AAIB
Air Accidents Investigation Branch

AAIB Bulletin 10/2023

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AAIB investigations are conducted in accordance with Annex 13 to the ICAO Convention on International Civil Aviation, EU Regulation No 996/2010 (as amended) and The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018.

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

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

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(ALL TIMES IN THIS BULLETIN ARE UTC)

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 Accidents Investigation Branch

This report was published on 6 September 2023 and is available in full on the AAIB Website www.aaib.gov.uk

Report on the accident to Leonardo AW169, registration G-VSKP at King Power Stadium, Leicester on 27 October 2018

Aircraft Accident Report No:	1/2023 (AAIB-25398)
Registered Owner:	Foxborough Limited (Isle of Man)
Registered Operator:	Starspeed Limited
Aircraft Type:	Leonardo AW169
Nationality:	British
Registration:	G-VSKP
Place of Accident:	King Power Stadium, Leicester
Date and Time:	27 October 2018 at 1937 hrs

Introduction

The Air Accidents Investigation Branch (AAIB) became aware of this accident during the evening of 27 October 2018. In exercise of his powers, the Chief Inspector of Air Accidents ordered an investigation to be carried out in accordance with the provisions of Regulation (EU) 996/2010 and the UK Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018.

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

In accordance with established international arrangements, the Agenzia Nazionale per la Sicurezza del Volo (ANSV) of Italy, representing the State of Design and Manufacture of the helicopter, appointed an Accredited Representative (Accrep) to participate in the investigation. The Transportation Safety Board (TSB) of Canada, representing the State of Design and Manufacture for the helicopter's engines, the National Transportation Safety Board (NTSB) of the USA, representing the State of Design and Manufacture of the tail rotor actuator and the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) of France representing the State of Design and Manufacture of the tail rotor duplex bearing, also appointed Accreps.

Experts[1] were appointed by the Aircraft Accident Investigation Committee of Thailand and the State Commission on Aircraft Accidents Investigation of Poland.

The helicopter, bearing, tail rotor actuator and grease manufacturers, the operator, the European Union Aviation Safety Agency (EASA), and the UK Civil Aviation Authority (CAA) also assisted the AAIB investigation.

Summary

At 1937 hrs the helicopter, carrying the pilot and four passengers, lifted off from the centre spot of the pitch at the King Power Stadium. The helicopter moved forward and then began to climb out of the stadium on a rearward flightpath while maintaining a northerly heading and with an average rate of climb of between 600 and 700 ft/min. Passing through a height of approximately 250 ft, the pilot began the transition to forward flight by pitching the helicopter nosedown and the landing gear was retracted. The helicopter was briefly established in a right turn before an increasing right yaw rapidly developed, despite the immediate application of corrective control inputs from the pilot. The helicopter reached a radio altimeter height of approximately 430 ft before descending with a high rotation rate. At approximately 75 ft from the ground the collective was fully raised to cushion the touchdown.

The helicopter struck the ground on a stepped concrete surface, coming to rest on its left side. The impact, which likely exceeded the helicopter's design requirements, damaged the lower fuselage and the helicopter's fuel tanks which resulted in a significant fuel leak. The fuel ignited shortly after the helicopter came to rest and an intense post-impact fire rapidly engulfed the fuselage.

The investigation found the following causal factors for this accident:

1. Seizure of the tail rotor duplex bearing initiated a sequence of failures in the tail rotor pitch control mechanism which culminated in the unrecoverable loss of control of the tail rotor blade pitch angle and the blades moving to their physical limit of travel.

2. The unopposed main rotor torque couple and negative tail rotor blade pitch angle resulted in an increasing rate of rotation of the helicopter in yaw, which induced pitch and roll deviations and made effective control of the helicopter's flightpath impossible.

3. The tail rotor duplex bearing likely experienced a combination of dynamic axial and bending moment loads which generated internal contact pressures sufficient to result in lubrication breakdown and the balls sliding across the race surface. This caused premature, surface initiated rolling contact fatigue damage to accumulate until the bearing seized.

Footnote

[1] Representing States which suffered fatalities to its citizens in the accident.

The investigation found the following contributory factors for this accident:

1. The load survey flight test results were not shared by the helicopter manufacturer with the bearing manufacturer in order to validate the original analysis of the theoretical load spectrum and assess the continued suitability of the bearing for this application, nor were they required to be by the regulatory requirements and guidance.

2. There were no design or test requirements in Certification Specification 29 which explicitly addressed rolling contact fatigue in bearings identified as critical parts; while the certification testing of the duplex bearing met the airworthiness authority's acceptable means of compliance, it was not sufficiently representative of operational demands to identify the failure mode.

3. The manufacturer of the helicopter did not implement a routine inspection requirement for critical part bearings removed from service to review their condition against original design and certification assumptions, nor were they required to by the regulatory requirements and guidance.

4. Although the failure of the duplex bearing was classified as catastrophic in the certification failure analysis, the various failure sequences and possible risk reduction and mitigation measures within the wider tail rotor control system were not fully considered in the certification process; the regulatory guidance stated that this was not required.

AAIB Special Bulletin S1/2023, published on 14 November 2018 and AAIB Special Bulletin S1/2023, published on 6 December 2018, provided initial information on the circumstances of this accident.

During the course of this investigation and as a result of the findings made, the helicopter manufacturer has issued sixteen Service Bulletins and EASA has published nine Airworthiness Directives for the continued airworthiness of the AW169 and AW189 helicopter types.

Eight Safety Recommendations have been made in this report. These have been made to EASA to address weaknesses or omissions identified in the regulations for the certification of large helicopters - Certification Specification 29. The recommendations address the main findings of the investigation and include: validation of design data by suppliers post-test; premature rolling contact fatigue in bearings; life limits, load spectrum safety margin and inspection programmes for critical parts; and assessment and mitigation of catastrophic failure modes in systems.

Conclusions

Findings

1. G-VSKP was operated out of Fairoaks Airport in compliance with the requirements for non-commercial operations with complex motor-powered aircraft established in Commission Regulation (EU) No 965/2012, in particular in Annex VI (Part-NCC).

2. The pilot was correctly licensed and qualified to conduct the flight.

3. The congested area permission for operations at the King Power Stadium required a Cat A departure to mitigate the risk of engine failure.

4. The average rate of climb during the accident flight rearwards climb exceeded the Cat A profile's parameters but the additional torque demand did not materially affect the post-failure controllability of the helicopter.

5. The helicopter was above an appropriate TDP height when the pilot committed to a CTO.

6. When above TDP height, but before completing the Cat A procedure acceleration profile, the pilot initiated a turn to the right while transitioning to forward flight.

7. A right yaw pedal input during the turn initiation resulted in the tail rotor actuator control shaft moving to the right under hydraulic pressure from the actuator.

8. The tail rotor duplex bearing seized resulting in the tail rotor actuator control shaft, driven by the high torque tail rotor drive system, rotating at high speed.

9. The axial movement of the tail rotor actuator control shaft maintained contact pressure between the pin carrier and the lock nut, causing the nut and pin carrier to friction weld together.

10. Both secondary locking features on the castellated locking nut at the actuator end of the shaft failed under the torque from the rotating shaft, and the control shaft unscrewed from the nut.

11. Once the control shaft was detached from the pin carrier, the feedback mechanism of the hydraulic control system became ineffective, and the control shaft continued to move under hydraulic pressure until the pitch of the tail rotor blades reached its physical limit of travel.

12. The rate of yaw of the helicopter continued to increase rapidly due to the unopposed main rotor torque couple and negative tail rotor blade pitch angle.

13. The pilot's yaw control pedals became ineffective after the TRA control shaft detached, resulting in the pilot being unable to control the direction or rate of yaw of the helicopter.

14. Without effective yaw control the pilot was unable to control the horizontal trajectory of the helicopter.

15. Cross-coupling of forces generated around the helicopter's normal axis by the high yaw rate, led to large deviations in pitch and roll.

16. Startle, surprise, disorientation and reduced visual cues due to the darkness were likely to have been performance shaping factors for the pilot response time; nonetheless, it was within the range expected considering simulator research, previous accidents and the circumstances when the failure occurred.

17. The position of the helicopter above the stadium roof at the point of loss of yaw control, may also have influenced the pilot's response.

18. The pilot lowered the collective to reduce main rotor thrust, thereby reducing its contribution to the destabilising torque which was driving the departure in yaw.

19. With the collective lowered the helicopter no longer had enough lift to maintain height and began to descend.

20. As the helicopter approached the ground, the pilot reduced the rate of descent by fully raising the collective lever.

21. The helicopter struck the ground across a 0.5 m step in the concrete surface of an area of rough ground and came to rest on its left side.

22. The analysis of the impact forces, experienced by the helicopter when it struck the step, indicated that they probably exceeded the design requirements of the helicopter.

23. The impact absorption features of the passenger cabin seats operated as designed and their condition indicated that the vertical deceleration force experienced by the passengers exceeded 30 g.

24. All the occupants suffered significant impact injuries; for one occupant these were likely to have been fatal.

25. Impact with the step resulted in disruption of the helicopter's fuel tanks allowing fuel to pool around the fuselage. This subsequently ignited.

26. The damage caused to the helicopter and its orientation provided numerous potential ignition sources for the leaking fuel.

27. First responders arrived at the accident site within one minute of the helicopter striking the ground and attempted to gain access to the cockpit and cabin. They were unable to do so due to the orientation of the fuselage, the strength of the cockpit windscreen and the rapid increase in the intensity of the fire.

28. The helicopter was rapidly engulfed by fire and the occupants who survived the initial impact died from inhaling the products of combustion.

29. Simulator trials confirmed to the investigation that the loss of yaw control was irrecoverable.

30. The helicopter was compliant with all applicable airworthiness requirements, had been correctly maintained and was appropriately certified for release to service prior to the accident flight.

31. The condition of the tail rotor duplex bearing could not have been predicted or identified by existing maintenance requirements prior to the accident.

32. The condition of the tail rotor duplex bearing began to deteriorate well before the accident flight.

33. An increase in contact pressure and temperature within the bearing races from a combination of axial and bending moment loads likely resulted in lubrication starvation events and degradation of the grease through aging.

34. High contact pressures and deterioration of the grease likely contributed to increased sliding of the ceramic balls leading to high surface shear stress and the development of surface initiated rolling contact fatigue.

35. The surface initiation of the cracks, shallow DER and the zone of changed material properties directly below the race surface were all indicative of the ceramic balls sliding rather than rolling.

36. The rolling contact fatigue resulted in distinctive surface initiated cracking which then progressed to extensive liberation of the race surface material.

37. The increased friction between the balls and the damaged race surface resulted in further heat generation which degraded the grease until it became powered carbon and created a zone of changed material properties below the race surface.

38. The erratic movement of the balls across the rolling surface placed high loads on the bearing cage, resulting in wear and fatigue fractures.

39. Failure of the cage allowed the balls to move unrestrained across the race surface increasing the extent of the damage.

40. Released material from the cage and race surfaces was ground to dust by the action of the balls and combined with the carbon dust to be re-laid as a new rolling surface for the race.

41. The non-homogeneous and extensively cracked new rolling surface suffered further rolling contact fatigue, causing large sections of material to be released.

42. Eventually the dimensional clearances were reduced by the released material to the extent that the bearing seized.

43. Once the level of damage reached a certain threshold it became self-perpetuating under all operational loads, with an accelerating rate of progression towards ultimate failure of the bearing.

44. Rig test data analysis conducted during the investigation identified that high contact pressures within the bearing were sufficient to initiate a damage cycle that could result in incipient seizure of the bearing before the discard life of 2,400 hours.[1]

45. Rig and flight test data analysis identified that a limited subset of manoeuvres within the normal operating envelope of the helicopter generated combined loads sufficient to cause potentially damaging contact pressures within the bearing.

46. Based on all the evidence available, it was likely that the accident helicopter tail rotor duplex bearing failed due to premature grease deterioration and accumulation of race damage, caused by high contact pressures, resulting from routinely conducted manoeuvres within the approved operating envelope of the helicopter.

47. The extent of damage observed on all the bearings investigated was not consistent with a simple relationship with increasing flight hours: the accident bearing showed the maximum level of distress, whilst having the lowest service life.

48. The inherent flexibility in helicopter manoeuvres and diversity of atmospheric conditions in which they operate, results in significant potential variability in the duration, magnitude and frequency of exposure to the potentially damaging contact pressures associated with this subset of manoeuvres.

Footnote

[1] The 2,400 hour life was based on assessment of the original development load spectrum. The highest actual contact pressure during the test was higher than the highest development spectrum contact pressure after the spectrum had been reassessed using the latest standard of modelling software. See section 1.16.1.4.

49. These differences in the timing and severity of exposure to high contact pressures, for each individual helicopter affected, resulted in significant potential variation in the accrued bearing life at which accumulation of damage was initiated, the rate at which the damage progressed towards failure and the extent of the damage observable at the time when they were inspected, following removal from service due to a maintenance inspection or as the result of an incident or accident.

50. In addition to the bearings chosen to be part of the investigation, it's possible that others removed from service had developed damage to some degree but were either not returned to the manufacturer or were not subjected to the same disassembly inspection to identify and document the damage.

51. Some helicopters in the AW169 and AW189 fleet may never have been subject to manoeuvres which generated contact pressures sufficient to cause premature damage, prior to the bearing being removed at the required discard life or replaced by the new standard bearing.

52. Findings 46-49 in combination may help to explain why only a relatively small number of tail rotor hybrid bearings operated in AW169s and AW189s either failed or were confirmed to have suffered damage.

53. Certification testing for the tail rotor duplex bearing on both the AW169 and AW189 was compliant with the regulatory requirements.

54. There were no certification design or test requirements explicitly addressing rolling contact fatigue in bearings used on helicopters certified to CS 29.

55. The duplex bearings fitted to the flight test helicopters during certification flight testing of the AW169 and AW189 were not removed for detailed inspection at the end of the certification flight test programme, nor were they required to be for certification of the tail rotor control system.

56. The flight test results for tail rotor axial and bending moment loads were not shared with the bearing manufacturer in order to use their proprietary modelling software to validate the original analysis of the theoretical load spectrum and assess the continued suitability of the bearing for this application, nor were they required to be.

57. The failure analysis work conducted by the helicopter manufacturer during certification correctly identified that failure of the duplex bearing by seizure would be catastrophic.

58. The castellated locking nut on the tail rotor actuator end of the control shaft was identified as a catastrophic single point of failure, but only fracture of the nut or release due to vibration were considered.

59. Once the failure of any component was classified as catastrophic by the manufacturer, no further analysis of the failure mode was required by the airworthiness authority to meet certification requirements.

60. The failure mechanism of the shaft rotating in the opposite direction to the thread on the actuator end locking nut, allowing the pin carrier and nut to be released, was not identified by the AW169 certification analysis as a potential outcome of the bearing seizing.

61. The pin carrier and actuator on the AW139 were designed with a reverse thread to address the risk of bearing seizure and shaft rotation.

62. This failsafe design worked successfully during a tail rotor bearing failure on an AW139 in 2012, around the same time the design of the AW169 and AW189 actuator was being developed.

63. Compliance with the various certification risk assessment requirements during development offered opportunities to identify and mitigate the failure sequence seen in the accident, but these opportunities were not realised at the time, in part due to a reliance on statistical analysis to mitigate risk.

64. Although classed as a critical part, prior to the accident, the manufacturer of the helicopter did not require bearings removed from service to be returned to facilitate an inspection of their condition; nor was there any regulatory requirement or guidance that required them to do so.

65. No requirements or guidance were provided in the regulations about how critical part theoretical load spectrums should be calculated to ensure adequate safety margins.

66. From the extensive accident helicopter flight data recovered, no flight system problems were evident before the accident flight.

67. Logged faults were shown to be nuisance faults, evident on other serviceable aircraft and prior to successful flights.

68. The recorded data showed a number of alerts were triggered during the accident flight and related to the high yaw rate which developed after the tail rotor failure.

69. Of the internally logged system faults that occurred during the accident flight, only one could not be definitively attributed to nuisance issues, the high rotation rate or impact. Time alignment indicated this occurred just prior to impact and was not associated with the bearing failure or flight controllability.

70. The high yaw rate, peaking at 209°/s, would have generated significant forces on the occupants of the cockpit given their distance from the centre of gravity of the helicopter.

71. HUMS was installed capable of identifying increasing vibration trends in key components, but its use was not required for NCC operations.

72. The accelerometers fitted at the time for the purpose of vibration monitoring were not positioned to detect vibrations on the critical bearing that failed and were unlikely to do so.

73. The data from the closest accelerometer to the failed bearing was lost in the fire.

Safety Recommendations and Actions

Safety Recommendations

The following Safety Recommendations were made:

Safety Recommendation 2023-018

It is recommended that the European Union Aviation Safety Agency amend Certification Specification 29.602 to require type design manufacturers to provide the results of all relevant system and flight testing to any supplier who retains the sole expertise to assess the performance and reliability of components identified as critical parts within a specific system application, to verify that such components can safely meet the in-service operational demands, prior to the certification of the overall system.

Safety Recommendation 2023-019

It is recommended that the European Union Aviation Safety Agency introduce additional requirements to Certification Specification 29 to specifically address premature rolling contact fatigue failure across the full operating spectrum and service life of bearings used in safety critical applications.

Safety Recommendation 2023-020

It is recommended that the European Union Aviation Safety Agency amend Certification Specification 29.602 to define the airworthiness status of life limits on non-structural critical parts and how they should be controlled in service.

Safety Recommendation 2023-021

It is recommended that the European Union Aviation Safety Agency define the airworthiness status of life limits and how they should be controlled for existing non-structural critical parts approved to Certification Specification 29.602 requirements, already in service.

Safety Recommendation 2023-022

It is recommended that the European Union Aviation Safety Agency amend Certification Specification 29.602 to require manufacturers to implement a comprehensive post removal from service assessment programme for critical parts. The findings from this should be used to ensure that reliability and life assumptions in the certification risk analysis for the critical part or the system in which it operates remain valid.

Safety Recommendation 2023-023

It is recommended that the European Union Aviation Safety Agency require manufacturers to retrospectively implement a comprehensive post removal from service assessment programme for critical parts, approved to Certification Specification 29.602 requirements, already in service. The findings from this should be used to ensure that the reliability and life assumptions in the certification risk analysis for the critical part or the system in which it operates remain valid.

Safety Recommendation 2023-024

It is recommended that the European Union Aviation Safety Agency amend Certification Specification 29.602 to provide guidance and set minimum standards for the calculation of design load spectrums for non-structural critical parts. They must encompass, with an appropriate and defined safety margin, the highest individual operating load and combination of dynamic operating loads, and the longest duration of exposure to such loads that can be experienced in operation.

Safety Recommendation 2023-025

It is recommended that the European Union Aviation Safety Agency amend the relevant requirements of Certification Specification 29 and their Acceptable Means of Compliance to emphasise that where potentially catastrophic failure modes are identified, rather than rely solely on statistical analysis to address the risk, the wider system should also be reviewed for practical mitigation options, such as early warning systems and failure tolerant design, in order to mitigate the severity of the outcome as well as the likelihood of occurrence.

Safety action

This report presents the following safety actions:

Safety action by the airworthiness authority

Emergency AD 2018-0241-E was issued 7 November 2018 to mandate ASB 169-120 and 189-213. This required a one-time visual inspection of the servo-actuator installation to identify movement of the castellated locking nut.

Emergency AD 2018-0250-E was issued on 19 November 2018. In addition to the requirements of the first AD, a precautionary one-off inspection of the duplex bearing was introduced.

EASA issued Emergency AD 2018-0252-E on 21 November 2018 to mandate ASB 169-125 and ASB 189-214. This introduced a one-time inspection and breakaway torque check of the duplex bearing, inspection and reinstallation of the servo-actuator castellated locking nut.

EASA issued Emergency AD 2018-0261-E on 30 November 2018 to mandate ASB 169-126 and ASB 189-217 to introduce repeat inspections.

EASA issued AD 2019-0023 on 1 February 2019 to mandate ASB 169-135 and ASB 189-224. These introduced a modification developed by the helicopter manufacturer to install and repetitively inspect a thermal strip on the bearing end of the tail rotor actuator control shaft.

EASA issued AD 2019-0121 on 3 June 2019, later revised to AD 2019-0121(R1), to require accomplishment of ASB 169-148 and 189-237, which provided instructions for more in-depth inspections of the duplex bearing.

EASA issued AD 2019-0193 on 7 August 2019, which mandated reporting from the new Vibration Health Monitoring modification introduced by the helicopter manufacturer, it also included all the other inspection requirements and superseded AD 2019-0121(R1).

The EASA issued Airworthiness Directive 2020-0048 on 6 March 2020, which superseded AD 2019-0193. This AD mandated the fitment of the new standard control actuator, with one-way interchangeability[2]. Fitting of the modified actuator alleviated the requirement to conduct an inspection of the lock nut every 10 flight hours. All the additional inspections were retained in the new AD.

Footnote

[2] The old part number actuator can be replaced by the new part number actuator, but not the other way around.

EASA issued AD 2020-0197 on 24 September 2020 to mandate the replacement of the tail rotor duplex bearing with a new design which used steel ball bearings rather than ceramic. The new bearing was introduced with a life limit of 400 flight hours. This allowed an extension of the inspection intervals on the thermal strip and bearing.

Safety action by the helicopter manufacturer

ASB 169-120 and 189-213 were issued on by the helicopter manufacturer. This required a one-time visual inspection of the servo-actuator installation to identify movement of the locking nut.

The helicopter manufacturer published ASB 169-125 and ASB 189-214. This introduced a one-time inspection and breakaway torque check of the duplex bearing, inspection and reinstallation of the servo-actuator castellated nut.

The helicopter manufacturer published ASB 169-126 and ASB 189-217 to introduce repeat inspections of the bearing and lock nut.

A modification was developed by the helicopter manufacturer to install and repetitively inspect a thermal strip on the bearing end of the tail rotor actuator control shaft. This was introduced in ASB 169-135 and ASB 189-224.

Operator feedback from the repetitive tail rotor inspections allowed improved techniques to be developed and the helicopter manufacturer published ASB 169-148 and 189-237, to provide instructions for more in-depth inspections of the duplex bearing.

The helicopter manufacturer introduced into service a modification to the Vibration Health Monitoring (VHM) system fitted to the AW169 and AW189 by issuing SBs 169-140 and 189-227. The modification relocated an existing accelerometer sensor on the tail to the servo-actuator control lever, to allow monitoring of the vibration signature of the duplex bearing as an optional aid to continued airworthiness.

In early 2020 the helicopter manufacturer issued modification Service Bulletins 169-153 and 189-249. These introduced a new standard of tail rotor actuator with a left-hand thread on the castellated lock nut and a washer, fitted to the actuator end of the shaft.

The manufacturer introduced a new tail rotor duplex bearing into service by issuing Service Bulletins 169-162 and 189-254 on 4 August 2020. Replacement with the new bearing was required within 400 flight hours or 4 calendar months of the SB issue date. The new bearing replaced the ceramic balls with steel balls. The new bearing had an introductory life limit of

400 flight hours. The Service Bulletin also required time expired bearings to be returned to the manufacturer for inspection following replacement.

Service Bulletins 169-178 and 189-272 were also issued on 4 August 2020 to increase the inspection intervals for the new bearing. The 10 hour repeat inspections of the thermal strip and the bearing were extended to 50 hour repeat inspections. While the 20 and 50 hour checks were extended to 100 hours and the 200 hour check reduced to 100 hours.

Safety action by the helicopter operator

The operator grounded all company operated AW169 the day after the accident and, in accordance with its SMS procedure, did not resume operations until the 30 November 2018 when they were satisfied that sufficient action had been taken to establish the airworthiness of the aircraft.

Full report published: 6 September 2023.

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:	Jodel DR1050-M1, G-BAEE
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1964 (Serial no: 579)
Date & Time (UTC):	6 October 2022 at approximately 1135 hrs
Location:	Near Jackrell's Farm airstrip, Horsham, West Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Serious)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	85 years
Commander's Flying Experience:	2,004 hours (of which at least 700 were on type) Last 90 days - 12 hours Last 28 days - 4 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was being flown for the renewal of its Permit to Fly. Having completed most of the required items, the pilot flew the aircraft back to Jackrell's Farm airstrip to land. The approach to the airstrip resulted in a go-around during which the aircraft struck the tops of tall trees beyond the end of the runway. The aircraft then struck the ground in the field beyond the trees in an upright attitude. Both the pilot and the aircraft owner suffered serious injuries in the accident. Although the aircraft owner recalled that the aircraft was high and fast on the approach and that a go-around was commenced from close to the end of the runway, this could not be verified as the pilot had no recollection of the flight. The investigation found no mechanical or technical cause for the accident.

History of the flight

The aircraft had not been flown for over two years due to a combination of the owner's health and the Covid-19 pandemic, and both the aircraft Permit to Fly and the owner's class rating had expired. The owner decided that he wanted to sell the aircraft as he was no longer using it, and as part of the sale arranged for the Permit to Fly to be renewed. The aircraft owner ran the engine of G-BAEE occasionally over the period it had not flown and a long layup inspection was also completed before the aircraft was approved to fly for the permit renewal flight. Since the owner was not able to do the flight himself, he arranged with a friend who also operated an aircraft from Jackrell's Farm airstrip to fly the aircraft, with the owner acting as observer.

Having fuelled the aircraft and ground run the engine, both the pilot and aircraft owner were seen in the aircraft as it taxied out for a takeoff on Runway 21. The pilot sat in the left seat, and the owner in the right seat. Witnesses reported watching the aircraft takeoff at around 1115 hrs. Radar detected the aircraft at 1124:50 hrs as it climbed out from Jackrell's Farm. Having conducted the planned items for the permit renewal, the aircraft returned to land. Its last recorded radar position was south of the airstrip at 1134:44 hrs. A few minutes later the aircraft struck tall trees beyond the end of Runway 03 having gone around from an approach to land. This impact substantially reduced the aircraft's forward speed and as a result it came down into the field just beyond the trees. Both the pilot and aircraft owner were seriously injured.

There were no witnesses to the approach or the accident. Having regained consciousness sometime after the accident, the aircraft owner was able to find the pilot's mobile phone to make an emergency call. This call was made at 1318 hrs, over 1.5 hours after the accident. The air ambulance was the first to arrive at the site at 1341 hrs, approximately two hours after the accident.

Accident site

The accident site was located in a field just beyond and to the right of the departure end of grass Runway 03 at Jackrell's Farm airstrip. The aircraft was upright and all the aircraft structure was present except for the outer two thirds of the right wing. Damage to trees on the adjacent field boundary and tree debris on the accident site indicated that the aircraft had struck the trees, which were approximately 15 m tall. The outer portion of the right wing was found on the opposite side of the tree line, with some small items of aircraft skin found in the trees. A single impact mark on the right wing leading edge close to the wing tip was consistent with the wing having struck a tree. The force of the right wing impact with the tree caused the aircraft to yaw to the right, pivoting around the impact point before continuing to the ground.

There were no appreciable ground marks other than in the immediate impact area, which indicated a predominantly vertical descent in a level attitude.

Figure 1
Accident site

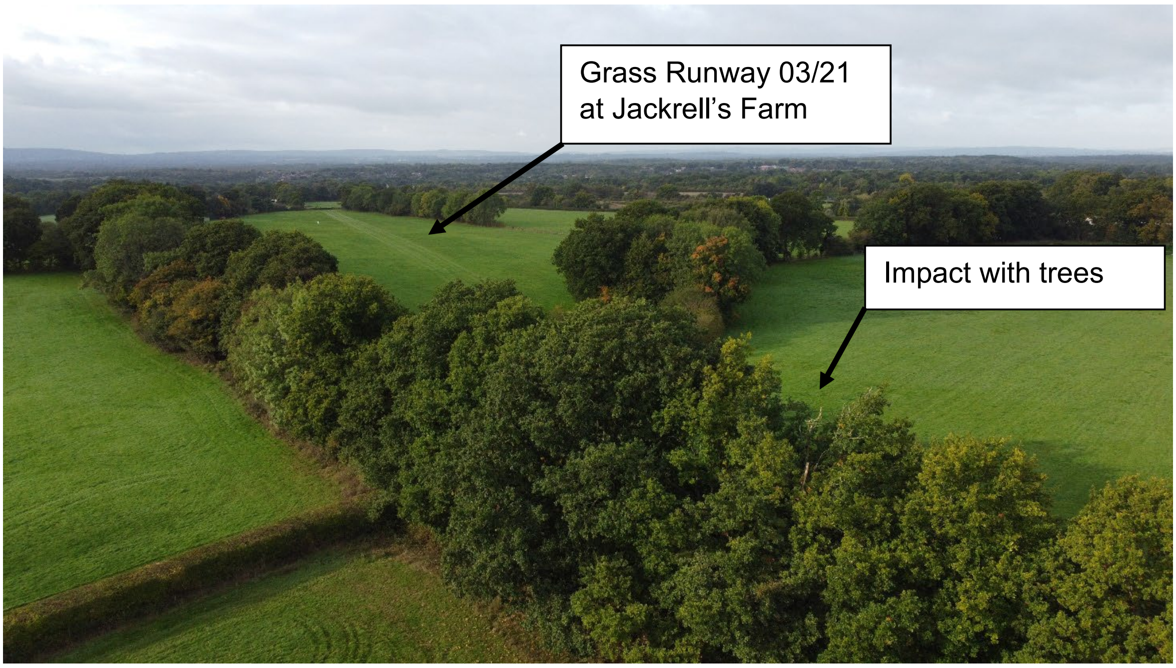


Figure 2
Aerial view toward Jackrell's Farm airstrip from the accident site

Figure 3
Tree line viewed from direction of aircraft travel

Recorded information

The radar stations at Gatwick and Pease Pottage detected the aircraft for parts of the accident flight south of the airstrip. The aircraft was equipped with a Mode S transponder but only primary radar returns were detected, indicating that the transponder was turned off and therefore no altitude information was recorded. Some altitudes can be inferred when the aircraft transitions in and out of the minimum height for radar coverage in the area based on the viewshed[1] from the Gatwick radar head, but not when in radar coverage with the transponder turned off. The first detection was at 1124:50 hrs as the aircraft climbed into line of sight of the Gatwick radar, implying the aircraft was at a height of about 800 ft agl. The last detection was about 10 minutes later at 1134:56 hrs, 1 nm south of the airstrip, at a height less than 890 ft agl.

Footnote

[1] A viewshed is the geographical area that is visible from a location. It includes all surrounding points that are in line-of-sight with that location and excludes points that are beyond the horizon or obstructed by terrain and other features such as buildings and trees.

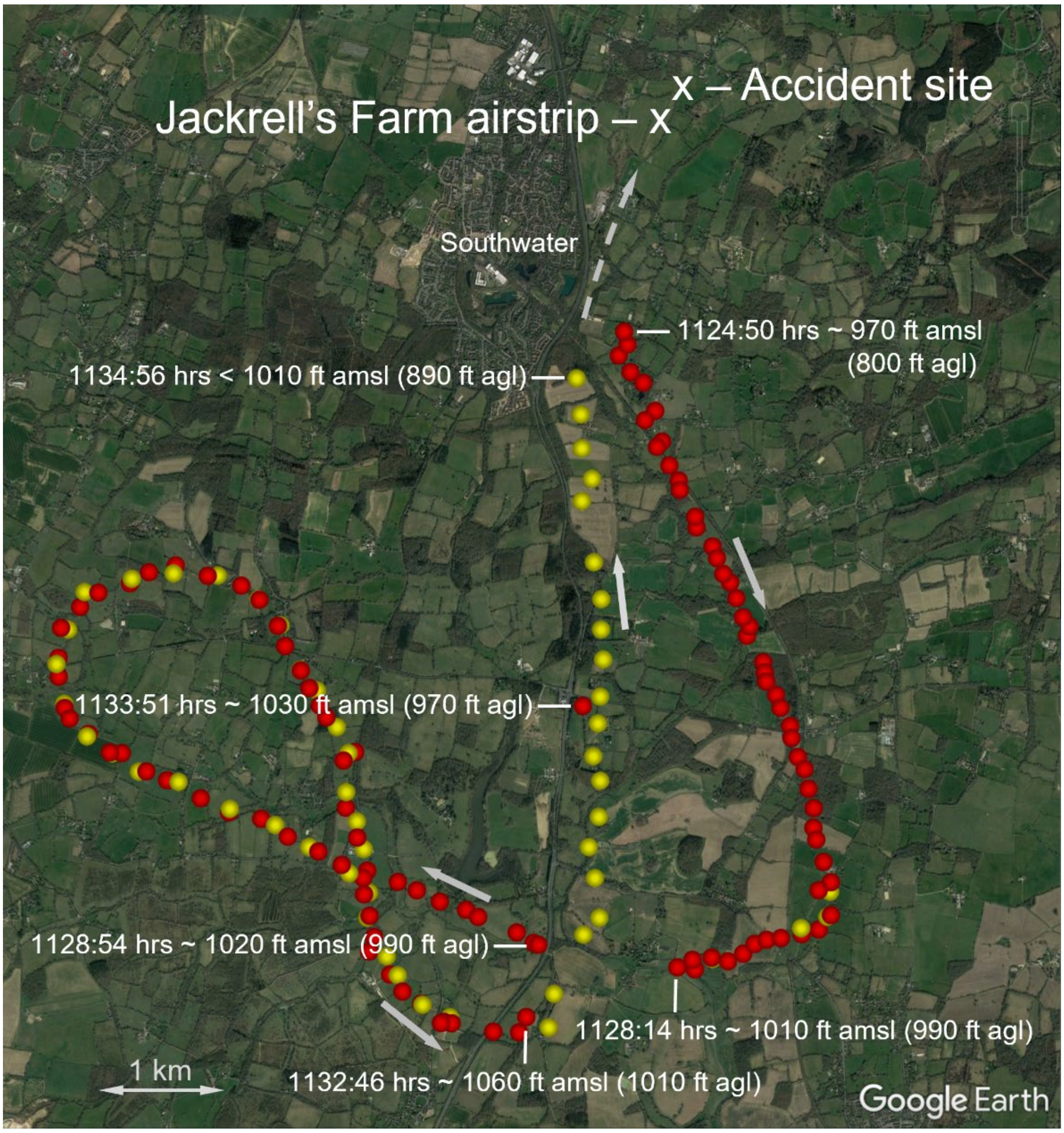


Figure 4

Gatwick (red) and Pease Pottage (yellow) primary radar track of aircraft

Aircraft information

The Jodel D1050-M1 is a four-seat, low-wing, tailwheel aircraft of fabric-covered wooden construction. G-BAEE was factory built in 1964 and was fitted with a Continental O-200-A horizontally opposed piston engine and two-bladed fixed pitch metal propeller. The owner purchased G-BAEE in 1991.

The aircraft's most recent Permit to Fly had been issued on 16 July 2018, when the aircraft had accrued 2,440 flying hours. It flew a further two hours before its Permit to Fly expired on 15 July 2019 and was not flown again until the accident flight.

Aircraft maintenance

The owner had decided to sell the aircraft and consulted his LAA inspector with a view to revalidating the lapsed Permit to Fly. The inspector advised the owner that the inspection would need to take account of the fact that the aircraft had not flown for several years, including looking for any evidence of corrosion, wood rot, rubber degradation, rodent or environmental damage. This inspection revealed no damage.

Other maintenance conducted by the owner included draining and refilling the fuel tanks with fresh fuel, cleaning the fuel filter and gascolator, draining and refilling the engine oil and replacing the oil and air filters. Engine ground runs were carried out and the static rpm was noted as 2,350 rpm at full throttle. The magneto timing was checked, and a cylinder compression test conducted when the engine was hot revealed good compression on all cylinders. The tubular frames of the front seats were inspected for cracking in accordance with a mandatory LAA Airworthiness Information Leaflet[2], no cracks were found. The functioning of the airspeed indicator was also checked and confirmed to be satisfactory. The maintenance was documented on worksheets.

The inspector was satisfied with the condition of the aircraft and engine and certified the work by signing the aircraft and engine logbooks and the Permit Maintenance Release on the worksheets. These were dated 14 July 2022. As the previous permit had lapsed by more than 12 months, the LAA required that a Permit Flight Release Certificate (PFRC) was issued by LAA Engineering rather than by an inspector in the field.

An *'Application for renewal (revalidation) of Permit to Fly'* form was completed jointly by the owner and inspector and submitted by the owner to LAA Engineering. The form included the inspector's recommendation that the Permit to Fly be revalidated, subject to the completion of a check flight.

Having reviewed the application, LAA Engineering issued a PFRC on 4 August 2022, valid for one month. The check flight did not take place during this period as the owner had been overseas and a second PFRC was issued on 16 September, again valid for one month.

Aerodrome information

Jackrell's Farm airstrip is a grass strip just to the south of Horsham, West Sussex. It has a single glass runway orientated 03/21 which is 550 m long. There are tall trees around the airfield including some oak trees which are 100 m from the end of Runway 03 on the extended centreline, although there are gaps in the trees at the thresholds at each end of the runway. Guidance for the airstrip states that takeoffs are to be on Runway 21 with landings on Runway 03, in part because of the tall trees. The exception to this is for microlights and very light two seaters, neither of which describes G-BAEE.

Footnote

2 LAA MOD/845/001 dated 27 November 2019, applicable to all factory-built Jodel DR100 series aircraft operating under an LAA administer Permit to Fly.

Preliminary aircraft examination

Damage to the aircraft was consistent with a vertical descent in a level attitude, with the impact loads having been absorbed predominantly by the undercarriage, engine and cockpit structure. The engine mounts and firewall had failed. The carburettor, mounted underneath the engine, had separated from the induction manifold. One of the metal propeller blades was largely undamaged and the other exhibited damage to the tip consistent with the propeller having been turning at the time of the accident.

The forward fuel tank was empty, having ruptured, and a strong smell of fuel was apparent. The rear fuel tank located in the fuselage was intact and approximately 11 litres of motor gasoline were retrieved from it.

Examination of the flight control runs showed that some had experienced distortion as a result of the impact, but integrity of the control runs was established.

The front seats were mounted on supporting structure above the main spar. Forward of this the cockpit was extensively disrupted. Although it remained in position, the right seat had completely separated from the aircraft structure. Both front seats were fitted with a combined lap strap and shoulder harness. The lap straps were mounted on the seats and the inertial reels for shoulder harnesses were mounted on a bulkhead underneath the rear seats. The harness fabric and attachments were intact and functional and there was evidence that they were being worn by the occupants at impact.

Detailed aircraft examination

General

Damage to the aircraft was consistent with striking trees and the subsequent impact with the ground. The underlying wooden structure and fabric covering was in good condition, with no evidence of moisture ingress, rot or other environmental damage.

Airbrakes

The airbrake lever was found in the locked closed position and could not be moved due to distortion. Together with the absence of damage to the airbrake panels themselves, this indicated that the airbrakes were closed at impact.

Seats

The front right seat had failed where the vertical portion of the frame joined the horizontal portion of the frame. This was consistent with the vertical loading sustained by the aircraft during impact with the ground and the failure was outside the area covered by the mandatory LAA inspection of the seat frame.

Engine and fuel controls

The engine controls were mostly cable-operated and, due to substantial disruption forward of the firewall, it was not possible to verify their pre-impact positions. The No 1 magneto was ON and the No 2 magneto was OFF. The battery and alternator master switches were ON.

The fuel selector valve, mounted on the aft face of the engine firewall, had three positions: POSITION 1 (off), POSITION 2 (rear tank selected) and POSITION 3 (front tank selected). The valve was found in an intermediate position between POSITION 1 AND POSITION 3. The valve operating linkage and the fuel selector handle mounted on the instrument panel were substantially disrupted, which may have caused the valve to move during the impact. By blowing compressed air through the valve it was determined that if it had been in the as-found position prior to the accident, fuel from the front tank would still have been able to flow through the valve to supply the engine, but likely at a reduced flow rate.

The aircraft owner recalled that the fuel selector handle had been selected to the front tank (clockwise) prior to the accident. No markings or decals were present to indicate the tank positions on the fuel selector handle, but the owner stated that labels had been present prior to the accident flight. It was not determined whether the engine or fuel controls were disturbed by the first responders, but it is unlikely in the case of the fuel selector due to the absence of labelling and the disruption it had suffered.

Engine

Apart from impact damage to the underside, the engine was relatively intact and rotated freely when turned. When tested, the cylinder compression ratios were lower than those noted in the maintenance worksheets, substantially so in the case of cylinder No 1. Air could be heard leaking past the piston rings and/or the exhaust valves. The compression test was performed when the engine was cold and at a reduced air pressure, so may not have been fully representative.

Partial disassembly of the engine revealed that it was generally in good condition although some minor anomalies were noted. The piston rings on all cylinders were intact and correctly seated. The inlet valves from each of the four cylinders had an encrusted burnt deposit on the seat face of the valve. This could indicate that the engine had been running hot at some point or that the mixture was too rich, but the valve seats were clean and free from debris.

Survivability

Both occupants of the aircraft sustained serious injuries in the accident including spinal damage. The aircraft deceleration was largely vertical because the aircraft had little forward speed as it fell to the ground. The right seat of the aircraft was detached from its mountings and the left seat remained in place. Neither seat was designed to mitigate the loads associated with large vertical decelerations. Both occupants were over the age of 75 and at increased risk of fracture.

The seriousness of the injuries may have been compounded by the delay in alerting rescue services. There were no witnesses to the accident, and neither occupant was able to raise the alarm for some time. Having regained consciousness and managed to reach the pilot's mobile phone, the aircraft owner was able to call the emergency services. The air ambulance and other services arrived at the scene around two hours after the accident.

As the aircraft was operated under a Permit to Fly it was not required to be fitted with an Emergency Locator Transmitter (ELT) or for a personal locater beacon to be carried. These radio devices are activated manually or automatically in the event of an emergency and must be carried in aircraft with a Certificate of Airworthiness. ELTs that operate automatically in an accident (without the need for any action by the aircraft occupants), provide a means of alerting emergency services even if those in need of assistance are incapacitated.

Whilst a witness did see G-BAEE takeoff, neither occupant of the aircraft had informed anyone when they were about to depart and what time they were expected back. Whilst there was no requirement to provide this information to anyone, giving a friend or relative an expected time to call after the flight might provide an alert if things should not go to plan.

Weight and balance

G-BAEE had 106 litres of fuel on board for the permit renewal flight, with 52 litres in the front tank and 54 litres in the rear tank. The pilot and aircraft owner recorded the actual loaded weight for the flight as 705 kg, with the centre of gravity position recorded as 0.47 m aft of datum. Both these figures are inside the approved envelope. Whilst the weight may have changed during the flight as the fuel was consumed, it would have made no appreciable difference to the centre of gravity position, which would have remained inside the approved envelope.

Aircraft performance

The Jodel Flight Manual indicates that the maximum rate of climb at sea level is 650 fpm at maximum takeoff weight (780 kg), 709 fpm at maximum landing weight (740 kg) and 945 fpm at 600 kg. The aircraft weight at the beginning of the flight was noted on the Flight Test Schedule paperwork as 705 kg, at which the expected climb rate would be approximately 770 fpm.

During the flight the pilot performed a timed climb from 1,000 ft to 2,000 ft with normal best climb speed, maximum throttle and the airbrakes retracted. The Flight Test Schedule paperwork found in the wreckage indicated this climb took 90 seconds, which gives a rate of climb of 666 fpm. This figure is around 15% less than the performance expected from the flight manual. Whilst the test was not conducted at sea level, the recorded QNH was 1033 hPa and the outside air temperature 15°C, giving a density altitude of approximately 330 ft at 1,000 ft QNH. These atmospheric conditions alone would not account for a significant performance reduction.

When the aircraft last underwent a permit renewal in 2018, the recorded climb rate of 770 fpm at 680 kg was only 5% less than the book figure of 810 fpm. The test in 2018 was carried out in similar weather conditions (pressure and temperature) to that on the accident flight.

The aircraft owner did not recall the details of the timed climb but was able to state that the engine sounded normal during the final stages of the flight.

Meteorology

The southern part of the country was affected by a high-pressure system centred over northern France causing mild weather with a south-westerly airflow. Conditions were fine with good visibility. The cloud base was observed at between 2,500 ft and 4,500 ft. The London Gatwick Airport METAR at 1120 hrs gave a surface temperature of 16°C with a dewpoint of 8°C with wind observed at 240° at 11 kt. If the wind was similar at the airstrip this would have given a 10 kt tailwind on the landing runway. A pilot who was at the strip observed that the windsock suggested there was an 8 kt tailwind on Runway 03. The landing distance for G-BAEE was calculated from the performance information for the aircraft type.

Using the factors contained in the CAA Safety Sense Leaflet - *'Strip Flying'*[3]*,* the runway at Jackrell's Farm was sufficient for the planned landing in the conditions reported.

Using the chart provided in the Skyway Code[4] the combination of temperature and dew point would put the aircraft at risk of moderate carburettor icing[5] at cruise power settings and severe icing at descent power settings.

Personnel

The pilot had significant experience in light aircraft including in aircraft similar to G-BAEE. This included at least 700 hours experience of the same model of Jodel but with a different engine fitted. He had also flown G-BAEE on several occasions previously, although not recently. All his most recent flying had been exclusively on a three-axis microlight aircraft. The pilot was very familiar with Jackrell's Farm as his own aircraft was also based there.

The pilot has no memory of the accident flight and was unable to provide the investigation with any information. The aircraft owner stated that the permit renewal flight was complete with the exception of the baulked landing and the landing. The pilot had begun an approach to land on Runway 03. During this approach the aircraft owner felt that the pilot was flying too high and fast. The aircraft owner recalls that at some point the pilot decided to abandon the approach, but the aircraft was at a low height and close to the tall trees beyond the end of the runway.

Footnote

[3] Civil Aviation Safety Sense Leaflet 'Strip Flying (SS12), https://www.caa.co.uk/media/zrwcxzv0/caa8230_safetysense_12-strip-flying_v12.pdf [accessed June 2023]

[4] Civil Aviation Publication CAP 1535, https://www.caa.co.uk/general-aviation/safety-publications-and-information/the-skyway-code/ [accessed April 2023].

[5] Ice formation in a carburettor caused by the reduction in air pressure and air temperature in the carburettor venturi under certain atmospheric conditions.

Other information

All pilots adapt to the aircraft they fly, becoming familiar with the sights, sounds and performance. The three-axis microlight that the pilot flew regularly was lighter and able to slow down for landing more rapidly than G-BAEE. This would mean that if the pilot flew an approach using the technique and visual picture he was familiar with, this might have led to G-BAEE being too high and fast for the landing, the aircraft being harder to slow down than he was used to. Humans tend to revert to mental models they are familiar with such as when a driver changes from a manual to automatic car yet still seeks to push the clutch pedal down. These ‘reversions’ are often unconscious, and the driver or pilot may only realise once the action has been taken and the results are clear.

Analysis

During a go-around the aircraft collided with trees which arrested the aircraft’s energy, causing it to pivot around the tree and land almost vertically and upright on its undercarriage. The absence of ground marks and the damage to the aircraft indicate predominantly vertical impact forces, which could account for the nature of the injuries sustained by the occupants.

The pilot had completed all his recent flying on a three-axis microlight aircraft which had significantly different performance to G-BAEE. As the pilot does not recall the flight, it is not possible to confirm his intentions or the techniques he was using. Given the recollection of the aircraft owner, it is possible that in making the approach into Jackrell’s Farm the pilot had adopted the technique and visual picture he was used to from his regular flying in his own aircraft. This may have placed G-BAEE in a position where a landing was not possible. The position of the accident site and the account of the aircraft owner would indicate that a go-around was attempted but the aircraft performance was not sufficient to allow it to climb above the top of the tall trees.

Examination of the aircraft did not reveal any defects which could have affected its controllability. Evidence from the accident site indicated that the engine had been operating until the point of impact and this was consistent with the aircraft owner’s account. Although examination and partial disassembly of the engine revealed several minor anomalies, it did not reveal any gross defects which could cause a substantial reduction in engine performance nor account for the reduced cylinder compression ratios. However, the satisfactory results of the compression test noted during maintenance, which was conducted when the engine was hot, indicate that this was probably not a factor that contributed to the accident.

Although the aircraft owner recalled that the fuel selector handle had been selected to the front tank prior to the accident, the fuel selector valve was found in an intermediate position. Possible explanations include that the fuel selector handle had not been rotated fully clockwise to the front tank position or that the disruption to the linkage caused the valve to move during the impact. However, if reduced fuel flow or reduced engine performance contributed to the accident in any way, it was in a subtle manner which was not detected by the aircraft owner.

The timed climb test performed during the flight for the permit renewal showed that the aircraft performance was around 15% below that in the performance tables provided by the manufacturer. The same climb test for the 2018 permit renewal flight, which was carried out in similar temperature and pressure conditions, saw only a 5% reduction from the book figures. It is possible that the aircraft performance was below that expected for reasons that could not be identified. It is also possible that the pilot's unfamiliarity with the type meant that the test was not performed exactly as required and this was the cause of the poorer climb performance recorded in the Flight Test Schedule paperwork. The investigation did not establish what contribution engine performance or pilot technique may have made to the aircraft's climb performance during the flight.

The occupants of G-BAEE were both rendered unconscious or unable to raise the alarm after the accident for a significant period. The accident was not witnessed nor was the site directly visible to anyone around the area. It was around 90 minutes before the alarm was raised and over two hours before the first emergency responders arrived at the scene and were able to render assistance to the seriously injured occupants. The lack of an automatically activating ELT meant that the pilot and aircraft owner were reliant on one of them being able to manually alert the emergency services. With the injuries suffered by both occupants, their ability to search for, reach and use a mobile phone were extremely limited. Fortunately, the aircraft owner was able to locate and use the pilot's mobile phone. Whilst it is not possible to speculate on what effect the delay might have had in the seriousness of the occupants' condition, such delays increase the risk of serious complication or fatality.

Conclusion

During an attempted go-around from an approach into Jackrell's Farm airstrip with a tailwind, the aircraft was unable to clear tall trees beyond the end of the runway. Although the aircraft owner recalled that the aircraft was high and fast on the approach, the pilot was unable to recall any of the flight.

There were no witnesses to the accident, the occupants were incapacitated, and an ELT was not fitted the aircraft. Consequently, no person or organisation was alerted to the accident for a significant period. Letting someone know a time to expect you to call after a flight is complete may enable appropriate assistance to be provided if things don't go to plan.

The investigation did not find any technical anomalies that could have substantially contributed to the accident.

Published: 24 August 2023.

ACCIDENT

Aircraft Type and Registration:	Schleicher ASW 20 L, G-CFRW
Year of Manufacture:	1978 (Serial no: 20202)
Date & Time (UTC):	24 September 2022 at 0856 hrs
Location:	Near Pulborough, West Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	UK Part-FCL Sailplanes/Powered Sailplanes Flight Crew Licence
Commander's Age:	21 years
Commander's Flying Experience:	454 hours (of which 201 were on type) Last 90 days - 71 hours Last 28 days - 14 hours
Information Source:	AAIB Field Investigation

Synopsis

Shortly after an aerotow takeoff and during a noise abatement turn to the left, the glider released the tow at approximately 300 ft agl. The glider then pitched down rapidly and struck the ground in a nose low attitude at high speed. The pilot was ejected from the aircraft during the accident sequence and was found approximately 26 m from the aircraft. He sustained fatal injuries.

An on-site inspection of the aircraft revealed that the elevator was not connected to the elevator control rod. Two Safety Recommendations have been made; the first to mandate Positive Control Checks and the second to amend the Flight and Operations Manual to include relevant information on the limitations of pitch control using flaps.

History of the flight

The accident pilot and a friend, also a glider pilot, both trailered gliders from Lasham Airfield to Parham Airfield on the morning of the accident. They arrived at Parham at approximately 0640 hrs, parked their glider trailers on the edge of the airfield and then immediately began to rig their aircraft. Working together the two pilots first rigged the non-accident glider which was a different type. After rigging the first aircraft they conducted a Daily Inspection (DI) and a positive check of that aircraft's flying controls.

The friend then helped the accident pilot to attach the wings to G-CFRW. When that was completed he returned to his own glider to position his parachute in the cockpit and check the electrical systems on his aircraft. The pilots, again working together, towed both of the now rigged gliders to the launch point on the grass Runway 04.

Once the two gliders had been positioned on the launch point both pilots went to the clubhouse for coffee. Members of the local gliding club began arriving at the airfield at around 0730 hrs and recalled seeing the two gliders already rigged and at the launch point. After coffee the two visiting pilots assisted the local club members in getting aircraft out of the hangar. They then worked together to conduct a DI of one of the club gliders, including positive checks of the flying controls.

The pilots then attended the morning brief which was conducted by the club Duty Instructor. The briefing covered the weather forecast and issues arising from it. The Duty Instructor discussed factors which might affect gliders ridge flying as the day progressed and the prospect of increasing cloud cover reducing lift. He also refreshed to those present airmanship points for flying on the ridge and covered touch drills for releasing a tow.

After the main briefing the Duty Instructor gave an additional brief to visiting pilots, including the two from Lasham Airfield. In this he discussed field landing options to the north of the airfield in the event of a failed aerotow and re-join procedures for the airfield, he then completed temporary membership forms for the visitors.

The club operates two launch lines, one for club aircraft and one for private and visiting gliders. The accident aircraft was second to launch in the private aircraft line. G-CFRW took off at 0855 hrs and was witnessed by numerous people. The witnesses described the initial stages of the takeoff as normal but then as speed increased noted that the glider seemed to be more nose down than usual. The tug aircraft left the ground before the glider which was also considered unusual. After becoming airborne following a longer ground run than usual, the glider pitched down and bounced twice. Once it became airborne again witnesses described the glider as being in a low towing position.

The pilot of the tug aircraft also noted the two bounces of the glider and considered this unusual. As the tug pilot began the planned noise abatement turn to the left, he was looking in his mirrors in case the glider flew wide. He saw the glider move to a “low tow” position. The tug pilot considered this abnormal but was not unduly concerned as he knew the glider pilot was experienced. The tug pilot then lost sight of the glider and shortly after felt the glider release the tow. He asked for confirmation via RTF that the glider pilot had released the tow but he received no reply. The tug pilot continued to turn left to check that the glider had released the tow and then saw the damaged glider in a field. He informed the launch point of the accident via RTF and orbited the accident site to assist with co-ordination of the ground response.

Eyewitnesses on the ground saw the glider release the tow in the left turn. After the release they described the glider pitching down at a steep angle until they lost sight of it behind trees. Personnel from the gliding club called the emergency services and made their way to the accident site with the airfield fire vehicle. On scene they conducted CPR on the injured pilot, but he had sustained fatal injuries.

Aerodrome information

Parham Airfield is located to the north west of Shoreham Airport (Figure 1).

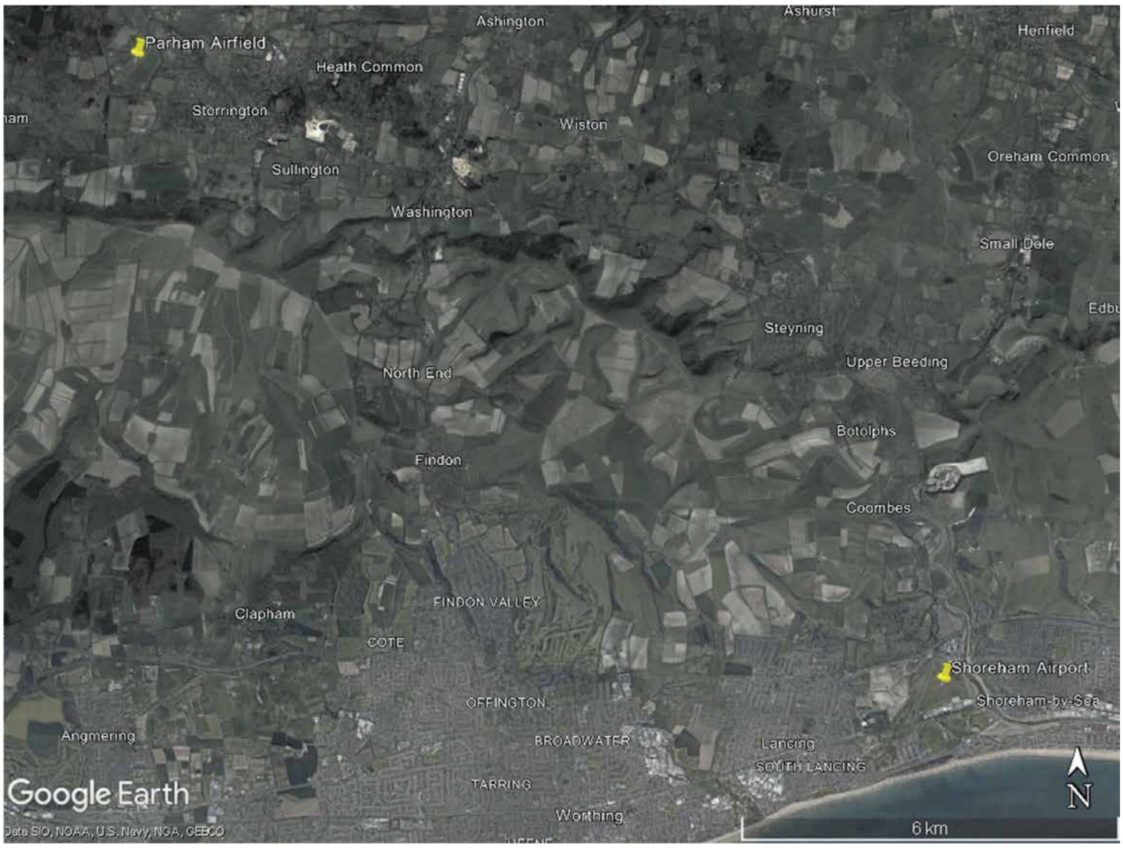


Figure 1
Location of Parham Airfield

It is a grass airfield with one Runway 04/22 which is 650 m long. The operating club has divided the surface into a glider landing area and an aerotow strip (Figure 2).

The operating club have established local procedures to avoid noise sensitive areas near the airfield. Runway 04 was in use for the accident flight and the suggested route is at Figure 3.

Figure 2
Airfield layout – contained in operating club's documents

Figure 3
Noise abatement route for Runway 04 – contained in operating club's documents

Accident site

The aircraft wreckage was found in a field north of Parham Airfield (Figure 4).

Figure 4
Location of accident site

The ground marks and damage to the aircraft structure indicated that the aircraft struck the ground with the right wing slightly low and in a steep nose-down attitude. Ground marks and scratches found on the lower surface of the left wing showed that after the right wing and nose had struck the ground, the aircraft rotated to the right, dragging the left wing along the ground as the aircraft's momentum carried it forwards. The aircraft came to rest pointing towards the initial impact point with the tail boom structure disrupted in two places and bent towards the right wing (Figure 5). The nose and cockpit structure were fragmented, leaving only the severely damaged flight controls, some twisted cockpit structure and the two uppermost seat harness shoulder straps still anchored to the aircraft. The lower two seat harness anchor points had been torn from the structure as the cockpit broke apart.

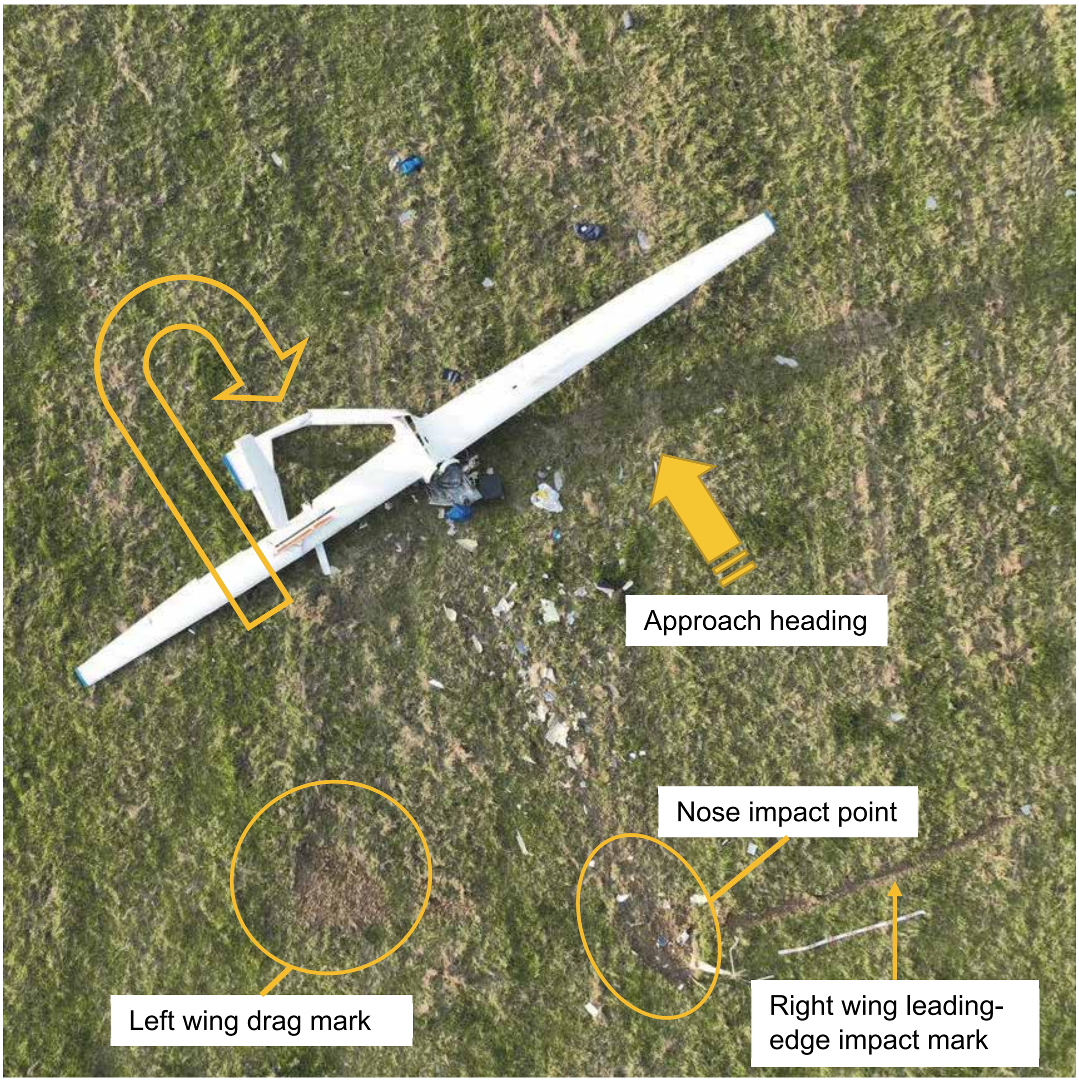


Figure 5

Overhead picture of wreckage showing ground marks

The upper surface of the fuselage skin had split longitudinally from the cockpit to the middle of the tail boom. Both wings were still attached to the fuselage and the right wing airbrake was deployed, but had been bent forwards by the force of the initial impact. The left airbrake also deployed but had not bent forwards.

The canopy transparency shattered as the canopy was thrown ahead of the aircraft landing approximately 14 m away. The pilot was found 26 m forward of the aircraft in a direct line with the aircraft's approach heading. Given the extent of the injuries sustained by the pilot and documented in the post-mortem report, this accident was not survivable.

Aircraft information

General

The ASW 20/20 L is a single seat sail plane (Figure 6) of composite construction. It features trailing edge flaps which interconnect with the ailerons to allow the entire trailing edge to operate as a flap.

Figure 6
Schleicher ASW 20

The wings and horizontal stabiliser are removable for storage and transportation in a trailer. After removal from the trailer and prior to flight, the wings and horizontal stabiliser need to be assembled to the fuselage, and the ailerons, flaps, spoilers and elevator controls connected to their respective control surfaces. This process is known as rigging the aircraft.

Elevator connection

The elevator pushrod on G-CFRW was capped with a L'Hotellier cup connector.

The elevator has a ball fitting attached to its lower surface which is inserted into the L'Hotellier cup connector to connect the control pushrod to the control surface (Figure 7).

Pressing the spring-loaded lock plate in allows the latch in the cup to move into the barrel of the connector to make room for the ball to fit into the cup. Once the ball is inserted and the lock plate released, the latch clamps onto the ball holding it in place. To ensure the latch remains seated against the ball, an 'R' shaped spring clip is inserted into the lock plate to prevent it from dislodging and allowing the latch on the cup to release the ball. The pin on the ball protrudes through the slot in the L'Hotellier cup when properly connected. There are six other manually connected L'Hotellier connections on the ASW 20 for the ailerons, flaps and airbrakes. These L'Hotellier connections are secured with a safety device known as a Wedekind sleeve, and do not use a spring clip, thus the elevator connection was the only control connection on G-CFRW which required the use of a spring clip. The presence of a spring clip is checked as part of the annual maintenance check.

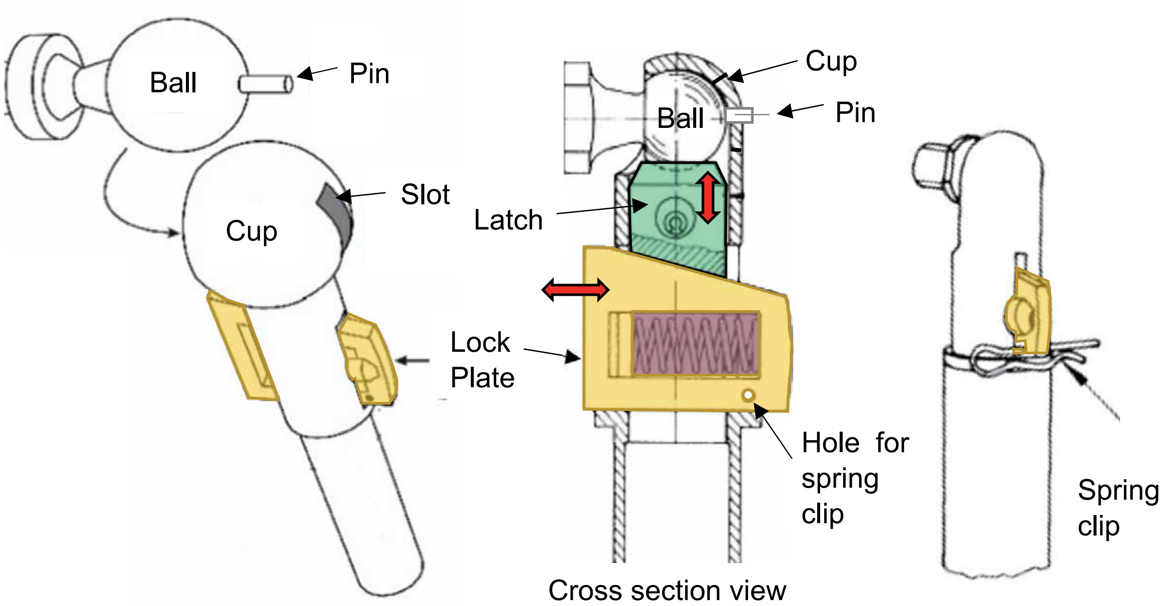


Figure 7

Diagrams showing details of the L'Hotellier cup and ball connection

Flight and Operations Manual elevator rigging

Page 36, Section 2.1 of the aircraft's Flight and Operations Manual (FOM) includes the following information when fitting the horizontal stabilizer or horizontal tail:

> *'The horizontal tail, first, is only inserted into the vertical tunnel of the fin. Then the ball fitting at the elevator is connected. And now the horizontal tail is pushed back until the Allan bolt at the nose can be screwed in.'*

Further information on how the L'Hotellier quick-release connectors should be checked and secured correctly is given on page 44b[1] of the FOM (Figure 8).

Footnote

[1] Issue 16.02.98 '*Jumtow*' Revision TN No.39.

Checking and securing the L'HOTELLIER quick-release connectors in the control linkages

1. Securing

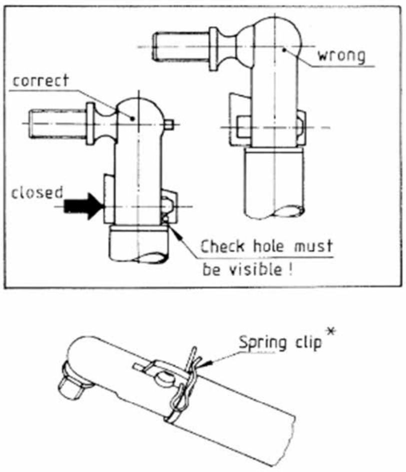
Past experience showed that the quick-release connectors in the control linkages, particularly the one at the elevator, were incorrectly assembled or their assembly was even completely forgotten. A sticker fixed to the fin serves to remind the pilot of the correct assembly. In addition all quick-release connectors **must** be secured by means of safety pins, spring clips etc.. With the older type of connectors their check hole must be drilled to approx. 1.2 mm dia. for this purpose. The aileron, flap and airbrake connectors in the fuselage must be secured analogously.

Figure 8

Paragraph 1 of page 44b of the FOM

No fin sticker was found on G-CFRW or two other exemplar ASW 20 gliders. The manufacturer was not able to provide any information about the fin sticker. Diagrams of the correct and incorrect connection of the L'Hotellier quick-release connectors and location of the spring clip are shown in Figure 9.

A S W 2 0 L - Flight Manual



* Spring pin no.50030771 can be ordered from Alexander Schleicher or from A.Wfirth, P.O.Box 1261, 7118 Kflnzelsau, F.R.Germany.

2. Inspection

According to experience accumulated in Australia the following inspection of the L'Hotellier connections must be carried out at every annual inspection, especially when the glider is operated frequently from sandy and dusty airfields.

TN No.17 44c

Figure 9

Page 44c of G-CFRW's FOM

Automatic elevator connection

On 6 November 1986, the aircraft manufacturer released optional modification ASW 20/20 L Technical Note No 29 which introduced an automatic elevator connection to the ASW 20/20 L aircraft series. The modification also became a factory standard installation on ASW 20 B and C models and subsequent variants.

The modification replaces a section of the elevator actuating hinge with a 'T-fitting' which is glued onto the tail fin upper surface forward of the elevator pushrod box section. At the top of the T-fitting is a 'bearing mounting' with a mid-section of elevator actuating hinge attached (Figure 10).

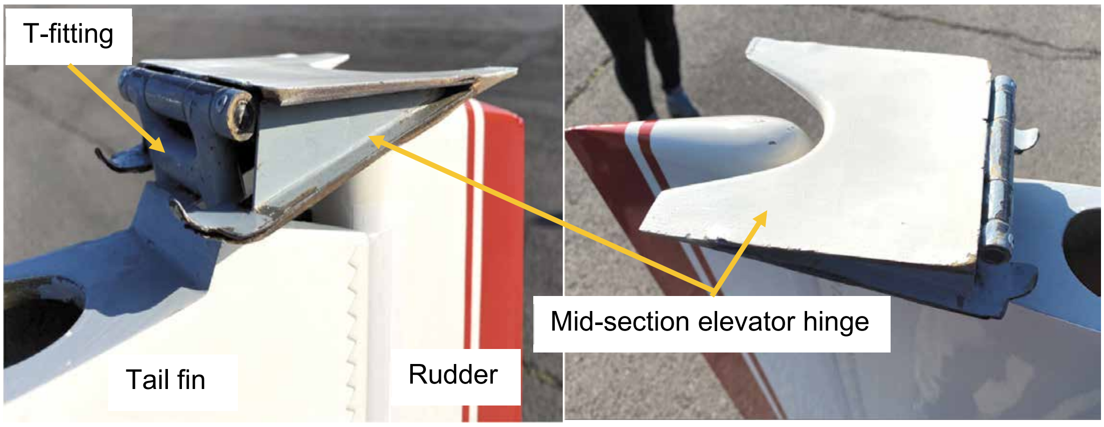


Figure 10

Automatic elevator connection showing T-fitting (Left)
and mid-section elevator hinge (Right)

This mid-section of elevator hinge is slid into place between elevator hinge ribs as the horizontal stabilizer is mounted onto the tail fin (Figure 11).

Figure 11

Horizontal stabilizer sliding aft onto mid-section elevator hinge (Left)
and elevator hinge section in place (Right)

To actuate the elevator hinge, an 'elevator pushrod' replaces the L'Hotellier cup connection and is fixed to the elevator control surface by a bracket (Figure 12). The modification may be considered expensive and potentially cost prohibitive by owners when compared to the cost of purchasing the glider. Whilst this optional modification was available, it had not been adopted on the accident aircraft.

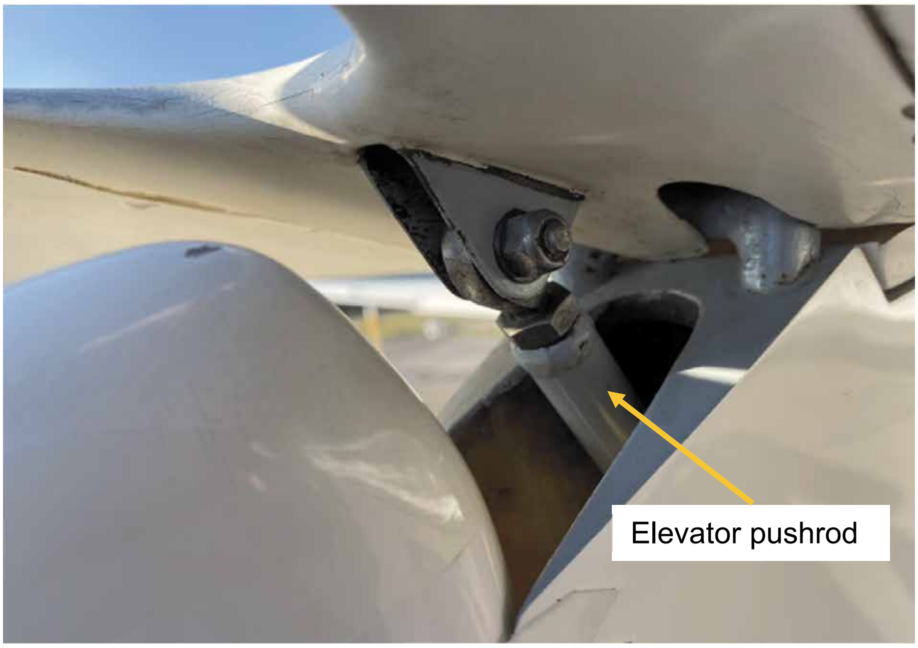


Figure 12

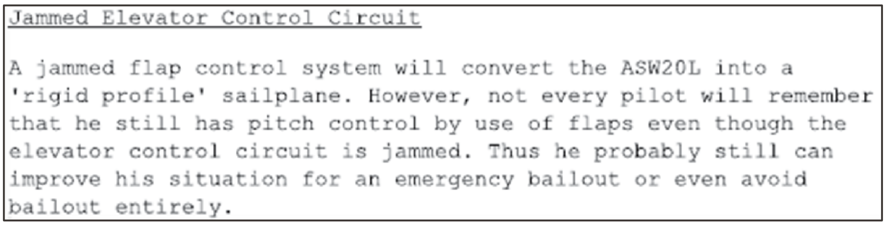
Elevator pushrod connection to the elevator control surface

Aerotow cable examination

Examination of the tow cable, which was still attached to the tug aircraft after the accident, and the weak link did not reveal any defects or breaks in the cable.

ASW 20 L Emergency Procedures

The FOM for the ASW 20 L contains a sub-section entitled 'Jammed Elevator Control Circuit' in the 'Emergency Procedures' section (Figure 13) which states that the aircraft is controllable in pitch by use of the flaps when the elevator control circuit is jammed.


Jammed Elevator Control Circuit

A jammed flap control system will convert the ASW20L into a 'rigid profile' sailplane. However, not every pilot will remember that he still has pitch control by use of flaps even though the elevator control circuit is jammed. Thus he probably still can improve his situation for an emergency bailout or even avoid bailout entirely.

Figure 13

Jammed Elevator Control Circuit procedure

When asked to expand, the manufacturer stated that flap control cannot replace the elevator and that only small corrections are possible. The manufacturer was not able to provide detailed information about the aircraft's response to flap input, however it did state:

> *'In the event that the elevator control is stuck in neutral, it may be possible to initiate a controlled descent. If the elevator is not connected or is stuck in another position, control of the flight is no longer possible.'*

It is not known if the pilot was aware of this procedure or if he attempted its use during the accident flight.

Elevator control connection examination

Examination at the accident site of G-CFRW revealed that all the flight controls other than the elevator were correctly connected. The elevator was found disconnected at the L'Hotellier joint (Figure 14).

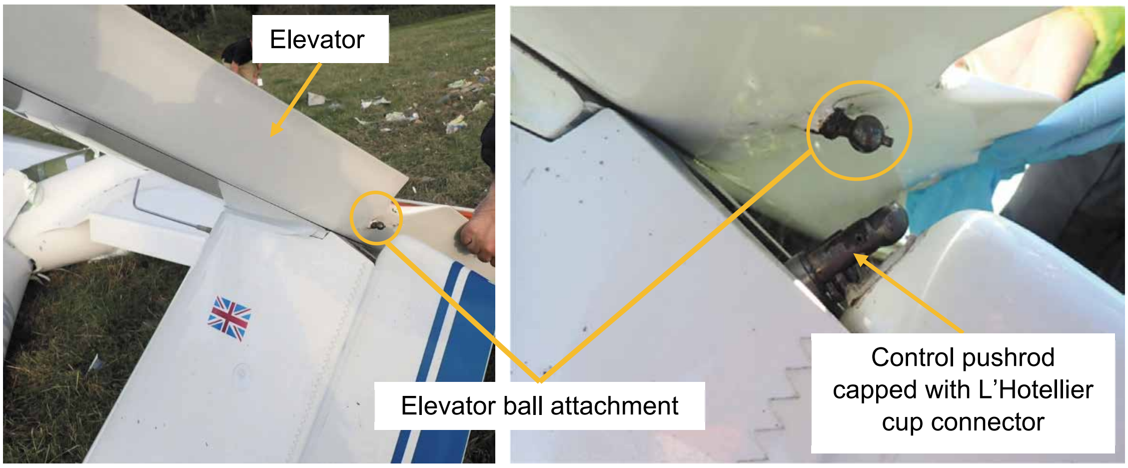


Figure 14

Images at the accident site showing that the L'Hotellier ball and cup were not connected

For comparison, Figure 15 shows an example of how the connection should look on a similar aircraft when correctly assembled. The red string attached to the spring clip was a personal modification by the owner of that aircraft to prevent the spring clip from dropping into the tail fin. It also helped the clip to remain visible and attached to the L'Hotellier cup connector when not fitted to the lock plate.

Detailed examination of the accident aircraft's elevator control mechanism revealed that it was free from any defects which would have prevented its proper assembly.

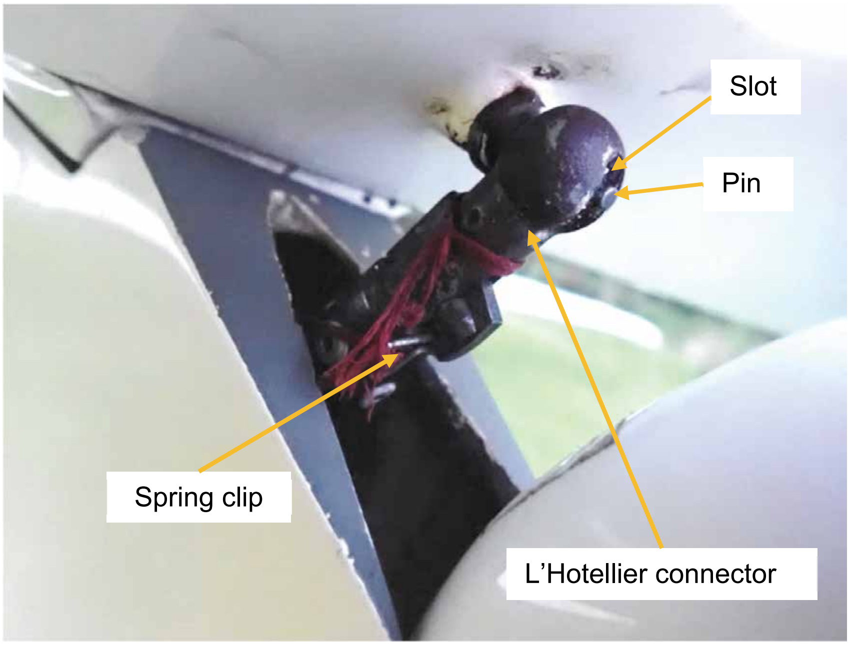


Figure 15

An example of correct elevator connection with spring clip fitted

No spring clip was found in G-CFRW's elevator L'Hotellier lock plate, although there were vertical scratch marks present on the inside of the fin, aft of the vertical tunnel, which may have been evidence of contact with the legs of the spring clip from previous fittings. Spare spring clips were found in a tool roll in the glider's trailer, along with the tool for fitting the Allan bolt[2] to the horizontal stabilizer. A packet of spare spring clips was also found in the pilot's car.

Incorrect elevator rigging tests

As part of the investigation several tests were undertaken to incorrectly rig the elevator L'Hotellier connector on the accident aircraft. The tests included partial location of the ball into the L'Hotellier cup. Whilst it was possible to partially locate the ball into the cup, even slight movement of the elevator control resulted in the ball either audibly 'snapping' back into the cup or disconnecting. In addition, when partially connected, the spring clip hole was hidden by the cup connector as the latch was forced into the barrel of the cup connector by the diameter of the ball. During these tests it was not determined whether a partial connection, which could subsequently have become disconnected, could be achieved.

Meteorology

The weather was fine with light winds and was not a contributory factor in the accident.

Footnote

[2] The Allan bolt secures the horizontal stabiliser to the tail fin once the stabiliser has been inserted into the vertical tunnel of the fin and pushed aft into place.

Pilot information

The pilot was an experienced glider pilot with 454 hours and 396 launches. He had considerable cross-country experience and had been selected as a member of the BGA Junior British Team. He was also a qualified Basic Instructor on gliders and held an EASA PPL(A).

The pilot had purchased G-CFRW in September 2021 and had operated it since then. It was routinely stored in a trailer. As part of the investigation, it was determined that the pilot was aware of the need for spring clips on the elevator L'Hotellier connection.

British Gliding Association guidance

The BGA publishes a Safety Briefing entitled *'Is Your Glider Fit for Flight'*[3] which highlights the importance of preparing correctly for flight and gives guidance on how to do so. It also identifies glider types and control mechanisms which are considered especially vulnerable to rigging errors. To avoid flying with an unprepared aircraft, the briefing suggests the following:

- *'Rigging should be directed by a person experienced on the type, in accordance with the flight manual, without interruption or distraction.*
- *A newly rigged glider should always have a Daily Inspection (DI).*
- *The DI should be conducted by a person experienced on the type, without interruption or distraction.*
- *Positive Control Checks*[4] *should be carried out every time for every rigging of a glider.*
- *It is essential for Positive Control Checks to be carried out every time for every rigging of a glider without automatic control connections.*
- *The pilot should carry out proper pre-flight checks, again without interruption or distraction.'*

While the briefing suggests that a DI should always be conducted, there is no BGA requirement for such checks to be recorded.

Footnote

[3] BGA Safety Briefing https://members.gliding.co.uk/library/safety-briefings/is-your-glider-fit-for-flight [accessed June 2023].

[4] A Positive Control Check requires the control surfaces to be restrained lightly by one person while the flying controls are moved by another person. It can reveal issues with control connections that have been only partially engaged.

The briefing also contains the following warning:

'SHORTCOMINGS IN PREPARING A GLIDER FOR FLIGHT CAN BE LETHAL AND ARE COMPLETELY AVOIDABLE.'

The briefing recognises that errors in rigging are frequently caused by interruption, distraction, forgetfulness and the making of unwarranted assumptions. The BGA stresses the importance of conducting rigging, DIs and pre-flight checks without interruption or distraction. The briefing suggests that to minimise such risks post rigging, a glider should be checked ideally by another qualified person but at least by someone with a *"fresh frame of mind"*. The BGA suggests that pilots maintain a DI book to record inspections and while many clubs and individuals follow the guidance, it is not mandated. No DI book was found for the accident aircraft and subsequent enquiries revealed that the pilot did not use one.

ASW 20 gliders are identified in the briefing as vulnerable to elevator rigging errors and particular attention is drawn to the L'Hotellier connectors. The briefing states:

> *'In all cases, check the connection carefully, and perform a Positive Control Check to ensure there is more linking the elevator to the control mechanism than just gravity. If the neutral position or range of travel looks strange, it could be the sign of an unconnected elevator.'*

A check of flying controls is also taught as part of the BGA Gliding Training Syllabus[5]. However, on an ASW 20 L, it is likely that if the elevator controls were left disconnected, the control surface would still move in the correct sense due to gravity and in response to control column movement. Therefore, such a check without resistance applied to the control surface would be unlikely to reveal the presence of the disconnected elevator control mechanism.

In another Safety Briefing entitled Aerotow Performance[6], the BGA suggests identifying a takeoff decision point. It defines this as follows:

> *'It makes sense to identify a runway point at which the tug and the glider can be safely stopped in the event of engine or other malfunction, eg low engine rpm, lack of acceleration or dragging brakes. If the grass is wet or damp, anticipate the extra space needed to stop. Do NOT become committed to a 'go-mode' to the exclusion of all else. If the tug is still on the ground and not accelerating, stick to the decision-point and abandon the launch.'*

In this case witnesses reported that the glider had become airborne after the tug aircraft and that was considered to be unusual. Glider pilots interviewed stated that at Parham if they were not airborne from Runway 04 abeam the windsock, they would release the tow and reject the takeoff. This suggestion was not discussed as part of the morning brief.

Footnote

[5] https://members.gliding.co.uk/library/pilot-training/bga-gliding-syllabus/ [accessed June 2023].

[6] BGA Safety Briefing Aerotow Performance Aerotow-Performance.-pdf.pdf (gliding.co.uk) [accessed June 2023].

Safety Actions

As a result of this accident the BGA has taken the following safety action:

> Published an online 'Safe Rigging Toolkit'[7] with significant emphasis on the human factors associated with mis-rigging.

At the time of publication of this report the BGA is planning an animated video to provide guidance to BGA members for rigging gliders.

The BGA is also reviewing the DI book format to include a dedicated box to record a Positive Control Check. A signatures box for when 'rigging is complete' and 'independent rigging checks if required' are also being considered.

Analysis

Introduction

The aircraft most likely became airborne with the elevator control disconnected. The tow was released shortly after takeoff, and the aircraft pitched down rapidly. The tow cable remained attached to the aerotow aircraft after the accident and there was no defect or break in the tow cable or the weak link, hence it was likely that the glider pilot released the cable during the aerotow takeoff. The distribution of the wreckage and ground marks were consistent with the aircraft striking the ground in a nose down attitude at a high rate of descent resulting in an accident that was not survivable.

The investigation did not identify any defects with the elevator control connection which would prevent it being properly connected. It is therefore considered that the connection had not been correctly made when the glider was assembled prior to the accident flight. It was not determined whether the task of connecting the elevator control was omitted during the rigging, or whether a partial connection was achieved, which may subsequently have become disconnected. But the investigation was not able to replicate a partial connection on the accident glider or other similar gliders.

Preparation for the flight

On arrival at Parham the pilot helped rig his friend's glider. Once the rigging was complete, they conducted a Positive Control Check on this glider in accordance with the BGA guidelines. Both then worked together to attach the wings to the accident aircraft. Once the wings were attached the friend went to work on his own glider leaving the pilot to complete the rigging of the accident aircraft by himself. The friend conducted other checks on his own aircraft and when they both came together again, they towed both aircraft to the launch point.

Footnote

[7] Safe Rigging - Pilot & Club Info (https://members.gliding.co.uk/bga-safety-management/managing-flying-risk-index/safe-rigging/) [accessed June 2023].

After towing the aircraft to the launch point the accident pilot and his friend went to the clubhouse for coffee and then assisted club members in preparing other gliders. They both worked together to conduct a DI of a club glider. No witnesses recalled taking part in a Positive Control Check with the pilot on the accident aircraft and, given that the task requires two people, it is probable that it was not conducted. One possibility is that the pilot was distracted which interrupted the process after rigging and that the pilot forgot to conduct the Positive Control Checks on his aircraft. It is further possible that by conducting those checks on a different aircraft he was cognitively satisfied that the checks were complete on his own aircraft.

It was not determined if, as part of his pre-flight checks, the pilot conducted a walk round inspection of the aircraft. It is not known whether the pilot performed a full and free control check at the launch point; however, as the control rod can still push the elevator surface up and it can fall under gravity, this would be unlikely to have detected a disconnected elevator control.

Aircraft rigging

L'Hotellier connections are fitted to many glider types and are known to be vulnerable to mis-rigging. Several safety devices exist to make L'Hotellier connections more robust and prevent them from disconnecting in flight. These include spring clips to secure the lock plate, Wedekind sleeves (such as fitted to G-CFRW's aileron, flap and airbrake connections) and Uerling sleeves. Of these safety devices, the spring clip is the simplest but offers the least protection as it is not an integral part of the L'Hotellier connection and is required to be fitted separately.

The ASW 20 L FOM states that the controls should be 'safe tied' by inserting spring clips through holes in the L'Hotellier connector lock plates. The spring clips can only be inserted when the mechanism of the L'Hotellier connector is correctly assembled and attached to their respective flying controls. No spring clip was found in the elevator's L'Hotellier lock plate, although the possibility of it being lost in the accident sequence could not be discounted. The vertical scratch marks present on the inside of the fin may have been evidence of contact with the legs of spring clips previously fitted to the elevator's L'Hotellier lock plate.

Unlike many other glider types, the elevator connection on the ASW 20/20 L is visible when the elevator control surface is lifted. This enables a secondary post-rigging visual inspection which, if performed, could identify a disconnected or partially connected L'Hotellier connection or a mis-installed or absent spring clip. The pin on the elevator ball protrudes through the slot in the L'Hotellier cup when properly connected (Figure 7). This, together with the position of the lock plate provides visual and tactile cues to verify correct engagement of the L'Hotellier connection. Pulling the control rod or trying to depress the lock plate can provide further indications of correct connection.

On the ASW 20/20 L, the likelihood of mis-rigging the elevator connection can be fully mitigated by installing the optional automatic elevator connection modification ASW 20/20 L Technical Note No 29. However, the high cost of the modification discourages many owners from embodying this option. Without the protection provided by automatically connecting controls, mitigation for mis-rigging relies entirely on rigging procedures, secondary checks and Positive Control Checks.

BGA rigging guidance

The BGA guidelines recommend that a newly rigged glider should have a DI and that it is essential for gliders without automatically connecting controls to have a Positive Control Check, although there is no formal requirement for a record of such checks. If a glider's flight controls have been mis-connected during rigging, the only reliable ways to identify this condition prior to flight are a secondary check of the control connections and a Positive Control Check. The guidelines also suggest that post-rigging checks should be carried out with '*fresh eyes'* by another person. Similarly, there is no formal requirement for this independent check. The BGA Briefing, *'Is Your Glider Fit for Flight'*, refers repeatedly to the risks posed to correct rigging by interruption or distraction during the rigging process.

As a result of this accident the BGA have taken the safety action of publishing of a '*Safe Rigging Toolkit*'. It is planning to publish an animated video about safe rigging. It is also drafting an update to the content and format of the DI book to include a dedicated box to record a Positive Control Check. The most effective barrier to prevent mis-rigging is by robust design at the outset, or retrospective approved modification, which can be a costly option for glider owners. Whilst the BGA's Safety Actions are likely to be beneficial for the safe rigging of gliders, an independent Positive Control Check is an effective barrier against mis-rigging. As this is not a formal requirement for BGA members, to increase the likelihood of Positive Control Checks being conducted before flight the following Safety Recommendation is made:

Safety Recommendation 2023-026

It is recommended that the British Gliding Association should mandate the conduct and documenting of Positive Control Checks as part of glider Daily Inspections.

Emergency procedures and pitch control

In the ASW 20 L FOM, the manufacturer refers to an alternative means of pitch control in the event of a failure of the elevator circuit. It is not known if the pilot was aware of this procedure or if he attempted its use during the accident flight. However, there is insufficient information for a pilot to understand the extent of the reversionary control and how to achieve it.

During the investigation the manufacturer stated *"In the event that the elevator control is stuck in neutral, it may be possible to initiate a controlled descent. If the elevator is not connected or is stuck in another position, control of the flight is no longer possible"*. Such limitations on pitch control by flap are not made clear in the FOM. The FOM does not give a procedure for controlling pitch with flap but the manufacturer stated that downward flap deflection would cause a pitch up moment on the aircraft.

In order to address the lack of clarity in the FOM regarding the level of pitch control available for a range of elevator control circuit failure scenarios, the following Safety Recommendation is made:

Safety Recommendation 2023-027

It is recommended that Alexander Schleicher GmbH & Co Segelflugzeugbau amend the Jammed Elevator Control Circuit section of the ASW 20 Flight and Operations Manual to include relevant information on the limitations of pitch control using flaps and its likelihood of allowing a safe landing.

Conclusion

The aircraft took off with the elevator control disconnected and control of the aircraft was lost shortly after becoming airborne. The aircraft struck the ground in a steep nose-down attitude and the pilot sustained fatal injuries.

Regardless of the type of control connection used on a glider, Positive Control Checks offer the ability to detect a mis-rigging condition before flight. In the case of G-CFRW, it is unlikely that Positive Control Checks, were carried out.

Published: 31 August 2023.

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:	AW169, G-UNIB
No & Type of Engines:	2 Pratt & Whitney Canada PW210A turboshaft engines
Year of Manufacture:	2022 (Serial no: 69152)
Date & Time (UTC):	21 February 2023 at 0800 hrs
Location:	Humberside Airport, North Lincolnshire
Type of Flight:	Hoist operations
Persons on Board:	Crew - 3 Passengers - 4
Injuries:	Crew - None Passengers - None
Nature of Damage:	Hoist hook and 20 cm of cable severed from hoist
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	5,440 hours (of which 490 were on type) Last 90 days - 50 hours Last 28 days - 25 hours
Information Source:	Aircraft Accident Report Form submitted by the commander plus further enquiries by the AAIB

Synopsis

During aircraft pre-start procedures, one of the passengers reported that he had seen something fall from the aircraft. The ground crew subsequently reported that the hoist hook had detached from the hoist cable and fallen to the ground. Although there were no functional, mechanical or electrical problems found with the hoist system, it was possible that procedural drift may have resulted in inadvertent activation of the hoist cut system, severing the hoist cable.

The Operator has stressed to their crews the importance of following the organisation's published aircraft start checklists. They have also amended their checklist to include a more detailed hoist start up sequence which contains the warnings from the aircraft's Rotorcraft Flight Manual external hoist system supplement.

History of the pre-flight operation

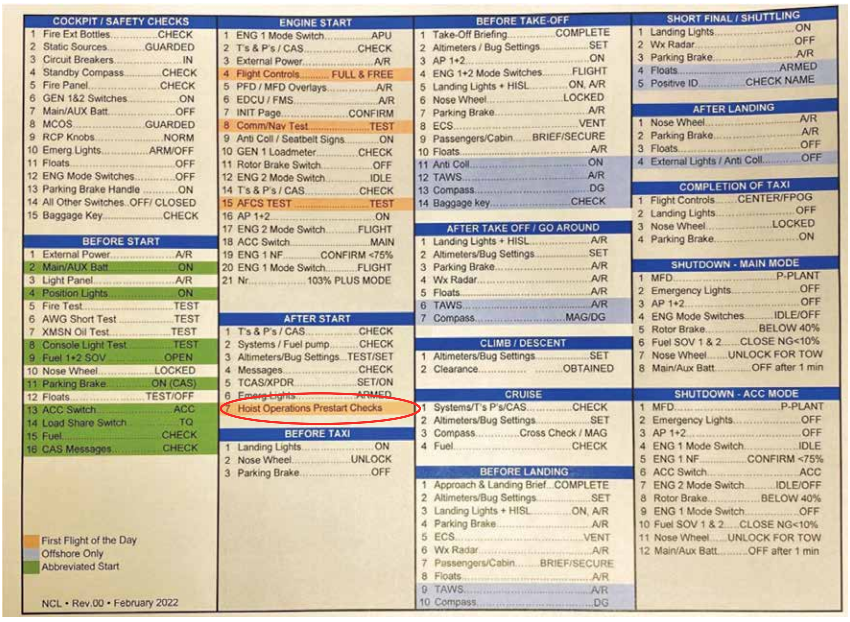
The operator's maintenance organisation had already completed a ground power check and an engine compressor wash procedure before the flight crew began their walk to the aircraft at approximately 0750 hrs. The crew arrived at the aircraft with plenty of time to spare before their scheduled takeoff time of 0800 hrs. The crew consisted of the Pilot Flying (PF) who was also the aircraft commander, the Pilot Monitoring (PM) plus an experienced hoist operator (HO). Their plan was to hoist Helicopter Landing Officers (HLOs) and Wind

Turbine Technicians onto various offshore turbines to undertake repairs and maintenance contracted by an offshore wind farm organisation (Figure 1).

Figure 1

Example pictures of wind turbine hoist operations

The PF proceeded with a ‘walkaround’ check of the helicopter’s external features whilst the PM climbed into the right cockpit seat to begin pre-flight preparations. The HO entered the cabin to assist HLO2, one of two HLOs to be transported that day, to get seated and secure various pieces of equipment. Ground power had already been connected to the aircraft during the previous power check and compressor wash procedure. The PM began his pre-start procedures with the cockpit safety checks listed in company check list document NCL Rev 00 dated February 2022 (company checklist), shown in Figure 2. He reached the engine start procedure but stopped before starting the engines because the PF was still outside the helicopter and had not finished his walkaround check.



COCKPIT / SAFETY CHECKS
1 Fire Ext Bottles....CHECK
2 Static Sources....GUARDED
3 Circuit Breakers....IN
4 Standby Compass....CHECK
5 Fire Panel....CHECK
6 GEN 1&2 Switches....ON
7 Main/AUX Batt....OFF
8 MCOS....GUARDED
9 RCP Knobs....NORM
10 Emerg Lights....ARM/OFF
11 Floats....OFF
12 ENG Mode Switches....OFF
13 Parking Brake Handle....ON
14 All Other Switches..OFF/ CLOSED
15 Baggage Key....CHECK

BEFORE START
1 External Power....A/R
2 Main/AUX Batt....ON
3 Light Panel....A/R
4 Position Lights....ON
5 Fire Test....TEST
6 AWG Short Test....TEST
7 XMSN Oil Test....TEST
8 Console Light Test....TEST
9 Fuel 1+2 SOV....OPEN
10 Nose Wheel....LOCKED
11 Parking Brake....ON (CAS)
12 Floats....TEST/OFF
13 ACC Switch....ACC
14 Load Share Switch....TQ
15 Fuel....CHECK
16 CAS Messages....CHECK

First Flight of the Day
Offshore Only
Abbreviated Start

NCL • Rev.00 • February 2022

ENGINE START
1 ENG 1 Mode Switch....APU
2 T's & P's / CAS....CHECK
3 External Power....A/R
4 Flight Controls.... FULL & FREE
5 PFD / MFD Overlays....A/R
6 EDCU / FMS....A/R
7 INIT Page....CONFIRM
8 Comm/Nav Test....TEST
9 Anti Coll / Seatbelt Signs....ON
10 GEN 1 Loadmeter....CHECK
11 Rotor Brake Switch....OFF
12 ENG 2 Mode Switch....IDLE
14 T's & P's / CAS....CHECK
15 AFCS TEST....TEST
16 AP 1+2....ON
17 ENG 2 Mode Switch....FLIGHT
18 ACC Switch....MAIN
19 ENG 1 NF....CONFIRM <75%
20 ENG 1 Mode Switch....FLIGHT
21 Nr....103% PLUS MODE

AFTER START
1 T's & P's / CAS....CHECK
2 Systems / Fuel pump....CHECK
3 Altimeters/Bug Settings...TEST/SET
4 Messages....CHECK
5 TCAS/XPDR....SET/ON
6 Emerg Lights....ARMED
7 Hoist Operations Prestart Checks

BEFORE TAXI
1 Landing Lights....ON
2 Nose Wheel....UNLOCK
3 Parking Brake....OFF

BEFORE TAKE-OFF
1 Take-Off Briefing....COMPLETE
2 Altimeters / Bug Settings....SET
3 AP 1+2....ON
4 ENG 1+2 Mode Switches....FLIGHT
5 Landing Lights + HISL....ON, A/R
6 Nose Wheel....LOCKED
7 Parking Brake....A/R
8 ECS....VENT
9 Passengers/Cabin....BRIEF/SECURE
10 Floats....A/R
11 Anti Coll....ON
12 TAWS....A/R
13 Compass....DG
14 Baggage key....CHECK

AFTER TAKE OFF / GO AROUND
1 Landing Lights + HISL....A/R
2 Altimeters/Bug Settings....SET
3 Parking Brake....A/R
4 Wx Radar....A/R
5 Floats....A/R
6 TAWS....A/R
7 Compass....MAG/DG

CLIMB / DESCENT
1 Altimeters/Bug Settings....SET
2 Clearance....OBTAINED

CRUISE
1 Systems/T's P's/CAS....CHECK
2 Altimeters/Bug Settings....SET
3 Compass....Cross Check / MAG
4 Fuel....CHECK

BEFORE LANDING
1 Approach & Landing Brief...COMPLETE
2 Altimeters/Bug Settings....SET
3 Landing Lights + HISL....ON, A/R
4 Parking Brake....A/R
5 ECS....VENT
6 Wx Radar....A/R
7 Passengers/Cabin....BRIEF/SECURE
8 Floats....A/R
9 TAWS....A/R
10 Compass....DG

SHORT FINAL / SHUTTLING
1 Landing Lights....ON
2 Wx Radar....OFF
3 Parking Brake....A/R
4 Floats....ARMED
5 Positive ID....CHECK NAME

AFTER LANDING
1 Nose Wheel....A/R
2 Parking Brake....A/R
3 Floats....OFF
4 External Lights / Anti Coll....OFF

COMPLETION OF TAXI
1 Flight Controls....CENTER/FPOG
2 Landing Lights....OFF
3 Nose Wheel....LOCKED
4 Parking Brake....ON

SHUTDOWN - MAIN MODE
1 MFD....P-PLANT
2 Emergency Lights....OFF
3 AP 1+2....OFF
4 ENG Mode Switches....IDLE/OFF
5 Rotor Brake....BELOW 40%
6 Fuel SOV 1 & 2....CLOSE NG<10%
7 Nose Wheel....UNLOCK FOR TOW
8 Main/Aux Batt....OFF after 1 min

SHUTDOWN - ACC MODE
1 MFD....P-PLANT
2 Emergency Lights....OFF
3 AP 1+2....OFF
4 ENG 1 Mode Switch....IDLE
5 ENG 1 NF....CONFIRM <75%
6 ACC Switch....ACC
7 ENG 2 Mode Switch....IDLE/OFF
8 Rotor Brake....BELOW 40%
9 ENG 1 Mode Switch....OFF
10 Fuel SOV 1 & 2....CLOSE NG<10%
11 Nose Wheel....UNLOCK FOR TOW
12 Main/Aux Batt....OFF after 1 min

Figure 2

Aircraft pre-flight, start, flight, landing and shutdown checklists

Whilst waiting for the PF to finish his walkaround, the HO decided to carry out the 'hoist operations pre-start' procedure on the reverse side of the company checklist (Figure 3).

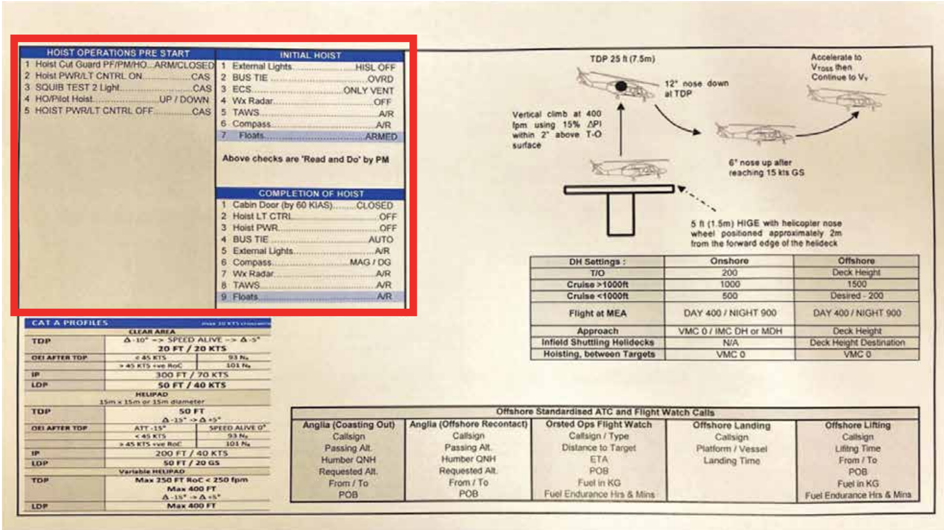


Figure 3

Hoist operation checklists and aircraft operating information

This hoist pre-start procedure required each hoist cable cut switch guard, one on each of the pilot's collective controls and one on the HO's control panel (HO's panel) in the cabin, to be lifted in turn to check that a HOIST CUT ARM caution message appeared on the two Primary Flight Displays (PFDs) and disappeared again once the guards were lowered. This was to be followed by a check of the squib via the HO's panel, with the Hoist Power ON, to ensure the two green squib LEDs illuminated when the squib test button was pressed (Figure 4).

Figure 4

HO control panel showing cut switch guard, squib test button and LEDs illuminated (left) and the panel with the cut switch guard lifted showing the cut button (right)

The HO began by asking the PM to switch on the hoist power (Hoist PWR) and lift the guard of the hoist cut switch on the PM's collective control. Both the PM and the HO verbally confirmed that a HOIST CUT ARM caution message had appeared on the left and right cockpit PFDs. The PM lowered the guard and both verbally confirmed that the caution messages had disappeared from view.

Once the PF had reached the left cockpit door at the end of his walkaround, the PM asked him to carry out the cut switch guard lift procedure on the left pilot's collective control from his position at the door. The PF lifted the guard and the PM, HO and the PF verbally confirmed the appearance of the HOIST CUT ARM caution on the PFDs. The guard was lowered again and they confirmed the caution messages had disappeared.

HLO1 was at the aircraft, loading and securing equipment into the helicopter's cabin whilst working around the HO. The HO repeated the guard lift process using the HO's panel in the cabin with a similar result. At this point he noticed that the two green LEDs (SQ 1 and SQ 2) on the HO panel were illuminated, but proceeded to press the squib test button, Step 3 in the hoist operations pre-start checklist shown in Figure 3, regardless.

The HLO2 had watched the HO lift the cut guard on the HO panel, although he didn't observe any buttons being pressed, and then noticed something fall from the aircraft's right side by the cabin door. He tapped the HO on the shoulder to tell him what he had seen. About the same time, one of the Ops team also approached the cockpit to let the crew know that the hoist hook had detached from the hoist and fallen to the ground. None of the crew had noticed the hook detach from the hoist cable.

Recorded information

There was no information available from the cockpit voice recorder or the flight data recorder during the period of the incident. However, the following information was determined from the Data Transfer Device (DTD) which had recorded various caution messages sent to the Crew Alerting System (CAS) and displayed on the two PFDs in the cockpit.

On the date of the incident, there were four separate CAS events recorded. The first lasted approximately 7 minutes and recorded the application of ground power. The second event started at approximately 07:41:00 hrs and showed that an engine cranking procedure had occurred which was later confirmed to be for an engine compressor wash. The third of the four events occurred during the incident period. Figure 5 shows the Flight Data Monitoring (FDM) timeline taken from 07:53:00 to 08:18:00 hrs showing the third (Figure 6) and fourth (Figure 7) CAS events.

The third event started at 07:52:49 hrs when the HOIST ON advisory message was activated, confirming that hoist power had been switched on, see Figure 6 expanded event timeline. At approximately the same time, the HOIST CUT ARM and HOIST CABLE FOUL cautions were briefly displayed on the PFDs. In the seconds that followed, a sequence of three HOIST CUT ARM messages were recorded. The data also shows an additional sequence of two caution messages starting at 07:54:15 hrs, with each lasting approximately two seconds. Hoist system power was switched off 36 seconds later at 07:54:51 hrs. The fourth event occurred after the hoist cable had been severed, see Figure 7 expanded event timeline.

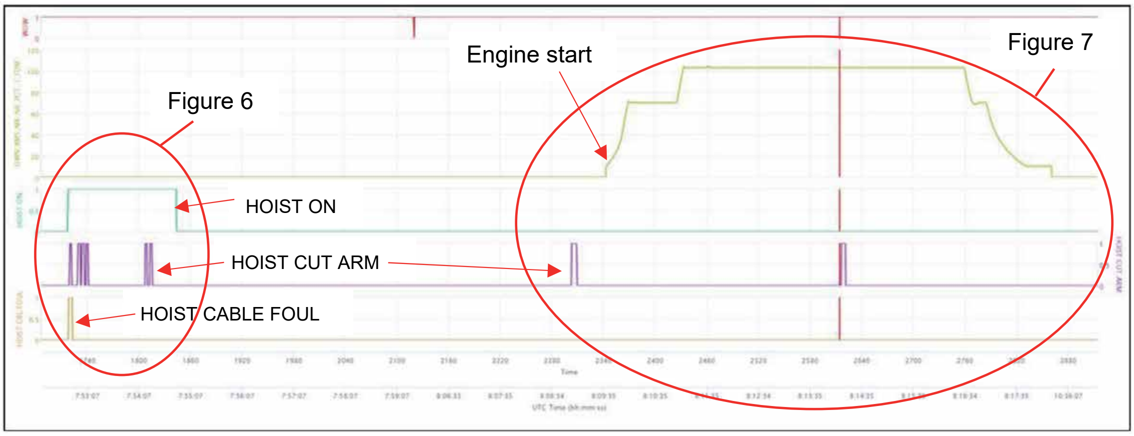


Figure 5

FDM messages recorded by the DTD showing the third and fourth events

Figure 6

Event 3 expanded timeline showing lifting sequence of hoist switch cut guards

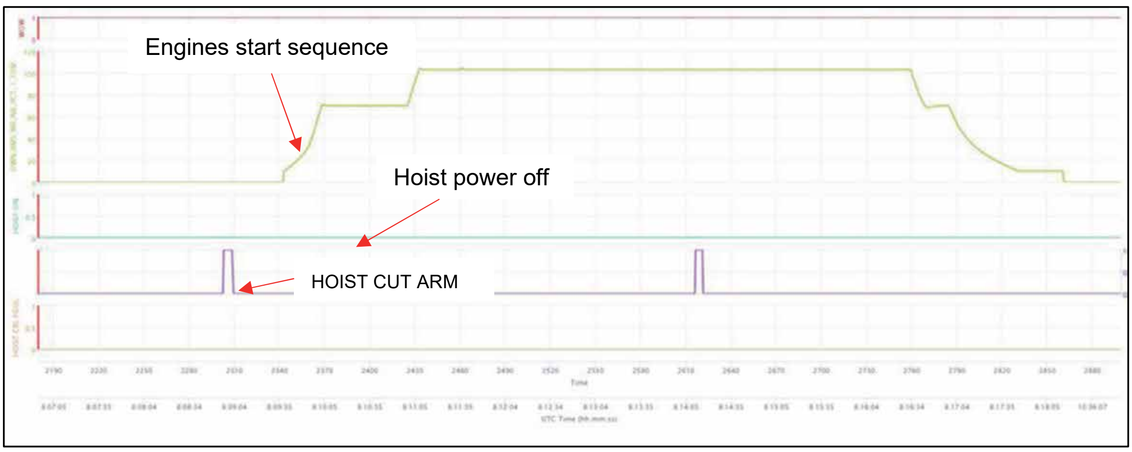


Figure 7

Event 4 expanded timeline - HOIST CUT ARMED cautions before and after engines start

All times are UTC

The fourth event began whilst engine 1 was running in APU mode at 08:08:58, during which there was a two second activation of a HOIST CUT ARM caution. The caution occurred again at 08:14:12, but in this case both engines were running and the helicopter's rotors were turning. Both caution activations took place with no power applied to the hoist system. At 08:16:33 both engines were selected to IDLE and then to OFF. CAS recordings ceased at 08:18:15.

Aircraft and hoist information

The incident aircraft, one of two AW169 Leonardo Helicopters, was purchased from new by the Operator in September 2022. The two helicopters were each equipped with a single Goodrich Model 44316 external hoist[1] for lowering personnel onto the platforms of offshore wind turbines to carry out repairs and maintenance. Whilst the Goodrich hoist original equipment manufacturer (OEM) was Collins Aerospace, integration of the hoist onto the aircraft was designed and installed by the aircraft manufacturer. Integration included software to provide cautions on the cockpit PFDs via the CAS when hoist power was applied, cut guards raised or hoist fouling was detected; although there is no PFD warning displayed to the pilots in the event of a cut switch activation. The only warning to the crew that the hoist cable has been cut by the squib is provided by the two LEDs on the HO's panel in the cabin.

The external hoist was specifically designed to meet the Human External Cargo (HEC) regulations[2] necessary to safely raise, hold and lower personnel under a variety of conditions. The hoist system employs an externally mounted, 28 Volt DC electrically powered rescue hoist which utilises a proprietary translating drum cable management system. A Weston style[3] load brake and overload slip clutch[4] provides safe braking mechanisms for the hoist. A secondary shaft locking mechanism that also meets the HEC requirements is employed to improve the level-wind system[5] design. The hoist system includes fault code readouts from the built-in-test system and cable length readouts in both feet or meters on the HO's pendant. The pendant allows the HO to control raising and lowering of the hoist hook and the direction of a searchlight, (Figure 8). The pendant is attached to the hoist system by a coiled electrical cable which allows the HO flexibility to view personnel or equipment suspended from the hoist whilst in flight.

Footnote

1 Manufactured by Collins Aerospace.
2 The definition of HEC is in FAA AC 27/29.865: Human External Cargo (HEC). A person(s) that at some point in the operation is carried external to the rotorcraft.
3 Weston style load brake - Uses the weight of the load to force a friction plate or coned surface against the rotating element. The hoist must be reversed to overcome the holding power of the brake.
4 Overload slip clutch – protects two rotating shafts from damage by slipping when one shaft is overloaded (a friction plate slip-clutch for example).
5 Level-wind system – a method of ensuring the hoist cable is efficiently wound onto the drum as the drum rotates.

Figure 8

External Goodrich hoist assembly after cable had been cut (left) and HO's pendant (right)

To release the winch cable if it becomes fouled and risks the safety of the aircraft, the cable can be cut using the hoist cut buttons located on each pilot's collective control (Figure 9) and the HO's control panel located in the cabin roof behind the headrest of the right pilot's seat.

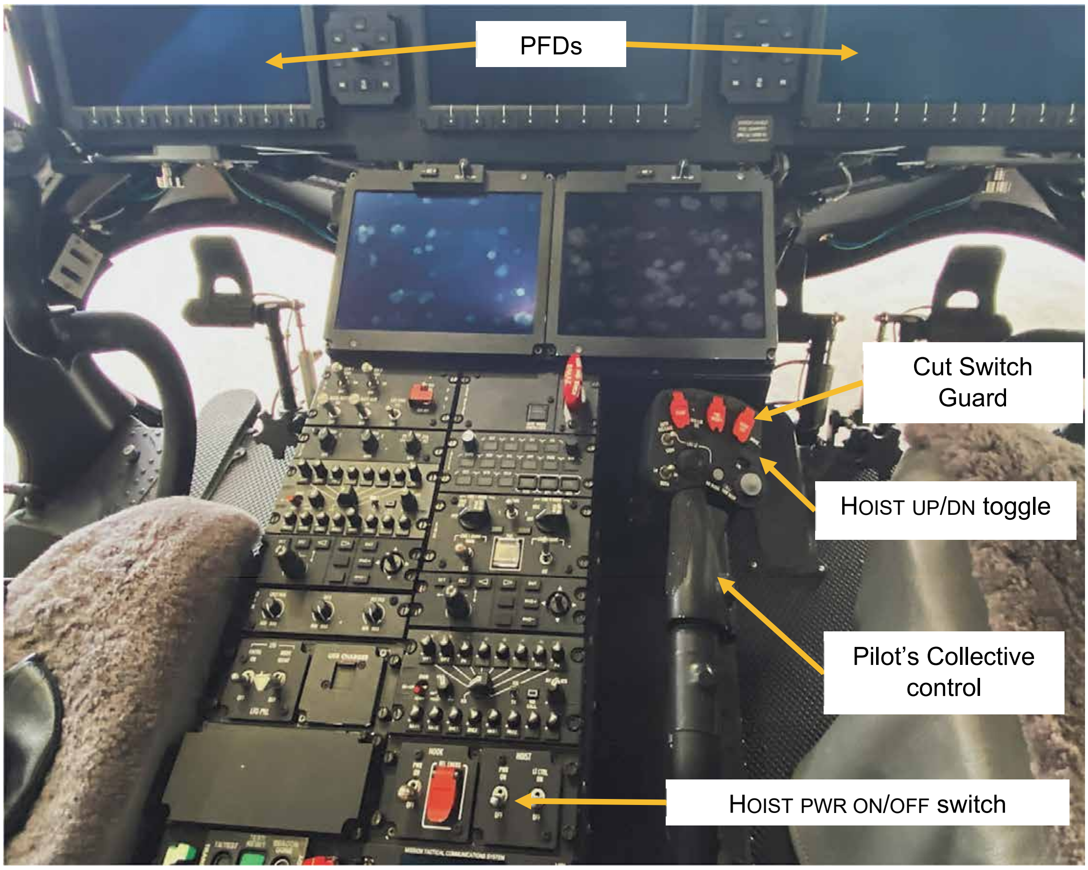


Figure 9

Cockpit showing PFDs, right pilot's collective with cut switch guard plus HOIST UP/DWN toggle button and hoist power switch

To prevent inadvertent activation of the cable cut mechanism, each cut button is shielded by a red cut switch guard which must be lifted before the cut button can be pressed. With the hoist power switched on, lifting the cut guard provides 28 VDC to the cable cut button. When the cut button is pressed, the 28 VDC activates the squib which cuts the cable at the winch point, separating the hook and part of the cable from the aircraft hoist.

Aircraft and hoist examination

The high tensile steel, multistrand hoist cable had been severed approximately 20 cm from the hook assembly (Figure 10). There was no other damage to the aircraft found during the examination.

Figure 10
Hoist hook showing severed cable

After the incident, both squib LEDs on the HO's panel illuminated immediately power was applied to the hoist (Figure 4).

Detailed functional tests were completed on the hoist system but no faults were revealed. Visual inspections were made of both collective controls' hoist cut button wiring connections (Figure 11) but no anomalies were found. The HO's control box was removed and sent to the OEM for examination and functional testing; no faults were discovered.

Out of sequence hoist operations pre-start checks

The company checklist, (Figure 2), begins with 'cockpit/safety checks' followed by a 'before start' checklist and then the 'engine start' procedure. Having started both engines, the checklist then details an 'after start' procedure containing the 'hoist operations pre-start checks' shown in Figure 3.

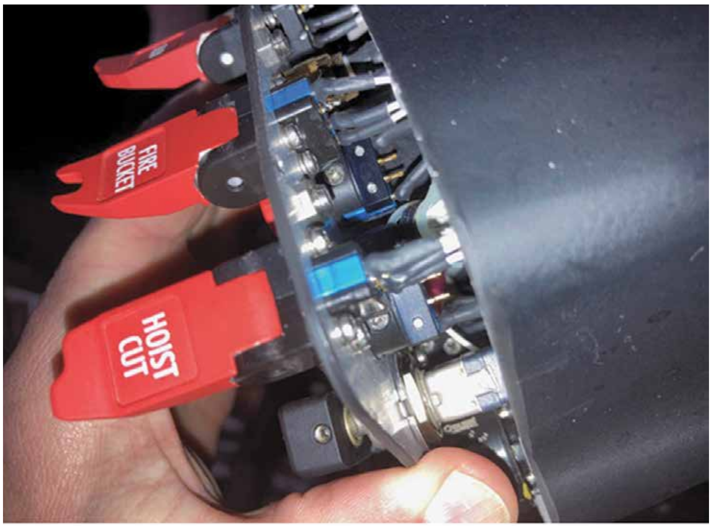


Figure 11

Pilot's collective hoist cut button (1 of 2) wiring visual examination

The crew interrupted the flow of the checklist before starting the engines because the PF was still walking round the aircraft, so the PM and HO decided to carry out the 'hoist operations pre-start checks' before the 'engine start' procedure. However, instead of following the 'hoist operations pre-start procedure,' the HO requested the PM to switch hoist power to ON. The PM recognised that the sequence was not in the usual order but proceeded as requested and switched on the hoist power.

Figure 12 shows a section taken from AW169 Rotorcraft Flight Manual (RFM) Supplement No 5 Section 2, '*Pre-Flight Checks*' issued by the aircraft manufacturer for operations with the Goodrich Rescue Hoist.

RFM Steps 1 to 2 state that the pilots' and HO's hoist cut pushbutton guards should be in the closed position. Step 2 is followed by a warning to ensure that if the HOIST CUT ARM caution is present in the PFDs with all three hoist cut guards closed, a malfunction of the cable cut system is present and the power must not be selected on or the guards raised as the hoist cable cut system may be activated. Note that the hoist power switch should not be selected ON until RFM Step 5 (Figure 13).

The expanded timeline in Figure 6 shows that when the out of sequence hoist power was selected ON, the HOIST CABLE FOUL caution was correctly displayed on the PFDs (step 5 of the RFM), but so was a HOIST CUT ARM caution which may indicate that either a cut switch guard was raised or a fault was present. However, both cautions disappeared from the PFD screens before the next cut guard sequence began, confirming that no system fault was present. Steps 3 and 4 of the RFM required the crew to raise and lower the cut guards in sequence starting with the PM, then the PF and lastly the HO. The three HOIST CUT ARM cautions caused by lifting the switch guards in turn can be seen in Figure 6 beginning a few seconds after the HOIST CBL FOUL and first HOIST CUT ARM cautions had disappeared.

AW169

AW169 - RFM
Document N°
169F0290X001

Supplement 5
External Hoist
Operations (Goodrich)

COCKPIT PRE START CHECKS

1. HOIST CUT pushbutton (on pilot and copilot collective grip) — Guard closed.
2. CUT pushbutton on HO control panel — Guard closed.

The following 'before the first flight of the day' checks should be carried out after connection of DC external electrical power, if DC external electrical power is not available carry out these checks during SYSTEM CHECKS AFTER ENGINE START CHECKS:

WARNING

Illumination of the HOIST CUT ARM caution at any time when the HOIST is selected OFF or ON and all HOIST/CUT guards are down indicates a malfunction of the hoist cable cut system. The hoist is unserviceable and must not be selected ON or the guards raised as the hoist cable may be cut.

3. HOIST CUT guard on pilot /copilot collective grip — Raise guard, confirm HOIST CUT ARM caution illuminates on CAS. Close guard confirm HOIST CUT ARM caution extinguishes.
4. CUT pushbutton on HO control panel — Raise guard, confirm HOIST CUT ARM caution illuminates on CAS. Close guard confirm HOIST CUT ARM caution extinguishes.

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Figure 12

Steps 1 to 4 of the RFM hoist start up procedure

Supplement 5
External Hoist
Operations (Goodrich)

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AW169

5. PWR switch (on Pilot HOIST control panel) — Select ON, HOIST ON advisory steadily and HOIST CBL FOUL caution transiently illuminate on CAS.
Confirm HOIST CUT ARM caution not illuminated on CAS.

6. LT CTRL switch (on Pilot HOIST control panel) — Select ON if night operations are envisaged, HOIST LT CTRL ON advisory illuminates on CAS.
Then select OFF or as required.

7. SQUIB TEST pushbutton on HO control panel — Push.
Confirm the 2 lights illuminate and HOIST CUT ARM caution illuminates.
Release pushbutton and confirm lights and caution extinguish.

Figure 13

Steps 5 to 7 of the RFM hoist start up procedure

A further two HOIST CUT ARM cautions occurred approximately 12 seconds after the group of three cautions in Figure 6, but the crew were unable to explain the additional guard lifts. From witness statements, it may have been during one of these two guard lifts that the hoist cable was cut. As step 5 in Figure 13 had already occurred out of sequence, the HO proceeded to step 7, but observed that the two squib LEDs were already lit. The squib LEDs are latched ON if a hoist cut switch is pressed and can only be switched off again using a specific maintenance procedure. The LEDs and the HOIST CUT ARM cautions are also illuminated during the squib test procedure but, under no fault conditions, disappear from the PFDs again once the test button is released.

The fourth hoist CAS event shown in Figure 7 occurred once the hoist cable had been cut. After the Captain had left the aircraft to report the incident, the PF was requested to start the engines to ensure there was no residual water remaining in the engines following the earlier compressor wash. During this period, the PF attempted to check the hoist cut CAS messages by raising the cut guard on his collective twice to observe that the appropriate cautions were displayed on the PFDs. The hoist power was not switched on during these additional checks.

Analysis

In the absence of an electrical or mechanical fault or a system anomaly which could have allowed 28 VDC to activate the hoist cut squib without a hoist cut button being pressed, the focus of the investigation was on the sequence of events during the aircraft start-up procedure.

The crew could not explain their exact sequence of cut switch guard raises, why the hoist power was applied out of sequence or why the hoist operations pre-start procedure in the company checklist was not followed in order. Although the pilots were not aware of the AW169 RFM hoist supplement or the warning before Step 3 of the supplement, the HO was aware of the RFM. He checked for the presence of a hoist cut arm caution with all cut guards lowered before proceeding with the cut guard raise and lower sequence.

Soon after the incident, the Operator issued instructions to all their crews that the company procedure must be followed whenever they are preparing the aircraft for operations.

The company start up procedure in Figure 3 contained no mention of checking for the presence of the HOIST CUT ARM caution with all cut guards lowered as stated in the RFM 'SYSTEM CHECKS AFTER ENGINE START CHECKS' (Figure 12). Whilst the application of hoist power is not required until RFM Step 5, there is no mention in the company checklist that Step 1 should be carried out with hoist power OFF. There was also no mention in the company checklist of the warning in Step 5 of the RFM to check for the presence of the HOIST CUT ARM caution when the hoist power is selected ON before continuing with the pre-start checklist.

The company procedures have since been amended to include the requirement to ensure the hoist power is off, all cut guards are lowered and there is no CUT GUARD ARM caution present before proceeding to Step 1. In addition, a warning has been added after Step 2 to ensure the HOIST FOUL caution extinguishes after hoist power is applied and there is no HOIST CUT GUARD caution present on the PFDs before proceeding to Step 3.

Had there been a hoist system fault, the out of sequence activation of hoist power and raising the cut guards whilst a HOIST CUT ARM caution was present could have caused 28 VDC to be supplied to the squib to cut the cable. No such fault was found during functional testing or examination of the wiring connections to the three hoist cut arm switches. As procedural drift occurred throughout the hoist start up process, the possibility that one of the hoist cut buttons was pressed inadvertently instead of the hoist lower/raise toggle, the next step in the company procedure after the squib test, could not be ruled out. The possibility that the squib was activated during the squib test could be ruled out because the squib test electrical current is insufficient to activate the squib. The fact that the LED lights indicating 28 VDC may have already been illuminated before the squib test button was pressed, shows that the hoist cable had been cut before the squib test button was pressed.

Conclusion

Procedural drift caused the crew to deviate from the Operator's aircraft pre-fight, start, flight, landing and shutdown checklists. The risk that the hoist squib could be activated when a CUT GUARD ARM caution message was displayed despite all three cut guards being in the lowered position, was not apparent in the Operator's checklists.

The company checklist did not adequately represent the AW169 RFM external hoist start up procedure and contained no warnings regarding the impact of warning cautions at specific points in the procedures. The Operator has changed the company checklist to address these problems.

No mechanical or electrical or functional faults were found with the hoist system. The possibility that one of the cut buttons may have been inadvertently pushed during the out of sequence hoist startup checks, which caused the squib to activate and cut the hoist cable, could not be ruled out.

SERIOUS INCIDENT

Aircraft Type and Registration:	Cessna 208B, G-EELS
No & Type of Engines:	1 Pratt & Whitney Canada PT6A-114A turboprop engine
Year of Manufacture:	1997 (Serial no: 208B0619)
Date & Time (UTC):	13 July 2023 at 1105 hrs
Location:	Perth Airport
Type of Flight:	Specialised Operations (Part-SPO)
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Minor propeller tip damage on 3 of the 4 blades
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	16,685 hours (of which 947 were on type) Last 90 days - 19 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

The pilot rejected the takeoff as he felt he had insufficient thrust to climb safely. The aircraft overran the runway and stopped in a field. Subsequent checks and testing did not find any faults with the engine.

History of the flight

The aircraft was scheduled to film a golf event and carried one pilot and a camera operator. The pilot planned a Flap 20 takeoff from Runway 21 as this was the longest runway. Four other aircraft were flying in the circuit using Runway 27. While taxiing the camera operator asked the pilot to open the window to give some additional ventilation.

After a period of holding on Runway 21, one of the aircraft in the circuit was asked to reduce speed to allow G-EELS to depart. When cleared, the pilot slowly moved the power lever forward for takeoff. He reported that it was quite noisy on the takeoff roll due to the open window. He also thought he may have forgotten to turn on his noise cancelling headset making it appear noisier.

He recalled the engine sounded like it was giving maximum power but he did not recall checking the engine instruments. He reported that he was distracted by looking for the circuit traffic.

The pilot rotated the aircraft at 75 kt, but as it lifted off, the speed reduced to 65 kt. The aircraft remained in ground effect for a short period before touching down again. He decided to reject the takeoff but was conscious there was little runway left. Beyond the runway was a small ditch followed by a field of standing crop. He elected to maintain the power for a few moments and rotated a second time to lift into ground effect and clear the ditch. As he passed the ditch he closed the throttle and settled into the field. He held the nose up for as long as possible and used minimal braking to avoid damaging the nosewheel. The aircraft stopped in the field without damage, except for some minor delamination on the tips of three propeller blades.

Aircraft examination

The engine was checked for damage using the manufacturer's guidance but none was found. After the propeller blades were repaired, engine runs did not reveal any faults. The aircraft was returned to service.

Conclusion

It could not be determined why the aircraft appeared to have insufficient power. The pilot reported he was distracted on the takeoff roll and this may have contributed to the overrun.

SERIOUS INCIDENT

Aircraft Type and Registration:	Piper PA-31-350, G-FCSL
No & Type of Engines:	2 Lycoming TIO-540-J2BD piston engines
Year of Manufacture:	1972 (Serial no: 31-7852052)
Date & Time (UTC):	28 March 2023 at 1330 hrs
Location:	South of Salisbury, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Right engine No 2 cylinder detached, mechanical and superficial fire damage to the engine and cowling
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	7,244 hours (of which 2,501 were on type) Last 90 days - 49 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries made by the AAIB

Synopsis

Whilst the aircraft was in the cruise at 2,000 ft agl, there was a loud bang as the right engine failed. The aircraft landed without further incident at Bournemouth. The engine failure was because the Number 2 cylinder had detached from the crankcase. This was caused by a fatigue failure of the cylinder flange attachment studs. It is likely that fatigue was initiated by a loss of preload in three of the studs at the front of the cylinder creating the conditions for the remaining studs and through-bolts to subsequently fail. The reason for the loss of preload could not be determined.

History of the flight

The aircraft was en route from Cardiff to its base at Shoreham, cruising at 2,000 ft agl and was just to the south of Salisbury under a Boscombe Down traffic service. The pilot had just completed routine checks and all the temperatures and pressures were normal with both engines running at 2,200 rpm. A couple of minutes later there was a loud bang and an adverse yaw. It became apparent the right engine had failed. The pilot and co-pilot could see the right engine cowling was covered in oil, the dipstick access flap had opened and there was a dent protruding from the side of the cowling. The pilot carried out shut down checks and feathered the propeller. As this was done, flames were observed emanating from the right engine. The firewall fuel shut off was activated and after about 10 seconds the fire extinguished. A PAN call was made to Boscombe Down and the pilot declared his intentions to land at Bournemouth Airport which by this time was the closest. The left engine was operating correctly throughout the incident. The pilot made a visual approach to Bournemouth and landed on Runway 26 without incident.

History of the engine

The engine was installed in G-FCSL in 2016 and since then it had accrued 1,000 hours of its 1,800 hour time between overhaul periodicity. Apart from routine servicing, no additional rectification work has been required and there has been no abnormalities that might indicate an impending malfunction or failure.

Engine examination

The front left side cylinder (No 2) had become detached from the crankcase with all six of the attachment studs and both through-bolts[1] broken. A section of crankcase with the remains of two of the studs in place had also detached and was lying in the bottom of the lower cowling. The piston ring damage had caused the piston to jam in the lower part of the cylinder and the connecting rod had separated from the big end bearing half shell. The cylinder inlet and exhaust manifolds were also displaced. The engine and accessories were covered in oil and there were signs of fire on and around the turbocharger. Several components associated with the cylinder and piston were found on and around the engine (Figure 1).

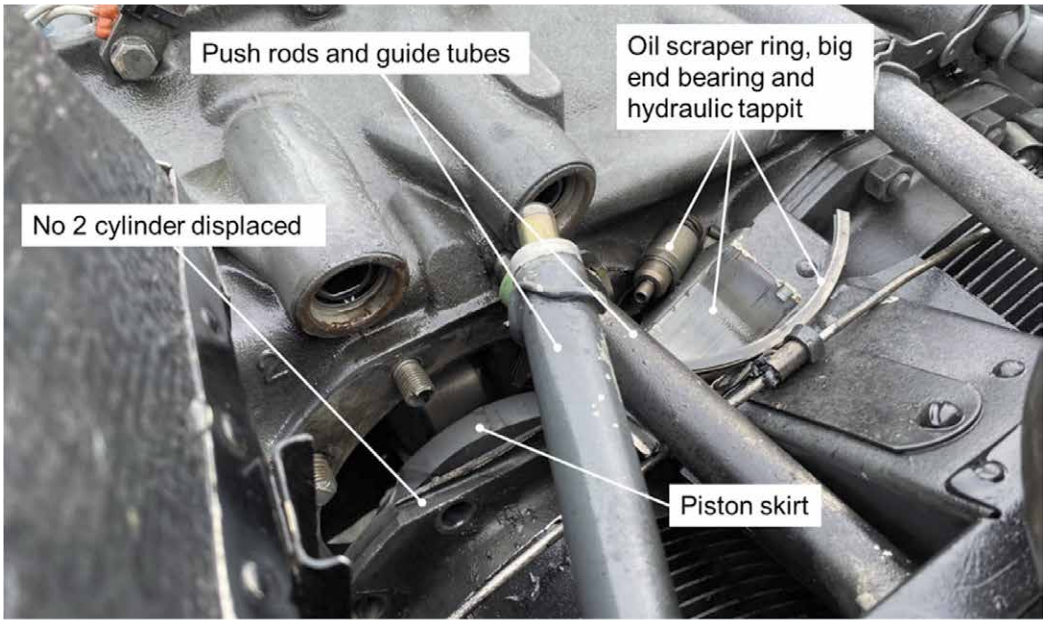

Figure 1

No 2 cylinder and distribution of parts

Footnote

[1] Through-bolts provide additional rigidity within the two halves of the crankcase. Two pairs of through-bolts pass through the crankcase and provide a clamping force to an opposing pair of cylinders. In this case cylinders left No 2 and right No 3, left No 4 and right No 5.

Tests and research

Each cylinder has a flange at the lower end which is held onto the crankcase by six threaded studs and two through-bolts. Four of the studs are 5/16 inch in diameter and the other studs and through bolts are 3/8 inch in diameter. All the studs and through-bolts had failed at the interface between the nut and the flange leaving a piece of each stud and through-bolt in the associated nut. One of the 3/8 inch diameter stud nuts was not found but its corresponding stud had broken in the same position as the other studs. Figure 2 shows the flange and identifies the location of the studs.

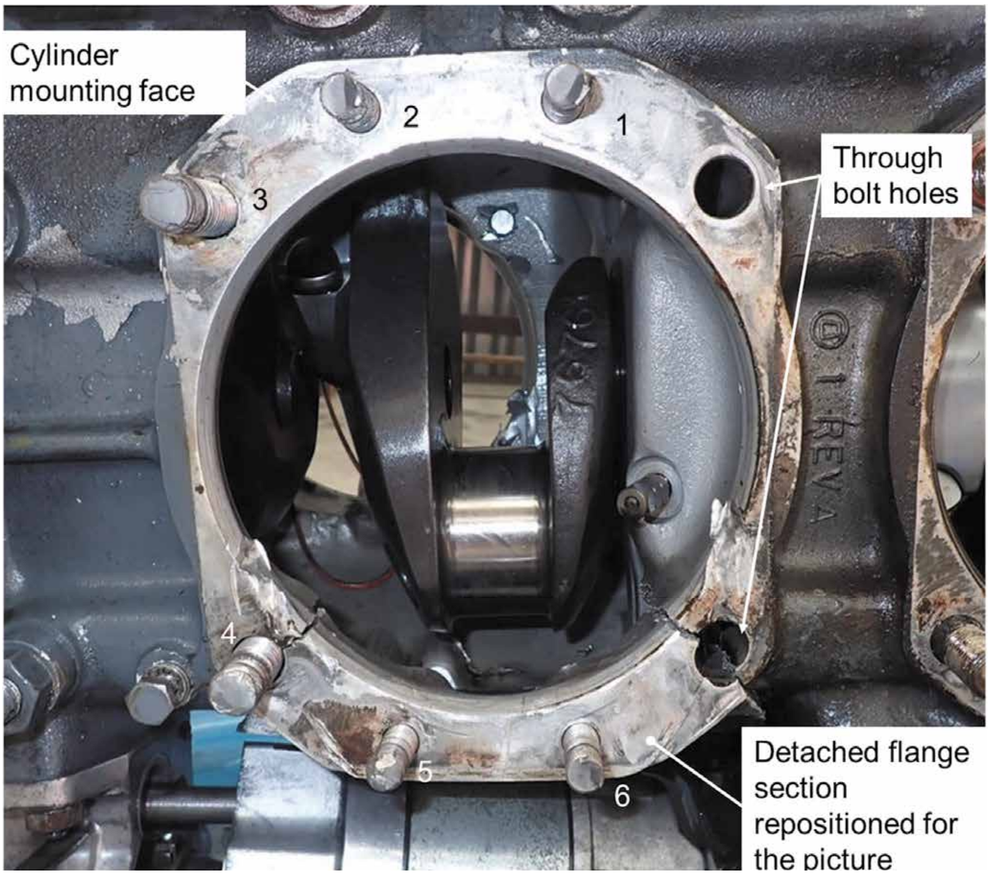

Figure 2

Cylinder mounting flange and location of the studs

The studs and through-bolts were removed from the crankcase using an extraction tool for examination. All were found with the characteristics of a high cycle fatigue failure. The studs numbered in Figure 2 as No 3 and No 5, were found to have different fatigue features than the other studs and through-bolts. The No 4 stud fracture face had suffered mechanical damage which was caused by the piston skirt impacting it during the failure sequence. This was likely to have occurred at the same time as the crankcase section was broken away. The No 4 stud nut was not found. The No 3 and No 5 studs appear to show several fatigue crack faces, initiated from multiple sites from the thread root around the circumference of the stud. Figure 3 shows both No 3 stud facture faces (the portion of the stud that remained within its nut was loose).

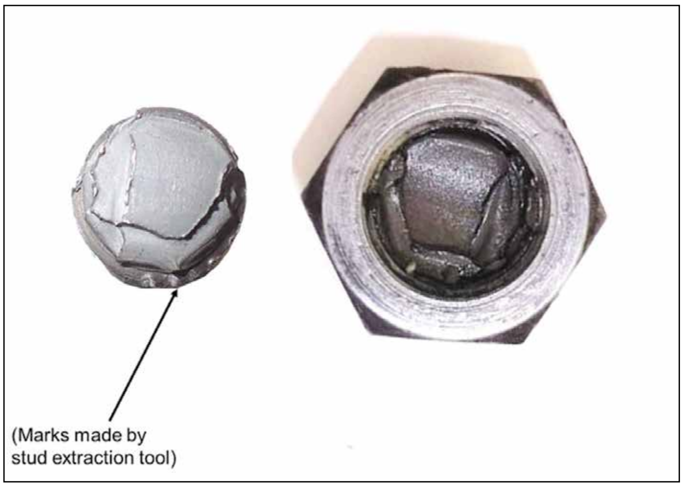

Figure 3

Stud No 3 and associated nut

Under magnification studs No 3 and No 5 exhibited ratchet[2] marks emanating from the thread roots. The through-bolt-fracture faces and those on studs No 1, No 2 and No 6, all show fatigue failure features indicative of unidirectional bending.

Analysis

Mechanical damage to the No 4 stud corrupted the fracture face so a clear identification of its failure mechanism could not be made. However, studs No 3 and No 5 (situated either side of stud No 4) exhibited different fatigue failure characteristics to the other studs and through-bolts. Their fatigue crack features were indicative of a loss of preload[3] or tightness of their nuts. The No 4 stud nut was not found which might suggest that its stud failed earlier, although it is not known how much earlier[4], and was followed by the No 3 and No 5 studs. With these studs failed, the cylinder flange was no longer rigidly attached to the crankcase cylinder mounting face around approximately one third of its circumference at its front edge. This resulted in non-uniform high cycle loads, predominantly tensile bending loads, within the remaining studs (No 1, 2 and 6) and both through-bolts, hence their unidirectional fatigue fracture features.

Conclusion

The Number 2 cylinder detached from the crankcase because of a fatigue failure of its attachment studs and through-bolts. It is likely that the failure sequence was initiated by the front studs of the attachment flange. These studs failed in fatigue and their features suggest a loss of preload within the nuts and studs. The potential cause of a loss of preload could not be determined.

Footnote

2 Steps or edges which occur as adjacent crack planes coalesce and converge into a single plane.

3 Although this may not appear as a visible looseness of the nut it describes a relaxation of the clamping load by the nut and stud exerted on the cylinder flange and crankcase.

4 The location of the No 4 stud on the crankcase behind the alternator, starter motor and cooling air ducting makes it very difficult to see and so an abnormality would be easily overlooked.

SERIOUS INCIDENT

Aircraft Type and Registration:	Tekever AR5 Evolution Mk 2, G-TEKV
No & Type of Engines:	2 3W 2-stroke piston engines
Year of Manufacture:	2019 (Serial no: E505)
Date & Time (UTC):	17 January 2023 at 1346 hrs
Location:	Temporary Danger Area EG D098, over English Channel
Type of Flight:	Commercial operations (UAS)
Persons on Board:	Crew - None Passengers - None
Injuries:	Crew - N/A Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Other
Commander's Age:	31 years
Commander's Flying Experience:	254 hours (of which 125 were on type) Last 90 days - 38 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

The unmanned aircraft encountered a loss of the communications link due to a fault in the Satcom antenna, such that it was not under the direct control of the remote pilot for a period of several minutes. In accordance with contingency procedures, the aircraft entered a holding pattern and the communications link was subsequently re-established. The remainder of the flight proceeded without incident.

As a result of this serious incident, the operator indicated that future variants of the aircraft will be equipped with a feature that automatically enables Satcom backup when fewer than two communications links are available.

History of the flight

The unmanned aircraft, G-TEKV, had taken off at 0538 hrs and was conducting a flight in Temporary Danger Area (TDA) EG D098 over the English Channel, in support of UK Border Force operations. Flight operations were conducted from a Ground Control Station (GCS) where the crew control the aircraft and operate the payload.

The aircraft was equipped with Satcom to enable Beyond Radio Line of Sight (BRLOS) operations. Satcom was selected as the primary command and control (C2) link, with a Satcom backup on standby. At approximately 1346 hrs the Satcom link dropped out. The aircraft's Return to Home (RTH) flight mode activated and it followed a pre-defined lost link route, remaining within the TDA.

At approximately 1348 hrs the Satcom backup channel went from standby to online and the C2 link with the aircraft was regained. The remote pilot (RP) flew the aircraft closer to the home location to re-establish Radio Line of Sight (RLOS) in order to gain an additional communications link. The RP carried out the procedures for losing Satcom, including resetting the Satcom page on the GCS. Once the aircraft was within range, additional communication links were established using RLOS and 4G. At approximately 1416 hrs the primary Satcom link was re-established. The remainder of the flight was conducted as planned and the aircraft landed uneventfully at 1521 hrs.

Aircraft information

System description

The Tekever AR5 Evolution UAS (AR5) consists of a manned GCS and an unmanned aircraft (Figure 1). The aircraft has a maximum takeoff mass of 180 kg[1], a wingspan of 7.29 m, a length of 4.03 m and is powered by two 170 cc two-stroke boxer engines. It has an endurance of up to 12 hours.

Figure 1

Tekever AR5 Evolution

G-TEKV was manufactured and operated by the same organisation and, for this report, is referred to as the operator.

Footnote

[1] G-TEKV's maximum takeoff mass is limited to 165 kg by the operator's CAA Operational Authorisation.

Communications links

Depending on the range at which the aircraft is operating, command and control of the aircraft is achieved through the use of RLOS and BRLOS communication data links. The system has six data links in total, five of which carry primary and secondary RLOS and BRLOS capability. Depending on the phase of flight, multiple communication links may be simultaneously active.

The RLOS control system operates in one frequency band and has a maximum range of 3 km, the backup RLOS system operates at a different frequency and has a range of 4 km. For BRLOS the system uses 4G and Satcom channels to maintain communication with the aircraft. Satcom is a satellite communication system. The primary Satcom channel allows C2, telemetry and video data exchange with the GCS; the Satcom backup channel, which has a different service provider, prioritises the C2 function but cannot transmit data.

In the event of a loss of the C2 link, the aircraft can remain in a holding pattern to try and reestablish communications. If, after a defined period, the aircraft has not regained the link, it can automatically return to a designated safe location by following a pre-determined 'rally route' included in the flight plan. The pre-defined route is established by the operator prior to takeoff, in coordination with ATC, to avoid conflict with other traffic and can be changed in flight to account for changing variables such as weather or other traffic. Once the aircraft re-enters RLOS range the C2 link is re-established via the RLOS channels. In the event of a total loss of communication the aircraft can perform an automatic landing.

Operator and Satcom service provider's investigation

The operator reported the occurrence and sent the log files to the Satcom service provider for analysis. There were no pre-notified periods of planned maintenance or degradation to the satellite service which could have accounted for the Satcom dropout.

The analysis indicated that the Satcom terminal had appeared to perform as expected during the flight between 0558 hrs and 1346 hrs. At 1346 hrs the Satcom terminal logged out due to TRANSMIT BLOCK UPCONVERTER (TXB) faults reported to the antenna control unit from the antenna.

The Satcom service provider indicated that possible causes of TXB faults include excessive antenna temperature or the loss of a 10 MHz reference signal on a cable that runs between the antenna transmit interface and the satellite modem. Antenna temperatures were confirmed to have been well within the operating specifications and replacement of the cable did not solve the issue, with further TXB faults generated during subsequent ground testing. The Satcom antenna was therefore replaced.

A Satcom data analysis was conducted by the Satcom service provider following a flight by G-TEKV on 6 March 2023 and no faults were recorded. The operator monitored the Satcom data over five subsequent flights and no further Satcom dropouts occurred.

While its exact nature had not been determined at the time of publication of this report, a fault with the Satcom antenna was identified as the cause of the Satcom dropout.

Organisational information and Operational Authorisation

The aircraft was operating under a CAA Operational Authorisation for Beyond Visual Line of Sight (BVLOS) unmanned aircraft operations in the Specific category. A condition stated in the Operational Authorisation is that the UA must be equipped with a mechanism that will cause it to land in the event of a disruption to, or failure of, any of its control systems, including the C2 link.

The operator had submitted an Operational Safety Case (OSC) to the CAA to support its application for the Operational Authorisation. The OSC contained a risk assessment which identified the hazard 'Loss of C2 link', with the associated safety risk of 'mid-air collision'. The mitigations identified for a loss of C2 link included crew training and procedures associated with a loss of data link, the redundancy offered by multiple independent C2 channels, the fitment of a Mode S ADS-B transponder and the aircraft's automatic RTH flight mode.

Analysis

A fault with the Satcom antenna resulted in a temporary Satcom dropout which caused a loss of the CA link between the GCS and UA. For a period of several minutes, the aircraft was not under the direct control of the RP. During this time the automatic RTH flight mode activated and the UA flew a holding pattern. The UA subsequently acquired the Satcom backup, such that the C2 link was re-established. This enabled the RP to fly the aircraft to within RLOS range, to gain an additional C2 channel. The remainder of the flight proceeded without event, and the primary Satcom link was subsequently re-established.

Loss of the C2 link had been documented as a hazard that in the operator's risk assessment and technical and procedural mitigations were in place to ensure the UA would avoid conflict with other airspace users. The UA behaved as anticipated during the loss of link, in accordance with the identified mitigations and in compliance with the conditions of its Operational Authorisation.

Safety action

> As a result of this occurrence, the operator indicated that all future variants of the Tekever AR5 will be equipped with a feature that automatically enables Satcom backup when fewer than two C2 links are available. It considered that this change will further mitigate the hazard associated with loss of the C2 link.

Conclusion

A fault in the Satcom antenna led the UA to encounter a temporary loss of the command and control communications link. Contingency procedures and redundancy within the UA's communications meant that the communications link was re-established and the flight proceeded without further incident.

AAIB Record-Only Investigations

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

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

The accuracy of the information provided cannot be assured.

Record-only investigations reviewed: July - August 2023

15 Feb 2023 **Pioneer 400** **G-CPPG** Blackbushe Airport, Surrey

During the landing roll the left main gear collapsed. The left wing struck the ground and the aircraft veered off the runway, striking a runway light before stopping. The left main landing gear actuator attachment had failed in overload, likely because of high side loads during the crosswind landing.

18 May 2023 **Piper PA-32-300** **G-PECK** Bodmin Airfield, Cornwall

Shortly after takeoff the top engine cowling detached, striking, and damaging the windscreens. The pilot decided to continue the short flight to aircraft's home base where it landed without incident. The aircraft had undergone minor maintenance at Bodmin during which the top engine cowling had been removed and refitted. The damaged cowling was recovered from a field. It was reported that it had several previous repairs including to the forward locating pins. The most probable reason for the cowling loss is though to be inadequate engagement of the locating pins.

13 Jun 2023 **Renegade Spirit UK (Modified)** **G-MWNF** Near Porthcawl, Bridgend County

While flying close to shore, the engine stopped without warning and the pilot ditched the aircraft in the sea. The aircraft flipped over but the pilot was able to exit the aircraft unassisted and swim ashore. The aircraft was destroyed and the cause of the engine stoppage was not determined.

14 Jun 2023 **AS355F2** **G-NBPL** Near Shenley, Hertfordshire

Prior to flight the pilot carried out a Check A. After completing the check the pilot completed the tech log before starting the helicopter and taking off. At approximately1,000 ft the pilot became aware that the right gearbox cowling was open. The pilot identified a landing site and descended. During the descent the cowling struck the main rotor releasing a section of the cowling. The helicopter landed without further incident. The pilot confirmed that the cowling have been left held open by a maintenance stay after completion of the Check A due to becoming distracted from their normal procedure by completion of the tech log.

15 Jun 2023 **Kiss 400-582(1)** **G-SNOG** Deenethorpe Airfield, Corby

As the flexwing microlight climbed through approximately 35 ft from RWY 04 at Deenethorpe Airfield, the aircraft descended rapidly. The pilot was unable to stop the descent; it struck the runway and the landing gear collapsed. It then veered off the runway into a crop field. Both occupants sustained minor injuries during the accident, but the aircraft was damaged beyond economical repair.

Record-only investigations reviewed: July - August 2023 cont

18 Jun 2023 Europa G-BWFH Monewden Airfield, Suffolk

The pilot made an approach to Runway 13 at Monewden Airfield but when the aircraft touched down he considered that the landing was long and applied full power to go around. The aircraft struck the boundary hedge and entered the field beyond the runway where it nosed over and came to rest inverted around 50 m from the end of the runway. Both the pilot and passenger were able to exit the aircraft without injury.

18 Jun 2023 Casa 1-131-E3B G-BSAJ Duxford Airfield, Cambridge

Towards the end of the landing roll the aircraft yawed uncontrollably to the left due to a lack of tail wheel steering, which had operated satisfactorily during taxi and takeoff. The right wing and right landing gear were damaged. Subsequent inspection revealed that there were ridges and burrs in the pilot-selectable tail wheel steering mechanism and application of a force, such as a load encountered during landing, could cause the mechanism to disengage resulting in the tail wheel castoring instead of steering. A regular operational check of the tail wheel steering system could help prevent a recurrence. The LAA are aware and plan to feature this in the 'Engineering Matters' section of their magazine.

25 Jun 2023 Rotorway Executive 162F G-CDBK Broom, Bedfordshire

With the helicopter running low on fuel and the nearest airfield, Duxford, very busy with airshow traffic, the pilot elected to divert to Old Warden rather than declare a fuel emergency. Three miles out the helicopter ran out of fuel and made a forced landing. There were no injuries and the helicopter suffered minor structural damage.

1 Jul 2023 Pegasus Quantum 15 G-MYYB Sandy Airfield, Bedfordshire

While landing in a wind reported as being strong, the aircraft tipped forward onto its nose and left wing leading edge.

1 Jul 2023 X'air Falcon Jabiru(3) G-CDDH Rhos Uchaf Airfield, Gwynedd

The aircraft stalled shortly after takeoff at approximately 50 ft and struck bushes at the side of the grass strip runway. The pilot and passenger received minor injuries and the aircraft sustained substantial damage. It is likely that taking off with full flap set had an effect on the aircraft's ability to climb and accelerate.

Record-only investigations reviewed: July - August 2023 cont

8 Jul 2023 **X'air Falcon D(1)** **G-TBYD** Felthorpe Airfield, Norfolk

After experiencing sink on short finals at Cromer Airfield, G-TBYD suffered a heavy landing and bounced back into the air, so the pilot performed a go-around. He then discovered the main undercarriage on the passenger's side had been damaged during the aborted landing. The aircraft appeared otherwise undamaged, so the pilot elected to return to the familiar environment of his home airfield at Felthorpe before landing. After touchdown the right main wheel detached, the left undercarriage collapsed, and the aircraft came to rest on its belly.

17 Jul 2023 **Jabiru J430** **G-PHYZ** Wolverhampton Airport

The pilot elected to return to the airfield following a single misfire with the engine when the engine abruptly stopped. He was unable to glide back to the airfield and landed in a grass field, during which the nose landing gear leg detached causing damage to the engine, propeller and left landing gear leg. The pilot's smartwatch automatically alerted the emergency services to the accident location.

18 Jul 2023 **Europa XS** **G-CFKZ** East Winch Airfield, Norfolk

The pilot was unable to stop the aircraft while landing in light rain on a slippery grass surface. The aircraft veered off the runway and hit a boundary hedge, causing substantial damage but no injuries.

19 Jul 2023 **Pietenpol Air Camper** **G-BRXY** Popham Airfield, Winchester

The aircraft bounced on landing and the landing gear collapsed on subsequent touchdown. The pilot reported that the approach was made 5 kt above the normal speed because the wind was gusting and changing direction, and that having flared high the aircraft descended suddenly.

20 Jul 2023 **Steen Skybolt** **G-RODC** North Coates Airfield, Lincolnshire

The aircraft landed heavily and the landing gear collapsed.

4 Aug 2023 **Pipersport** **G-MRVK** Clipgate Airstrip, Kent

After a return flight from Lydd Airport to Clipgate Airfield, G-MRVK touched down at 55 kt from a "normal approach". The pilot applied full braking, but the aircraft did not decelerate as expected. With insufficient distance remaining for a safe go-around, the pilot continued braking and the aircraft came to rest in shrubs at the end of the runway. The pilot ascribed the lack of braking action to an unexpectedly wet runway. When the pilot departed Clipgate earlier that day, the grass had been dry and he was unaware that heavy showers had affected the airfield during the day.

Record-only investigations reviewed: July - August 2023 cont

7 Aug 2023 **Piper PA-28R-200-2** **G-BBDE** Enstone Airfield, Oxfordshire

At approx 3,000 ft in the climb after takeoff, the nose cowling opened and began flapping in the airflow. The pilot returned to the departure airfield but omitted to lower the landing gear before the aircraft touched down on the runway. The pilot considered that he had been distracted by the loose cowling and that this contributed to him not lowering the landing gear.

7 Aug 2023 **Vans RV-7** **G-KELS** Tonbridge, Kent

The pilot lost control during a takeoff on a grass runway, the nose tipped forward onto the ground, and the aircraft skidded off the runway and came to halt in a ditch.

10 Aug 2023 **Pegasus Quik** **G-CEDN** Watnall Airfield, Nottinghamshire

After touchdown the pilot applied power to carry out a go-around but the aircraft stalled and the right wing dropped, striking the windsock pole. The aircraft landed in an adjacent crop field where the wing dug into the ground tipping the aircraft over.

13 Aug 2023 **Vans RV-6A** **G-RVCE** Rendcomb Airfield, Gloucestershire

During the rollout after a normal touchdown the aircraft bounced and landed on the nosewheel. The nosewheel dug into the grass runway causing the aircraft to pitch onto its nose and become inverted.

16 Aug 2023 **Aeroprakt A32 Vixxen** **G-GBUA** Eddsfield Airfield, East Yorkshire

Following an unexpected loss of lift just before touchdown, the aircraft landed heavily and the nose gear collapsed.

19 Aug 2023 **Cessna T210N** **G-BSGT** London Biggin Hill Airport

The pilot realised that the landing gear was not down when the lower fuselage struck the runway during landing. He lifted off, put the landing gear down and then landed back on the runway.

23 Aug 2023 **DH82A Tiger Moth** **G-ANKZ** Norton St Philip, Avon

The aircraft struck power lines on approach to Runway 33 at Brown Shutter Farm, decelerating rapidly and landing inverted. The short grass airfield is described in its own literature as "challenging" and has a displaced threshold to account for the wires. The pilot reflected that he did not positively identify the wires early enough. He reported that, to compensate for a possible tailwind, he used an aiming point before the displaced threshold markers to maximise the landing distance available, and that he allowed the aircraft to become too low on its approach.

Record-only investigations reviewed: July - August 2023 cont

25 Aug 2023 **Cirrus SR-22T** **N225RB** Bagby Airfield, North Yorkshire

The aircraft floated during the landing and, after touchdown, ran into the field beyond the end of the runway. The nose landing gear collapsed.

28 Aug 2023 **Skyranger 912S(1)** **G-JEZZ** Lempitlaw Airfield, Scottish Borders

The aircraft bounced on landing and, on touchdown, the nose landing gear caught in the ground and the aircraft turned onto its back.

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

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

Published August 2015.

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

Published October 2015.

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

Published March 2016.

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

Published September 2016.

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

Published March 2017.

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

Published March 2018.

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

Published November 2018.

1/2020 Piper PA-46-310P Malibu, N264DB
22 nm north-north-west of Guernsey
on 21 January 2019.

Published March 2020.

1/2021 Airbus A321-211, G-POWN
London Gatwick Airport
on 26 February 2020.

Published May 2021.

1/2023 Leonardo AW169, G-VSKP
King Power Stadium, Leicester
on 27 October 2018.

Published September 2023.

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

http://www.aaib.gov.uk

GLOSSARY OF ABBREVIATIONS

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

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