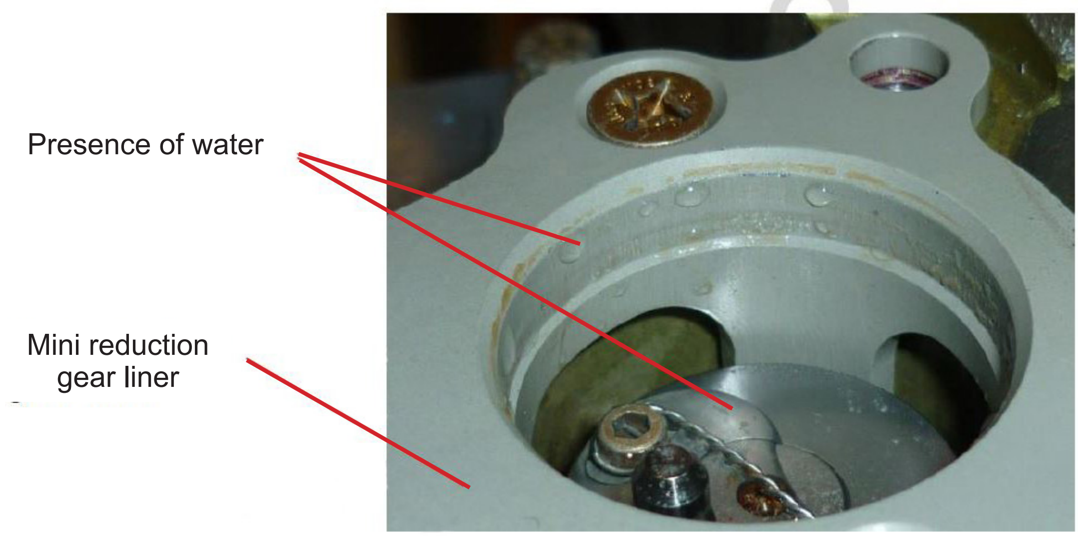

Figure 2
Water inside mini reduction gear liner/cavity

The output shaft of the mini reduction gear was found to be jammed and disassembly of the unit revealed damage to the gears.

The COM transducer was opened which also revealed the unexpected presence of water (Figure 3). Corrosion was also found within the transducer housing. The seals and sealant used to seal the component were in satisfactory condition. However, a leak check of the seal was not conducted before the transducer was opened as the manufacturer was not expecting water to be present. According to the manufacturer this was the first instance of water ingression into this component.

Operator comments

When the operator received confirmation from the THSA manufacturer that water ingress was the probable cause, the operator performed a detailed inspection of the area in which the THSA was installed on the incident aircraft. No signs of water, moisture or signs of previous wetting were identified in or around the area in which the THSA was fitted.

As a precaution, the COM transducer was removed from a similar age aircraft in the fleet and sent to the component manufacturer for analysis. The analysis included a pressure leak check of the case, electrical tests and visual inspections. None of these tests identified any issues with the sample unit and no signs of water were identified within the unit during inspection.

Figure 3

Water inside THSA COM transducer, cover (left) and internal RVDTs (right)

Analysis

Although the FDR data indicated that the elevator had not been trimmed to the neutral position, the flight crew were conscious of the need to keep the aircraft in trim. The commander checked the flight control page and the co-pilot confirmed that the aircraft was in trim. The flight crew did not encounter any difficulties controlling the aircraft.

According to the THSA manufacturer and the aircraft manufacturer the failure of the THSA was most probably due to water ingress into the THS COM transducer which then migrated into the mini reduction gear. The water in the mini reduction gear probably froze during flight and movement of the THSA caused torque on the gear to damage the mini reduction gear. The stabiliser would have moved as commanded and been sensed by the MON transducer but there would have been no movement sensed by the COM transducer; this discrepancy was detected and the system logic then prevented any further electrical commands to the THSA.

Although the source of the water and how it entered the transducer could not be determined, the aircraft manufacturer stated that the worst case scenario from water in this component is the one experienced by G-EZWX. Due to the system monitoring no increased attitude deviations would be expected, and the aircraft would remain fully controllable in 'Alternate Law' with manual stabiliser trim remaining available.

SERIOUS INCIDENT

Aircraft Type and Registration:	DHC-8-402 Dash 8, G-ECOF
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines
Year of Manufacture:	2008 (Serial no: 4216)
Date & Time (UTC):	30 October 2016 at 1340 hrs
Location:	Belfast City Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 77
Injuries:	Crew - None Passengers - None
Nature of Damage:	Heat damage to tail cone
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	6,370 hours (of which 6,190 were on type) Last 90 days - 211 hours Last 28 days - 68 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB inquiries

Synopsis

During preparations for takeoff the flight crew were made aware that smoke could be seen emanating from the rear of the aircraft around the APU. The commander initiated a precautionary disembarkation and the APU, which had been running, shut itself down. It was apparent that the tail cone of the aircraft had become very hot, resulting in discolouration of the external surfaces. It was subsequently found that the APU exhaust duct liner had partially disintegrated, resulting in hot exhaust gases being directed outside the liner. Two days prior to this event, a piece of the liner had been ejected from the APU exhaust whilst the aircraft was on stand at Birmingham. However it was incorrectly identified as originating from an airport vehicle and the aircraft was allowed to continue in service.

History of the flight

The aircraft was boarded, the passenger doors were closed and the crew was preparing for departure. The APU was running, with the intention of using it for engine start during pushback. One of the ground handlers informed the crew that smoke was emanating from the rear of the aircraft around the APU. The absence of flight deck indications of an APU fault and the calm demeanour of the ground handler led to the commander not being overly concerned at this stage. He asked the No 1 cabin attendant to open the forward door, with the intention of investigating the problem himself. Meanwhile the co-pilot contacted ATC and asked if they could see anything unusual. After a short delay a reply was received stating that smoke could be seen around the rear of the aircraft. At this point the commander decided to initiate a precautionary disembarkation and briefed the cabin crew over the intercom. Only the forward main passenger door was used as the rear airstairs were unserviceable. He also asked the co-pilot to put out a PAN call to ATC, informing them of the situation. At around this time the APU shut down, generating a FAIL caption. At no time were any fire or smoke warnings received on the flight deck, nor were any fumes or smoke observed inside the aircraft, although a burning odour became apparent as the incident progressed.

All the passengers had disembarked by the time the airfield fire service had reached the aircraft and, after consultation with the fire chief, the crew pulled the FDR and CVR circuit breakers, shut down the electrical systems and vacated the aircraft.

The fire crew used thermal imaging equipment to determine that the temperature in the APU area was around 158°C, which reduced to 40°C at the rear pressure bulkhead. The heat had resulted in discolouration of the external surfaces of the tail cone.

Earlier incident

Two days before the APU incident, on 28 October 2016, the same aircraft, with a different crew, was on stand at Birmingham and had received pushback clearance with the APU running. The pushback tug driver then noticed a piece of debris lying approximately 10 m behind the aircraft; it was hot when he picked it up. The commander examined the object and conducted a walk-round inspection of the aircraft. There was no obvious aircraft damage and the object bore no markings, such as a part or serial number. He discussed the matter with the co-pilot, who confirmed that nothing abnormal was observed during his walk-round some 30 minutes earlier. Photographs were taken of the debris item (Figure 1), which was then disposed of in a FOD (foreign object damage) bin. The engines were started on stand and were noted to operate normally. In the absence of any evidence to indicate that the object was associated with the aircraft the pilots assumed that it had come from a passing truck on the roadway behind the aircraft.

The aircraft had been parked at the stand for approximately 50 minutes, during which time a ground power unit had been used until the doors were closed. The object was found after the walk-round had been conducted; the APU had been running for about five minutes.

Following the incident two days later, attempts were made to locate the debris item, but without success.

Figure 1
Debris item photographed by crew after discovery

Aircraft examination

The APU is located within a bay in the tail cone on this aircraft type. An exhaust duct, fabricated from titanium, is installed within the aft section of the tail cone. Within this is a duct liner made from a fibre-metal acoustic material; it is elliptical in section, supported on frames within the duct and bolted to it at its forward end (Figure 2).

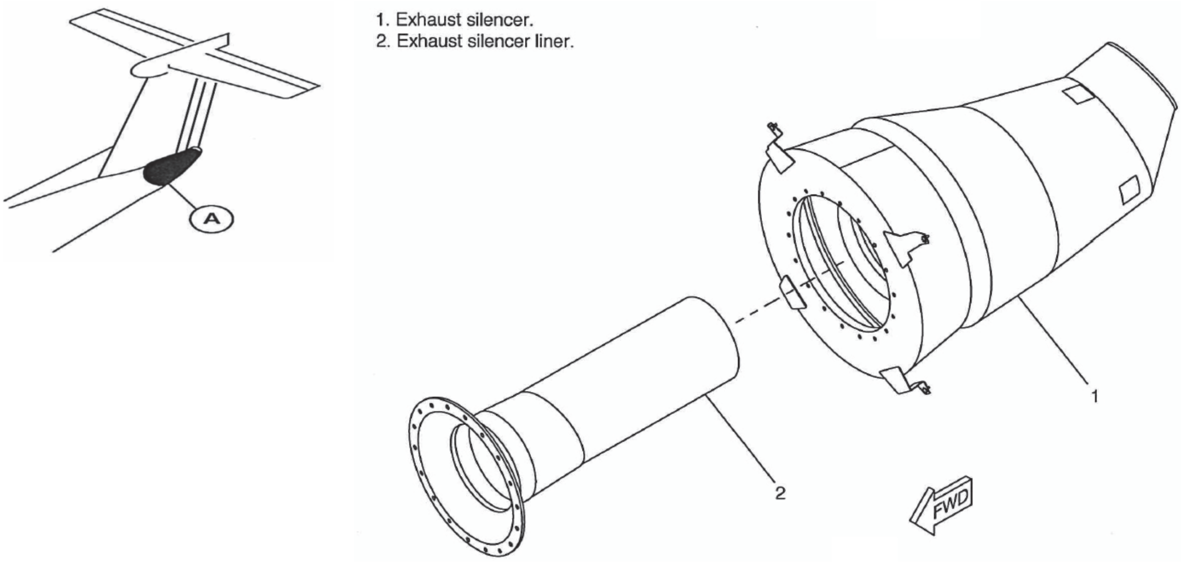

Figure 2
APU exhaust duct and liner

It was apparent that the front half of the liner had partially disintegrated and that the item discovered on the ground at Birmingham was a circumferential section from the front end, having separated both at the junction with the bolted ring and several inches aft. The portion of the liner that remained within the duct was removed, possibly causing some additional distortion (Figure 3).

Figure 3

Recovered part of the exhaust duct liner

The operator commented that they had observed instances of the liner cracking close to the first frame (furthest forward).

Although the ejected piece of liner was not available for examination, Figure 1 shows what appears to be fretting or abrasion damage on the outer surface.

The internal surfaces of the tail cone were discoloured as a result of high temperatures causing the paint to blister, and electrical cables in the area had sustained visible heat damage. A subsequent download of the APU data memory module by the operator confirmed that the APU had shut down as a result of an open circuit condition and that this was probably associated with the cable damage.

Other information

An examination of the recent maintenance history revealed that the APU had been changed by a contracted company on 13 October, approximately two weeks prior to the incident. This followed a FAIL caption followed by an auto shut-down. Removal and installation of the APU does not in itself involve disturbing the exhaust duct liner, although the Aircraft Maintenance Manual calls for an 'Opportunity Inspection' of it, using Maintenance Task 49-80-04-210-801. The company stated they had a contract with G-ECOF's operator to deliver 250 man hours per 24 hour period spread over three aircraft. Their hangar is modern and well lit, and they were familiar with conducting APU changes on Q400 aircraft. A general visual inspection was duly carried out and the appropriate worksheet signed off. There is no scheduled inspection of this component. The subject duct liner had been installed in the aircraft at initial build.

On 18 October the APU failed to start and this was logged as a deferred defect until it was cleared on 26 October after replacing a thermocouple. This was only two days prior to the piece of exhaust duct liner being ejected whilst on the stand at Birmingham.

The aircraft manufacturer disclosed that, in addition to the subject event, they were aware of 17 reported events of duct liner cracks since September 2003. Most of the failures were cracks or separation along the weld lines and occurred on aircraft that had achieved between 2,355 and 25,063 flight hours. G-ECOF had achieved 16,703 flight hours. Two of these incidents involved pieces that were missing from the liner and a third suffered a 'collapsed' liner, causing exhaust gas to enter the tail come in a similar manner to the subject event. Smoke, but no fire, was also reported and there was heat damage to electrical wiring and paint blistering on the tail cone structure. Many of the incidents were associated with the APU either failing to start or shutting down unexpectedly.

It should be noted that the APU on this aircraft type is certificated for ground use only and, in the event it is not shut down by the crew prior to takeoff, it is turned off by a weight-off-wheels signal.

Discussion

It was concluded that the disintegration of the APU exhaust duct liner allowed hot exhaust gases into the exhaust duct volume outside the liner and into the tail cone itself.

The duct liner is located within a jet efflux and as such is exposed to a severe thermal and acoustic environment. Whilst no calendar or flight hours limit, or regular inspection period, is specified, it is reasonable to expect the liner to deteriorate in service. However, the 17 prior events logged by the aircraft manufacturer covered a wide range of time in service. The duct's location in the airframe means it is difficult to inspect effectively unless the APU is removed. Such removals, and consequent 'opportunity' inspections, seem to occur at relatively frequent, although necessarily irregular, intervals. Indeed, the subject duct had been inspected only two weeks prior to ejecting a substantial piece of the liner; it was also found that the APU itself had been unserviceable for eight days out of the two weeks. It is therefore likely that some aspect of the failure was present at the time of the last inspection, despite the good working environment of the hangar in which the APU change had been carried out.

The nature of the failure was not determined, although chances of obtaining more information may have been improved had the ejected piece of the duct liner been correctly identified and retained. There were some marks visible in photographs taken of this item, although it could not be concluded if they were the result of in-service fretting or abrasion during installation.

No flames were observed during the incident although the temperature clearly was sufficiently high to cause blistering and charring of the paint, thus generating smoke. The electrical harnesses in the area were also damaged, leading to the APU shutting down, thus removing the heat source. Had this not occurred, it is possible that an actual fire may have developed, although this might have been accompanied by flight deck warnings or indications from the ground handlers, which should have prompted the flight deck crew to shut down the APU. It was found however that none of the previously reported incidents had resulted in a fire. In addition, it is considered that there is little likelihood of a duct liner failure resulting in an airborne fire as the APU is not capable of being used in the air.

ACCIDENT

Aircraft Type and Registration:	Socata TBM 700N[1], M-VNTR
No & Type of Engines:	1 Pratt & Whitney Canada PT6A-66D
Year of Manufacture:	2015 (Serial no: 1097)
Date & Time (UTC):	15 October 2016 at 0732 hrs
Location:	Fairoaks Airport, Surrey
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Major) Passengers - 1 (Minor)
Nature of Damage:	Extensive
Commander's Licence:	Private Pilot's Licence
Commander's Age:	79 years
Commander's Flying Experience:	5,272 hours (of which 1,585 were on type) Last 90 days - 18 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, telephone interviews with the pilot and passenger, Air Traffic Control reports, witness interviews, accident site photographs and aircraft examination

Synopsis

The pilot lost control of the aircraft during a turn onto the final approach at Fairoaks Airport. The final turn had been commenced from a relatively close downwind leg, requiring a higher angle of bank than usual to complete. In the latter stages of the turn, with flaps at the takeoff setting, the bank angle was increased and there was a sudden and rapid departure from controlled flight that was consistent with a stall. The occupants were able to recover to an approximately level aircraft attitude but were unable to arrest the descent rate which ensued. The aircraft struck the ground and slid for a distance, sustaining extensive damage and causing injuries to both occupants.

History of the flight

The accident occurred as the aircraft was preparing to land at Fairoaks Airport at the end of a private flight from Ronaldsway Airport on the Isle of Man. On board were the aircraft commander and a passenger who occupied the front right seat.

As the aircraft neared Fairoaks, the pilot listened to the Farnborough ATIS broadcast, which reported a visibility of 4,000 m in mist. He and the passenger discussed the visibility,

Footnote

[1] Marketed as the TBM 900.

and agreed that they would proceed to Fairoaks while retaining the option to divert to Farnborough Airport (9 nm to the south-west) if a landing was not possible.

The visibility at Fairoaks was recorded as 4,500 m, with 'few' clouds at 4,000 ft and a surface wind of 3 kt from 240°. Runway 24 was in use with a left-hand circuit. The circuit height, based on the Fairoaks QNH was 1,100 ft (the elevation of Fairoaks Airport is 80 ft amsl). Runway 24 is a hard runway, 813 m long and 27 m wide.

The pilot identified the airfield visually, although there was low lying mist in the area. In order to maintain visual contact with the landing area he joined the circuit and flew a downwind leg that was closer to the runway than usual. He recalled carrying out the pre-landing checks while downwind, including lowering the landing gear and extending the flaps to the TAKEOFF position[2]. Based on a final approach with flaps at the LANDING setting, the pilot planned for an initial approach speed of 90 kt, reducing to a final approach speed of 80 kt.

The pilot recalled the aircraft being slightly low as it turned from the downwind leg onto its final approach track. He believed he had selected flaps to the LANDING position, and recalled seeing the airspeed just below 90 kt, which prompted him to increase power slightly. The aircraft flew through the extended runway centreline and the pilot increased the bank angle to regain it.

The pilot's next recollection was of being in a right bank and seeing only sky ahead. He pushed forward on the control column and attempted to correct the bank with aileron. The aircraft then rolled quickly in the opposite direction and he again applied a correction. He became aware of being in an approximately wings-level attitude and seeing the ground approaching rapidly. He responded by pulling back hard on the control column, but was unable to prevent the aircraft striking the ground. He did not recall hearing a stall warning, or any other audio warning, before the loss of control occurred.

The aircraft struck flat ground and slid for about 85 m before coming to rest against a treeline, about 500 m from Runway 24 and approximately on the extended centreline. The propeller was destroyed in the accident sequence and the landing gear legs detached, causing damage to the wings which included a ruptured fuel tank. In the latter stages of the slide the aircraft yawed right, coming to rest heading approximately in the direction from which it had come.

The pilot and passenger remained conscious but had both suffered injury. The passenger saw flames from the region of the engine and warned the pilot that they needed to evacuate. He went to the rear of the cabin, opened the main door and left the aircraft. The pilot initially attempted to open his side door, but his right arm was injured and he was unable to open the door with only his left. He therefore followed the passenger out of the rear door.

Rescue activities

The accident was witnessed from the control tower by the Fairoaks FISO and also by some of the airport fire and rescue crew. The standby response vehicle was quickly deployed to

Footnote

2 The flaps were selectable to three positions: UP, TAKEOFF and LANDING.

the accident site, which was beyond the airfield boundary. The two occupants were guided to safety and given first aid. There was no fire (the flames seen by the passenger were believed to have come from the engine exhaust and did not persist or spread), but a foam blanket was laid as a precaution. The civil emergency services arrived soon afterwards and the two occupants were taken to hospital.

Passenger's account

The passenger was a current commercial pilot, experienced on light general aviation types, and had flown other TBM variants. He confirmed the pilot's account that the downwind leg was flown closer to the runway than usual and thought the aircraft would not be able to turn tightly enough to avoid flying through the extended runway centreline.

The pilot maintained a steep angle of bank while turning, but the aircraft flew through the centreline as the passenger had expected. He recalled hearing an audio warning tone, but did not know if it was a stall warning. He checked the airspeed, which was between 80 kt and 90 kt, and the landing gear indications, which were correct. He was about to draw the pilot's attention to the audio warning when the bank angle increased significantly.

The passenger took the controls and applied full right aileron while pushing the power lever fully forward. He also pushed the control column forward, believing that the aircraft had stalled. He was aware that the pilot was also making control inputs at this time, and he thought it possible that opposing inputs may have been made.

Witness information

Witnesses to the accident included three members of staff on duty at the airport. All three, who were used to observing normal aircraft operations, described the aircraft as being lower and much closer to the runway than usual. The aircraft's significantly different appearance prompted one of the witnesses to draw his colleague's attention to it before the accident occurred. The aircraft was described as turning with a high angle of bank when it rapidly rolled further left. It then rolled and yawed to the right. The nose dropped and the aircraft descended rapidly, although it was evident to one of the witnesses that the aircraft's attitude levelled in the final stages.

Aircraft flap system examination

It was reported that the aircraft's flap control lever was found set to the 'UP' position, which was supported by photographic evidence from the accident site. The pilot thought he had selected landing flap while turning finals. The passenger, who could not recall the flap selection, thought it possible he had knocked the lever forward to the 'UP' position while getting out of his seat.

There was considerable disruption of the wing trailing edges and flap assemblies, although visual inspection suggested that the flaps had been at a setting between 'UP' and 'LANDING'. A technical examination revealed that the flaps had been set at the 'TAKEOFF' position at the time of the accident.

Recorded information

The aircraft was fitted with an avionics suite capable of recording flight parameters on a miniaturised memory card, fitted in the front of the multi-function flight display and accessible in the cockpit. The memory card was not present in the aircraft as inspected after the accident. The aircraft was not fitted with a flight data recorder, nor was one required. Recorded radar data was available from radar heads at Heathrow, Pease Pottage and Bovingdon. The following information is based on the Heathrow data, which is shown in pictorial form at Figure 1.

Initially the aircraft tracked directly towards the airfield until, at a range of about 4,000 m, it deviated to the right to join a downwind leg for Runway 24. The aircraft descended as it did so, and passed abeam the Runway 24 threshold at a height of 400 to 500 ft agl. The height then remained constant until approaching the point of the accident.

The aircraft was 650 m displaced from the runway threshold as it passed abeam it. It maintained approximately straight flight for a further 15 seconds before starting a left turn. There were a further 5 radar returns, at 4 second intervals. The first two returns showed a turn rate of approximately 5º/second for the first part of the turn, which doubled to about 10º/second in the second part of the turn and immediately before the accident.

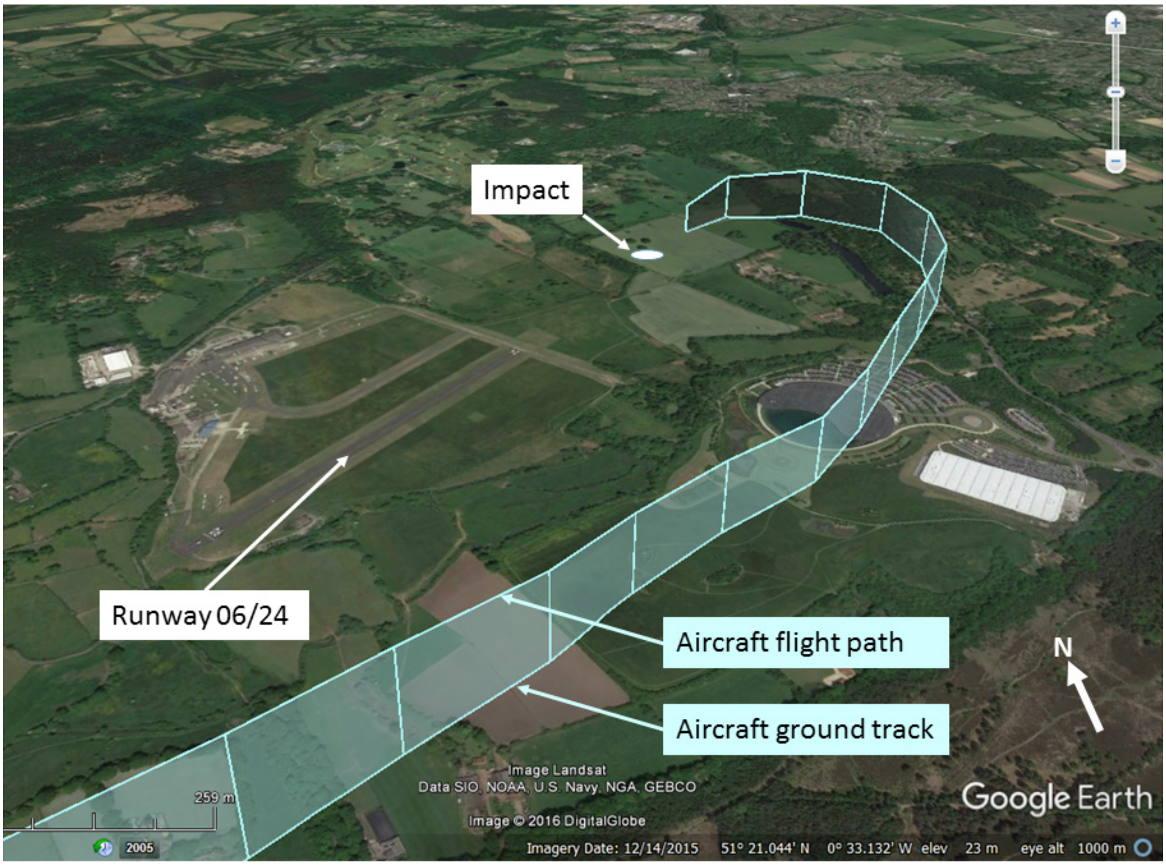

Figure 1
Aircraft flight path (Heathrow radar data)

Aircraft performance information

Information supplied by the pilot indicated that the aircraft mass was 2,706 kg at the time of the accident; the maximum landing mass was 3,186 kg.

The Pilot's Operating Handbook for the aircraft type listed stall speeds for various configurations, masses and angles of bank. By interpolation, stall speeds for an aircraft mass of 2,706 kg were calculated and are given in Table 1. The figures are applicable to flight with the landing gear down, flaps at the TAKEOFF and LANDING positions, and power at flight idle.

Aircraft Mass (kg) 2,706 kg	Angle of Bank			
	0°	30°	45°	60°
	Stall speed (KIAS)			
TAKEOFF flap	68	73	81	96
LANDING flap	59	63	70	83

Table 1

Aircraft stall speed: Gear down, flight idle

A continuous turn at 90 kt from a downwind heading onto the final approach track would have required a continuous bank angle of 35°. The aircraft's actual bank angle during the first and second parts of the finals turn were calculated from heading changes and apparent radius of turn, both derived from the radar data. The average angle of bank early in the turn was between 18-20°, which increased to about 40° as the turn progressed.

Analysis

There were no indications that the aircraft had been subject to any defects or malfunctions that may have contributed to the accident. Reports from the two occupants, eye witness accounts and radar data all confirm that the aircraft commenced its final turn from a position closer to the runway than usual. This would have required a sustained moderate angle of bank through about 180° of turn.

The radar data indicates that the turn onto the final approach was initially flown with less angle of bank than required. The pilot therefore either lost visual contact with the runway or did not fully appreciate the turn requirements. An explanation for the latter might be that the low height on the downwind leg combined with the relatively poor visibility to produce a runway visual aspect that gave a false impression that the aircraft spacing was not abnormal.

As the finals turn progressed, there was a need to increase the angle of bank to a relatively high value. With the flaps remaining at the TAKEOFF setting, and maintaining level flight, this placed the aircraft close to its stalling speed. Any increase in angle of bank or 'g' loading (as may have occurred when it became evident that the aircraft would fly through the extended centreline) risked a stall.

The available evidence indicates that the aircraft stalled during the turn onto the final approach. Recovery actions taken by the occupants appear to have been partially successful, but there was evidently insufficient height in which to effect a full recovery.

ACCIDENT

Aircraft Type and Registration:	Aero AT-3 R100, G-SACY
No & Type of Engines:	1 Rotax 912-S2 piston engine
Year of Manufacture:	2007 (Serial no: AT3-029)
Date & Time (UTC):	4 September 2016 at 1108 hrs
Location:	Near Sherburn-in-Elmet Airfield, Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	102 hours (of which 5 were on type) Last 90 days - 6 hours Last 28 days - 2 hours

Shortly after takeoff on a circuit detail, the pilot noticed that the front-hinged canopy had started to open on the right side. He attempted to reseat it while continuing the circuit, with the intention of landing. At 1,000 ft, the canopy lifted by 10 to 12 inches and the pilot was concerned that it would open further, affecting the aircraft handling. There was also a "great increase in wind and noise within the cabin" and the aircraft began to descend. He, therefore, held the canopy and decided to land immediately in a bare-earth field ahead. During the landing roll the aircraft overturned, resulting in it being damaged beyond economic repair and causing minor injuries to the pilot.

A similar accident occurred in June 2012 to another Aero AT-3 R100, registration G-SRUM, and was reported in AAIB Bulletin 10/2012. That report concluded:

> *'…the Civil Aviation Authority and the Light Aircraft Association will be publishing articles in their public journals and urging care in both the operation and maintenance of the locking mechanism. These articles will include informing them of the need for a thorough understanding of the locking mechanisms and a double-check that the locks are secure before flight.'*

ACCIDENT

Aircraft Type and Registration:	Auster 5 Alpha, G-APAF
No & Type of Engines:	1 Lycoming O-290-3 piston engine
Year of Manufacture:	1957 (Serial no: 3404)
Date & Time (UTC):	30 September 2016 at 1335 hrs
Location:	500 m north-east of Netheravon Airfield, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Left landing gear damaged
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	83 years
Commander's Flying Experience:	1,410 hours (of which 869 were on type) Last 90 days - 3 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

At approximately 300 ft agl, during the final approach to land with carburettor heat ON, the aircraft's engine began to lose power and failed to respond to control inputs. The pilot carried out a forced landing during which the aircraft's left landing gear was damaged. The pilot attributed the loss of engine power to carburettor icing as a result of a malfunction of the carburettor heat system.

ACCIDENT

Aircraft Type and Registration:	Eurofox 912(LS), G-ODGC
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2014 (Serial no: LAA 376-15274)
Date & Time (UTC):	15 October 2016 at 1100 hrs
Location:	Eyres Field, Wareham, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Right main landing gear failure
Commander's Licence:	Light Aircraft Pilot Licence
Commander's Age:	62 years
Commander's Flying Experience:	694 hours (of which 557 were on type) Last 90 days - 7 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst carrying out glider-towing flights the forward attachment bolt of the right landing gear failed, which allowed the landing gear to hang from the aircraft. The mounting bolt had failed due to the presence of a fatigue crack. The manufacturer has since introduced a mandatory life to the landing gear mounting bolts.

History of the flight

The aircraft was carrying out glider towing on a grass field. Shortly after takeoff, on the aircraft's fifth flight of the day, the glider released the towing cable. The pilot continued to climb into the airfield circuit with the intention of landing. He was then informed by airfield personnel that the right landing gear leg was hanging below the fuselage. After discussion with the CFI over the radio the pilot flew the aircraft for approximately one hour to reduce the fuel load and to carry out a number of practice approaches. During the final approach to land the pilot shut the engine down at 100 ft agl and switched off the fuel supply and electrics. The aircraft touched down on the left mainwheel and the pilot held the right wing up until aileron effectiveness was lost as the aircraft slowed. When the right wing touched the ground the aircraft rotated though approximately 100° before coming to rest. The pilot was uninjured.

Investigation

Examination of the aircraft identified that the forward bolt holding the right landing gear leg to the fuselage had failed. The remains of the bolt were removed from the aircraft and images of the fracture surfaces were sent to the LAA for examination. The images showed that the bolt had failed due to crack progression in fatigue. The presence of corrosion across a significant portion of the fracture surface indicated that the crack had been present for some time.

Safety action taken

As a result of the incident and discussions with the LAA, on 1 November 2016 the aircraft manufacturer issued Mandatory Service Bulletin, EuroFOX SB 03/2016 LAA (v2). This required the replacement of the landing gear mounting bolts within 20 flying hours of the release date of the Bulletin and introduced a 500 flying-hour mandatory life on the bolts. On 4 November 2016 the LAA published Airworthiness Alert LAA/AWA/16/07 which detailed the failure and alerted operators of the aircraft to the requirements of the Mandatory Service Bulletin. The incident was also publicised in the LAA's November 2016 Safety Sense article.

ACCIDENT

Aircraft Type and Registration:	Isaacs Fury II, G-BEER
No & Type of Engines:	1 Lycoming O-235-C1 piston engine
Year of Manufacture:	1979 (Serial no: PFA 1588)
Date & Time (UTC):	14 December 2016 at 1230 hrs
Location:	4 nm north of Billericay, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Leading edge of top left wing, fabric damage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	5,245 hours (of which 38 were on type) Last 90 days - 179 hours Last 28 days - 47 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was performing what he considered as "light aerobatics" in an area to the north of Billericay in fine weather conditions. At the bottom of a "normal loop" he reported encountering wake turbulence, after which the aircraft rolled left. The pilot recovered the aircraft to a wings-level attitude, but noted that some fabric had separated from the forward area of the top left wing.

After performing a control check in the approach configuration, the pilot considered the aircraft controllable enough to perform a normal landing, despite a "marked rolling tendency". The aircraft landed successfully and was subsequently inspected by the LAA who discovered a failure of the affected wing's leading edge structure. They considered the most likely cause was the result of previous damage to the leading edge which may have been small enough to be unnoticed during pre-flight walkaround checks. This damage had then progressed during the higher energy aerobatic manoeuvring. The source of this previous damage could not be established.

The LAA reported this event in further detail in their February 2017 edition of Safety Spot magazine which is available on their website. They highlighted that the area in question could not be inspected without a step ladder and that thorough pre-flight inspections of all aircraft surfaces is extremely important.

ACCIDENT

Aircraft Type and Registration:	Jodel DR1050 Ambassadeur, G-BKDX
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1960 (Serial no: 55)
Date & Time (UTC):	13 November 2016 at 1300 hrs
Location:	Netherthorpe Airfield, Nottinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Landing gear, propeller and trailing edge of right wing damaged
Commander's Licence:	Light Aircraft Pilot's Licence
Commander's Age:	82 years
Commander's Flying Experience:	8,502 hours (of which 230 were on type) Last 90 days - 5 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

After a normal landing on grass Runway 24, the aircraft veered left and departed the runway surface. The left main landing gear entered an area of soft ground and the aircraft ground-looped to the left through 180°. During the ground loop, the landing gear collapsed.

The surface wind at Netherthorpe was not reported but Doncaster Sheffield Airport, 12 nm to the north-east, reported the surface wind at the time as being from 220° at 5 kt. The pilot considered that a possible gust of wind, with a slight tailwind component, may have been a factor in the accident.

ACCIDENT

Aircraft Type and Registration:	Piper PA-32R-301T, N551TT	
No & Type of Engines:	1 Lycoming TIO-540 piston engine	
Year of Manufacture:	1997 (Serial no: 3257026)	
Date & Time (UTC):	16 November 2016 at 1815 hrs	
Location:	Blackbushe Airport, Surrey	
Type of Flight:	Training	
Persons on Board:	Crew - 2	Passengers - 0
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Propeller damaged, engine shock-loaded	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	54 years	
Commander's Flying Experience:	367 hours (of which 112 were on type) Last 90 days - 24 hours Last 28 days - 15 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

A training flight, with an instructor, was being undertaken from Blackbushe Airport as part of a night rating qualification. It was dark and raining but the visibility was good and the surface wind was calm.

After a short local navigation exercise, the pilot re-joined the circuit and flew an approach to Runway 25. The runway has a tarmac surface, with a PAPI set at 3.1º for a displaced threshold and a landing distance available (LDA) of 1,059 m.

The pilot carried out a normal touchdown and, while rolling along the runway for a touch-and-go, asked the instructor to raise the flaps. The instructor was surprised by the request but carried out the action. As he did so, the pilot raised the landing gear and the gear unsafe warning sounded. The pilot, sensing the aircraft pitching up, lowered the nose and the propeller struck the ground. The instructor took control, lifted the aircraft into the air, re-selected the landing gear down and, having allowed time for it to lock down, landed on the remaining runway. The engine was shut down immediately and ATC was advised.

The instructor commented that he had not wanted to risk going around with a damaged propeller.

ACCIDENT

Aircraft Type and Registration:	Flight Design CTSW, G-CGVG	
No & Type of Engines:	1 Rotax 912ULS piston engine	
Year of Manufacture:	2011 (Serial no: 8575)	
Date & Time (UTC):	8 October 2016 at 1638 hrs	
Location:	Hunsdon Airfield, Hertfordshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to left wingtip, left landing gear leg and surrounding structure	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	62 years	
Commander's Flying Experience:	1,534 hours (of which 867 were on type) Last 90 days - 38 hours Last 28 days - 19 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

Whilst taxiing across a grass parking area, the aircraft's left main landing gear leg collapsed due to a fatigue crack originating at the main attachment bolt hole. It was unclear for how long the leg had been cracked and, as the aircraft was built in 2011, it was not subject to a dye penetrant crack inspection at 300 flying hours as per Service Bulletin CT123. The UK agent intends to issue a new Service Bulletin, CT145, requiring all CT2K and CTSW main landing gear legs to be removed from the aircraft and dye penetrant crack inspected at periods of 300 flying hours, or following heavy landings.

History of the flight

After a normal landing on grass Runway 03 at Hunsdon Airfield, the pilot was taxiing the aircraft across a grass parking area when the left main landing gear leg collapsed. The aircraft settled onto its left wingtip, causing damage to the left wingtip and left fuselage adjacent to the main landing gear leg. The pilot shut the engine down normally and he and his passenger, who were both uninjured, vacated the aircraft without further incident.

Aircraft information

The CTSW is a two-seat microlight with a fixed tricycle landing gear. The main landing gear legs are tapered 7075-T6 aluminium alloy beams, supported at their upper ends by a bolted joint in a welded tubular steel socket, and restrained approximately a third along their length by an M8 steel main attachment bolt. The main attachment bolt passes through a fuselage frame, a hole drilled through the leg and a glassfibre rear reinforcement plate, which covers the leg in this area (Figure 1).

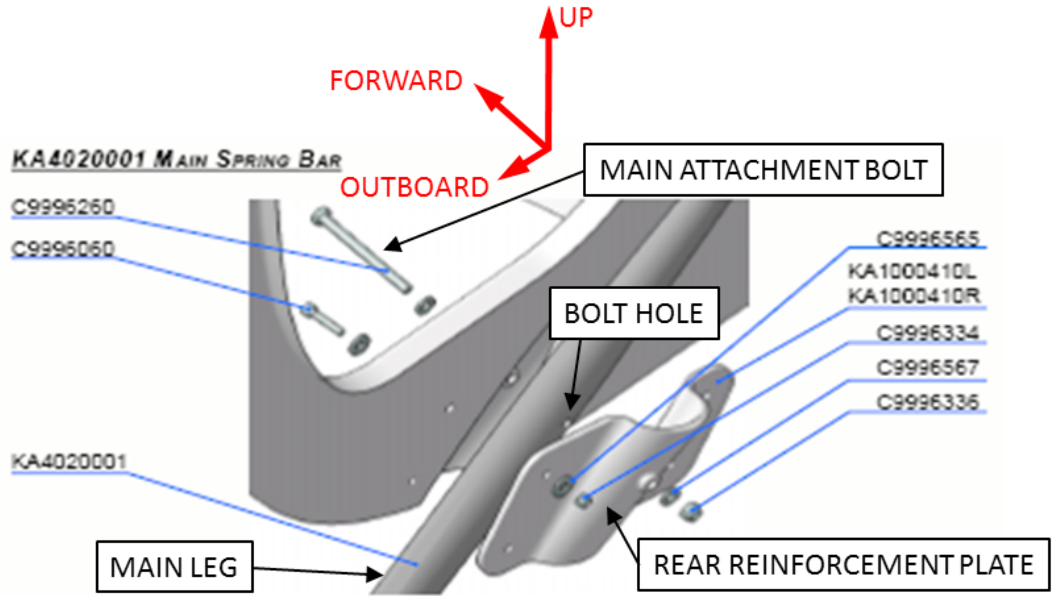

Figure 1

CTSW left main landing gear leg and support structure

Aircraft examination

The landing gear leg had failed due to a fatigue crack propagating from the aft lower edge of the main attachment bolt hole (Figure 2). The crack had propagated through approximately 60% of the thickness of the lower section of the leg, before the leg subsequently failed in ductile overload.

The left fuselage was locally damaged in the area where the leg passes through the fuselage skin, due to excessive upward rotation of the leg during the landing gear collapse. The left rear reinforcement plate was delaminated. The left wingtip was damaged due to ground contact.

Other information

Previous event

Following a similar failure on a CT2K[1] main landing gear leg in July 2006, the UK agent issued Service Bulletin (SB) CT123 in February 2007, requiring removal of both main landing gear legs for dye penetrant crack inspection at the top of the legs and at the main attachment bolt hole positions. This one-time inspection is applicable to all CT2K and CTSW aircraft, registered before 22 February 2007, at 300 flying hours. It is also applicable to all CT2K and CTSW aircraft that have experienced a heavy landing.

Footnote

[1] The CT2K is an earlier model of the CTSW, and is similar in most respects apart from having a longer wingspan. The landing gear design is identical on both aircraft.

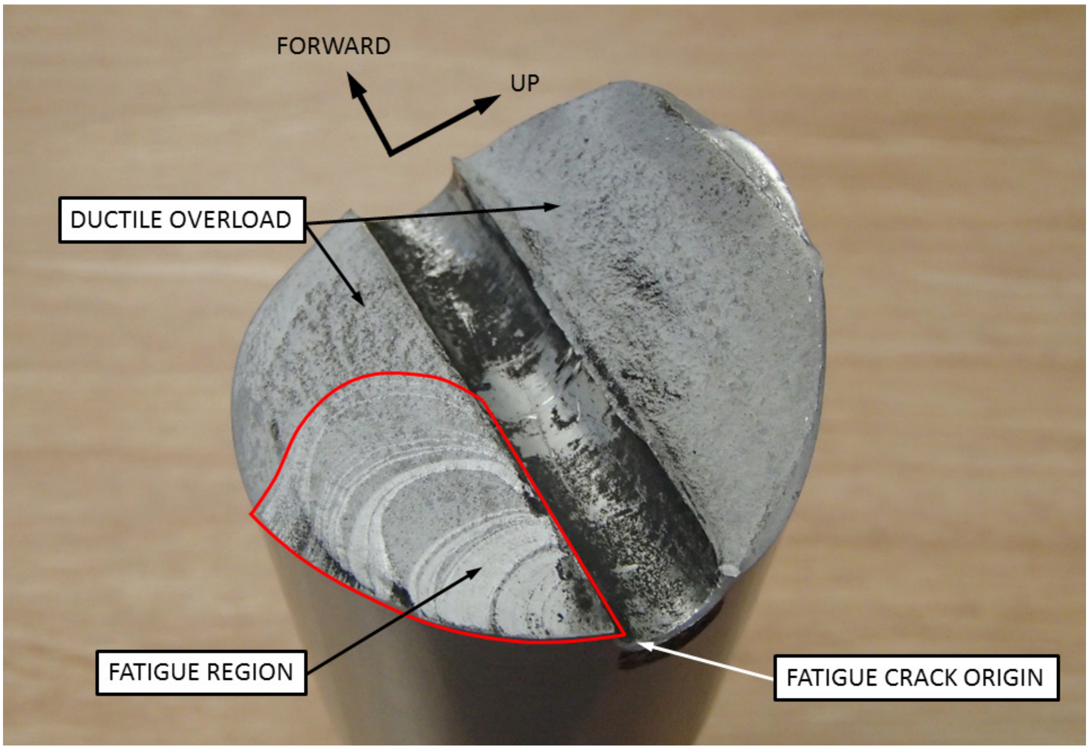

Figure 2

Fracture surface of upper part of the left main landing gear leg

As G-CGVG was manufactured in 2011, and no heavy landings had been reported in its 478 flight hours accumulated since new, it was not subject to the dye penetrant inspection specified in SB CT123.

Maintenance Instructions

Scheduled maintenance instructions are contained within the CTSW Operator's Manual[2] and require that the main landing gear legs are dye penetrant crack tested, whilst installed in the aircraft, every 300 flying hours:

> *Every 300 hours or after any heavy landing, the main undercarriage leg bolt rear plate must be removed and the leg dye penetrant tested for cracks/ distortion at the mounting holes. If removed, legs must be replaced in the same orientation that they were removed in.*

It was not possible to ascertain whether this inspection had been performed on G-CGVG as the aircraft's logbook, covering the period the inspection was due, had been lost in a burglary. Since the main landing gear inspection as defined in the CTSW Operator's Manual does not require removal of the landing gear legs from the aircraft, it would not detect a crack on the forward edge of the main attachment bolt hole as this area is not accessible without removal of the main landing gear legs.

Footnote

2 Currently at Issue 1.2.

Analysis

The left main landing gear leg collapsed due to propagation of a fatigue crack originating at the aft edge of the main attachment bolt hole. It was unclear for how long the leg had been cracked, and no heavy landings had been reported that would have triggered removal of the leg for dye penetrant inspection as per SB CT123. As the aircraft was manufactured in 2011, it was not subject to the main landing gear leg dye penetrant inspection at 300 flying hours as required by SB CT123. It is not known whether the leg was dye penetrant inspected in situ at 300 flying hours, as required by the CTSW Operator's Manual, as the relevant aircraft records had been lost.

Safety actions

In response to this accident the UK agent intends to issue Service Bulletin CT145, which requires removal and dye penetrant crack inspection of the main landing gear legs of all CT2K and CTSW aircraft at intervals of 300 flying hours. Service Bulletin CT145 will supersede SB CT123. Service Bulletin CT145 will also introduce modification M309, in which the edges of the main attachment hole in the legs are peened, leaving residual compression stress at the hole edges intended to supress fatigue crack initiation. Service Bulletin CT145 continues to include the requirement to inspect the legs for cracks and straightness following heavy landing events.

ACCIDENT

Aircraft Type and Registration:	Flylight Dragonlite Fox, G-CIEK
No & Type of Engines:	1 Polini Thor 250 piston engine
Year of Manufacture:	2016
Date & Time (UTC):	6 September 2016 at 1515 hrs
Location:	Moor Farm, Chickerell, Weymouth, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers – None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Damage to landing gear, front strut, keel and fuel tank
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	72 years
Commander's Flying Experience:	75 hours (of which 7 were on type) Last 90 days - 1 hour Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

The Flylight Dragonlite Fox is a flex-wing microlight aircraft in the 'single-seat de-regulated' (SSDR) category with a maximum takeoff weight of 200 kg. It is powered by a 36 hp Polini Thor 250 piston engine.

After normal pre-flight and engine run-up checks the aircraft took off. Once airborne the pilot reduced power a little in accordance with the engine running-in instructions. He then initiated a shallow climbing turn during which the engine stopped suddenly without warning. He selected a large stubble field to land, as it was flat, level and with no obstructions or livestock. As he crossed a hedge he applied right bank to correct some drift and then the aircraft suddenly hit the ground very hard, nosewheel first followed by the right wheel. The ground was soft and the aircraft came to rest 15 feet from the impact point. The pilot submarined[1] under the lap belts and received assistance from a caravanner in the field who released him and took him to hospital. The pilot had fractured a vertebra.

The wind was about 5 kt from the south-west and the forced landing was in a westerly direction. The pilot stated that he had a very short time to perform the forced landing and that, during the flare, his instincts from three years of 3-axis flying caused him to pull back on the control instead of pushing, thus causing the nosewheel to hit first.

Footnote

1 Submarined means to have slid out of the seat harness during deceleration.

The airframe damage meant than an engine test could not be carried out. The pilot is awaiting an engine examination. If the cause of the failure is determined an addendum will be published in a future Bulletin.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15, G-MYMX
No & Type of Engines:	1 Rotax 582-40 piston engine
Year of Manufacture:	1993 (Serial no: 6705)
Date & Time (UTC):	15 August 2016 at 1100 hrs
Location:	Insch Airfield, Aberdeenshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Significant airframe damage
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	156 hours (of which 155 were on type) Last 90 days - 10 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Shortly after takeoff, at approximately 250 ft agl, the pilot experienced a total loss of engine power. The terrain ahead of the aircraft was unsuitable for a landing so the pilot initiated a left turn to land in an adjacent field. During the turn the wing stalled and the aircraft began to sideslip. The pilot was unable to correct this before the aircraft struck the ground. The pilot attributed the sideslip to a combination of low airspeed, the steepness of the turn and a tailwind component. The cause of the engine power loss has not been identified.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quik, G-CCOW
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2004 (Serial no: 8008)
Date & Time (UTC):	5 January 2017 at 1145 hrs
Location:	Athey's Moor (Longframlington) Airfield, Northumberland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Substantial damage to wing, trike and propeller
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	71 hours (of which 4 were on type) Last 90 days - 4 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries made by the AAIB

Synopsis

During takeoff the pilot lost directional control and the aircraft overturned when it departed the runway into an area with long grass. It is possible the pilot inadvertently applied the wheelbrakes while trying to use the foot pedals to steer the aircraft.

History of the flight

The pilot was a member of a syndicate that previously operated a Pegasus Quantum aircraft, which he last flew in May 2016. After the syndicate replaced the Quantum with Pegasus Quik G-CCOW the aircraft's designer provided familiarisation training. The pilot was not present for this training, although he was later briefed by the other syndicate members. He had not flown for seven months, and had not received any dual instruction on the Pegasus Quik, before he flew G-CCOW on two uneventful solo flights from Athey's Moor.

One week later he prepared for his third flight; the grass runway at Athey's Moor was wet but it was a fine day with 3 kt or less of wind and visibility was good. At 40 - 45 kt on the takeoff run, the pilot realised the aircraft was drifting to the right and he was unable to prevent it departing the runway. His recollection of the accident is limited but he believes the right wing dropped as the aircraft veered into an area of long grass and it then overturned.

Operation's manual information

There is a warning in the Pegasus Quik Operator's Manual stating:

> *'Do not attempt to operate the aircraft without having carried out the full training syllabus and having satisfied a qualified instructor/examiner of your competence to do so and having been issued with a certificate of competency. Without proper instruction the Quik aircraft is not safe to operate and almost certainly will cause injury or death.'*

A further note titled '*Currency*' states:

> *'If you have not flown within the previous 3 months, take a refresher lesson with a Qualified Instructor before flying as Pilot in Command, and do not operate the aircraft until the Instructor is satisfied with your ability.'*

The aircraft designer is aware of instances when inadvertent brake application on wet grass has caused the wheels to lock and directional control to be lost. While on the ground, the aircraft is steered using foot pedals and the left pedal incorporates a toe brake mechanism which is activated when the pilot's toes are pressed down to pivot the straight pedal. A modified, curved pedal is now available which requires a more positive rotation of the left foot to apply the toe-brake.

Pilot comment

On reflection, the pilot thinks it possible that he inadvertently applied the toe-brake mechanism while attempting to steer the aircraft left using the foot pedals. In hindsight, he now realises he should have sought dual instruction when learning to fly a new type, especially as he had not flown for more than three months.

Miscellaneous

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

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

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

2/2011 Aerospatiale (Eurocopter) AS332 L2 Super Puma, G-REDL
11 nm NE of Peterhead, Scotland
on 1 April 2009.

Published November 2011.

1/2014 Airbus A330-343, G-VSXY
at London Gatwick Airport
on 16 April 2012.

Published February 2014.

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.

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 System
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)
mb	millibar(s)
MDA	Minimum Descent Altitude
METAR	a timed aerodrome meteorological report
min	minutes
mm	millimetre(s)
mph	miles per hour
MTWA	Maximum Total Weight Authorised
N	Newtons
N_R	Main rotor rotation speed (rotorcraft)
N_g	Gas generator rotation speed (rotorcraft)
N_1	engine fan or LP compressor speed
NDB	Non-Directional radio Beacon
nm	nautical mile(s)
NOTAM	Notice to Airmen
OAT	Outside Air Temperature
OPC	Operator Proficiency Check
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PIC	Pilot in Command
PNF	Pilot Not Flying
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
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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