AAIB
Air Accidents Investigation Branch

AAIB Bulletin 7/2014

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Summaries of Aircraft Accident Reports

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

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

Aircraft Accident Report No: 2/2014

This report was published on 11 June 2014 and is available in full on the AAIB Website www.gov.uk

Report on the accidents to Eurocopter EC225 LP Super Puma G-REDW, 34 nm east of Aberdeen, Scotland on 10 May 2012 and G-CHCN, 32 nm southwest of Sumburgh, Shetland Islands on 22 October 2012

ACCIDENT INVOLVING G-REDW (EW/C2012/05/01)

Aircraft Type and registration:	EC225 LP Super Puma, G-REDW
Registered Owners and Operators:	Bond Offshore Helicopters Ltd
Nationality:	British
Date & Time (UTC):	10 May 2012 at 1114 hrs
Location:	34 nm east of Aberdeen

ACCIDENT INVOLVING G-CHCN (EW/C2012/10/03)

Aircraft Type and registration:	EC225 LP Super Puma, G-CHCN
Registered Owners and Operators:	CHC Scotia Ltd
Nationality:	British
Date & Time (UTC):	22 October 2012 at 1425 hrs
Location:	32 nm southwest of Sumburgh, Shetland Islands

Introduction

The Air Accidents Investigation Branch (AAIB) was notified at 1112 hrs on 10 May 2012 that an EC225 LP Super Puma, G-REDW, was preparing to ditch in the North Sea approximately 32 nm east of Aberdeen.

On 22 October 2012 the AAIB was notified at 1428 hrs that an EC225 LP Super Puma, G-CHCN, had ditched in the North Sea approximately 32 nm southwest of Sumburgh, Shetland Islands.

In both cases the AAIB deployed a team to Aberdeen to commence an investigation. In accordance with established International arrangements the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA), representing the State of Manufacture of the helicopter, and the European Aviation Safety Agency (EASA), the Regulator responsible for the certification and continued airworthiness of the helicopter, were informed of the accidents. The BEA appointed an Accredited Representative to lead a team of investigators from the BEA and Eurocopter[1] (the helicopter manufacturer). The EASA, the helicopter operators and the UK Civil Aviation Authority (CAA) also provided assistance to the AAIB team.

Owing to the similarities of the circumstances that led to the two accidents, the Chief Inspector of Air Accidents ordered that the investigations be combined into a single report.

Synopsis

While operating over the North Sea, in daylight, the crews of G-REDW and G-CHCN experienced a loss of main rotor gearbox oil pressure, which required them to activate the emergency lubrication system. This system uses a mixture of glycol and water to provide 30 minutes of alternative cooling and lubrication. Both helicopters should have been able to fly to the nearest airport; however, shortly after the system had activated, a warning illuminated indicating that the emergency lubrication system had failed. This required the crews to ditch their helicopters immediately in the North Sea. Both ditchings were successful and the crew and passengers evacuated into the helicopter's liferafts before being rescued. There were no serious injuries.

The loss of oil pressure on both helicopters was caused by a failure of the bevel gear vertical shaft in the main rotor gearbox which drives the oil pumps. The shafts had failed as result of a circumferential fatigue crack in the area where the two parts of the shaft are welded together.

On G-REDW the crack initiated from a small corrosion pit on the countersink of the 4 mm manufacturing hole in the weld. The corrosion probably resulted from the presence of moisture within the gap between the PTFE plug and the countersink. The shaft on G-REDW had accumulated 167 flying hours since new.

On G-CHCN, the crack initiated from a small corrosion pit located on a feature on the shaft described as the inner radius. Debris that contained iron oxide and moisture had become trapped on the inner radius, which led to the formation of corrosion pits. The shaft fitted to G-CHCN had accumulated 3,845 flying hours; this was more than any other EC225 LP shaft.

The stress in the areas where the cracks initiated was found to be higher than that predicted during the certification of the shaft. However, the safety factor of the shaft was still adequate, providing there were no surface defects such as corrosion.

The emergency lubrication system operated in both cases but the system warning light illuminated as a result of an incompatibility between the helicopter wiring and the pressure switches. This meant the warning light would always illuminate after the crew activated the emergency lubrication system.

Footnote

[1] On 1 January 2014 Eurocopter changed its name to Airbus Helicopters.

A number of other safety issues were identified concerning emergency checklists, the crash position indicator and liferafts.

Ten Safety Recommendations have been made. In addition, the helicopter manufacturer carried out several safety actions and is redesigning the bevel gear vertical shaft taking into account the findings of the investigation. Other organisations have also initiated a number of safety actions as a result of this investigation.

The following causal factors were identified in the ditching of both helicopters:

a A 360º circumferential high-cycle fatigue crack led to the failure of the main gearbox bevel gear vertical shaft and loss of drive to the oil pumps.

b The incompatibility between the aircraft wiring and the internal configuration of the pressure switches in both the bleed-air and water/glycol (Hydrosafe 620) supplies resulted in the illumination of the MGB EMLUB caption.

The following factors contributed to the failure of the EC225 LP main gearbox bevel gear vertical shafts:

a The helicopter manufacturer's Finite Element Model underestimated the maximum stress in the area of the weld.

b Residual stresses, introduced during the welding operation, were not fully taken into account during the design of the shaft.

c Corrosion pits were present on both shafts from which fatigue cracks initiated:

i On G-REDW the corrosion pit was located at the inner countersink in the 4.2 mm hole and probably resulted from the presence of moisture within the gap between the PTFE plug and the countersink.

ii On G-CHCN the corrosion pit was located at the inner radius and probably resulted from moisture trapped within an iron oxide deposit that had collected in this area.

Findings

General

1. The bevel gear vertical shafts on both G-REDW and G-CHCN failed as a result of a 360º circumferential high-cycle fatigue crack.
2. Failure of the bevel gear vertical shaft resulted in the loss of drive to the main and standby oil pumps.
3. Loss of oil pressure from the main and standby pumps required the use of the emergency lubrication system.

4. Within a minute of the crews activating the emergency lubrication system, the MGB EMLUB caption illuminated.

5. The emergency procedure required the crew to *'land immediately'* if the MGB EMLUB caption illuminates.

6. Both helicopters ditched in the North Sea; the flotation system activated and the helicopters remained upright.

7. In both accidents, the passengers and crew evacuated the helicopters onto liferafts.

8. There were no reported serious injuries.

9. Neither helicopter sustained any structural damage as a result of the ditching.

Operational aspects

10. Both crews were properly licensed, qualified to conduct the flights and rested.

11. The flights were uneventful until the indication of the loss of the MGB oil pressure.

12. In each case the flight crew actioned the appropriate checklists.

13. The crew of G-CHCN were aware of the accident to G-REDW and had read reports on the initial findings, including the fact that the emergency lubrication system had operated.

14. It took 8 minutes and 55 seconds from the loss of oil pressure until G-REDW ditched.

15. It took 7 minutes and 6 seconds from loss of oil pressure until G-CHCN ditched.

16. The helicopter manufacturer does not provide an emergency checklist and is not required to do so.

17. The operators are responsible for providing their own checklists based on the manufacturer's documentation.

G-REDW CPI

18. The CPI did not deploy automatically following the ditching, nor was it manually activated by the flight crew.

19. In May 2012, the operator's Emergency Procedures contained no requirement for manual activation of the CPI.

20. No defects were found with the components in the system which would have prevented automatic deployment of the CPI.

21. The failure of the CPI to deploy did not adversely affect the search and rescue effort.

G-CHCN CPI

22. The CPI was selected manually by the flight crew to TRANSMIT during the final preparations for the ditching.

23. The design of the CPI system prevents automatic deployment, following manual activation, unless a system reset is performed.

CPI Standards

24. The EASA determined that the Type 15-503 CPI system was not fully compliant with the Minimum Operational Performance Standards specified in EUROCAE ED-62.

Liferafts

25. G-REDW and G-CHCN were fitted with Type 18R MK3 liferafts.

26. Some of the passengers on G-REDW commented that the liferafts were slow to deploy.

27. The Type 18R MK3 liferaft did not meet the certification requirement for a maximum inflation time to a suitable boarding condition of 30 seconds at -30ºC.

28. During inflation of G-CHCN's left liferaft the mooring lines and rescue pack lines became entangled, preventing the liferaft from being used.

29. On G-CHCN, the co-pilot was able to un-twist the lines to free the raft.

30. The CMM for the Type 18R MK3 liferaft did not provide clear diagrams and descriptions on how to route the rescue pack and mooring lines.

31. An inspection of liferaft installations on a sample of Super Puma helicopters revealed two installations where the mooring lines were routed incorrectly. In one of these cases the rescue pack lines were twisted round the mooring lines.

32. The AMM for the Super Puma helicopters did not contain diagrams clearly depicting how the mooring and rescue pack lines should be routed.

33. The tests to certify the Type 18R MK3 liferaft installation on the Super Puma included two tests conducted with a sponson partially submerged in water. No deployment tests from a sponson were carried out in simulated choppy sea conditions.

34. The EASA certification requirements do not specify any deployment reliability or sea state conditions for externally mounted liferafts fitted to offshore helicopters.

35. Following the ditching of G-REDW and G-CHCN the occupants of the liferafts were concerned about the proximity of the rotor blades to the raft, so they cut the long mooring line.

36. The long mooring line on the Type 18R MK3 liferaft is 12 m long which is 8 m less than the 20 m length specified in the AMC to JAR-Ops 3.830.

37. The certification requirements relating to the length of the long mooring line on liferafts do not make any reference to the size and geometry of the helicopter.

Emergency lubrication system

38. In both accidents the emergency lubrication system, once activated, appeared to have successfully cooled and lubricated the main rotor gearbox.

39. A mixture of oil, water and glycol was found on the transmission decking aft of the MGB and down the sides of both helicopters.

40. EC225 LP helicopters, with MOD 0752520 embodied, have a pressure switch configuration that results in illumination of the MGB EMLUB failure caption once the system is activated and after the 30-second delay.

41. The bleed-air pressure from the engine is, under certain conditions, lower than the pressure used in the design and certification of the emergency lubrication system.

42. In some areas of the operational envelope, the Hydrosafe 620 and the bleed-air pressure is such that the pressure switches, which are within specification, can generate a low pressure signal when the emergency lubrication system is operating normally. This would result in an erroneous MGB EMLUB caption.

43. Both Hydrosafe 620 pumps were tested and operated to specification. Both pumps would have operated during the accident flights.

44. Several minutes after activation of the emergency lubrication system, the pressure in the Hydrosafe 620 system decreased to around 0.7 bar relative. This value is higher than the threshold for the pressure switches fitted to the accident helicopter, but lower than the maximum specification for these components.

MGB general

45. There were no external leaks from the MGB and the fluid found on the transmission decking and on the outside of the helicopter had come out of the MGB vent.

46. The MGB on both helicopters had been correctly assembled and with the exception of the damage to the bevel gear vertical shafts, there was no evidence of damage or signs of overheating to any other components in the gearboxes.

47. No additional loads, or resonant frequencies, were identified during the testing of the bevel gear vertical shaft and MGB other than those previously identified during the certification of the EC225 LP helicopter.

G-REDW history of the bevel gear vertical shaft

48. The shaft (M385) fitted to G-REDW was manufactured in March 2012 and had been kept in the manufacturer's stores for a year before it was fitted to the MGB.

49. At the time of the accident, the shaft fitted to G-REDW had flown 167 flying hours and approximately 20 million shaft cycles. The MGB had been fitted to the helicopter two months prior to the accident.

G-CHCN history of the bevel gear vertical shaft

50. The shaft (M122) fitted to G-CHCN was manufactured in April 2008.

51. The shaft, and its MGB, had undergone a 2,000 hour overhaul 1,813 flying hours and sixteen months prior to the accident.

52. At the time of the accident, the shaft had flown 3,845 flying hours and approximately 533 million shaft cycles. The shaft had remained with the MGB since new, but prior to its overhaul had been fitted to another helicopter.

53. At the time of the accident, the shaft fitted to G-CHCN was considered to be the fleet leader on the EC225 LP.

Bevel gear vertical shafts

54. 63% of EC225 LP shafts are scrapped at the first overhaul, of which approximately 50% are due to excessive wear on the splines that drive the first stage sun gear.

55. In comparison with the AS332 shaft, the EC225 shaft is 1.2 mm thicker in the area of the weld and incorporates a new feature identified as the inner radius. There is also approximately 15% more load on the splines that drive the first stage sun gear.

56. In common with other gearbox components, the bevel gear vertical shaft had no surface protection, other than the oil in the MGB, to protect it against corrosion.

Examination of the bevel gear vertical shafts

57. With the exception of the inner countersink on the shaft fitted to G-REDW (M385), both shafts had been manufactured to the design specification and the welds were correctly formed.

58. Corrosion was found in the inner countersink of the 4.2 mm hole on both shafts. This corrosion occurred after the PTFE plugs had been fitted into the 4.2 mm holes.

G-REDW bevel gear vertical shaft examination

59. The geometry of the inner countersink on the shaft fitted to G-REDW was outside the design tolerance.

60. The change in angle of the countersinks and the out of tolerance inner countersink on G-REDW were not factors in this accident.

G-CHCN bevel gear vertical shaft examination

61. A red deposit which contained iron oxide was found in the inside of the top section of the bevel gear vertical shaft fitted to G-CHCN.

62. The deposit on G-CHCN was concentrated in three rings located at the inner radius, and above and below the splines that drive the first stage sun gear.

63. Corrosions pits were discovered under the concentrated areas of deposits on the shaft fitted to G-CHCN. Corrosion pits were not discovered elsewhere on the shaft.

64. The deposit was found on a small number of EC225 LP shafts in the same areas as on the shaft fitted to G-CHCN. There was evidence of corrosion in the same areas as on G-CHCN.

Metallurgic examination of the bevel gear vertical shaft

65. Both shafts failed as a result of a 360º circumferential fatigue crack in the area of the weld that joined the two parts of the shaft.

66. The crack on the shaft fitted to G-REDW initiated in a corrosion pit 60 µm deep, located on the inner countersink in the 4.2 mm hole on the fusion line of the weld.

67. Cracks in the fusion line may initiate and propagate at stress levels lower than the fatigue limit of the weld.

68. The crack on the shaft fitted to G-CHCN initiated in a corrosion pit 60 µm deep located on the inner radius in the parent material.

69. It is difficult to detect corrosion pits visually approximately 60 µm deep located in the inner countersink or inside the shaft in the area of the weld.

70. Prior to these accidents, there had been no previous reports of cracks or corrosion on the Super Puma bevel gear vertical shafts.

71. The area of the shafts that failed is not subject to the carburising or nitriding case-hardening process.

72. The change in case-hardening and the high-strength low-alloy steel used in the bevel gear vertical shaft were not a factor in the accidents.

73. There was no evidence of corrosion fatigue on the fracture surfaces of either shaft.

74. Beachmarks and striations, which are characteristic of fatigue, were present on the fracture surfaces of both shafts.

75. It is not known how long it took for the cracks on the shafts to initiate and propagate to the first beachmark.

76. Beachmark analysis estimated that the time for the cracks to propagate from the first beachmark to the final failure of the shafts was 15 to 21 flying hours for G-REDW and 14 to 21 flying hours for G-CHCN.

77. The change from 16NCD13 steel to the 32CDV13 steel used in the manufacture of the EC225 shaft was not a factor in these accidents.

Stresses within the bevel gear vertical shaft

78. The EC225 bevel gear vertical shaft was classified at certification as a Critical Part.

79. The EC225 shaft was derived from the AS332 shaft and certification of the EC225 shaft was based on the results of an FEM.

80. The maximum stress in the area of the weld is similar on the AS332 and EC225 shaft.

81. In the initial fatigue substantiation document (Issue A) for the EC225 shaft, the 4.2 mm hole was identified as Critical Area 2. The inner radius was not identified as a critical area.

82. In the FEM used to establish the maximum stress for the certification of the EC225 shaft, the boundary conditions for the upper roller bearing were incorrect.

83. The maximum stress at the 4.2 mm hole occurs when the relative angle between the 4.2 mm and 29 mm hole is 40º. On the shaft fitted to G-REDW the relative angle between these features was 38º.

84. No account was taken of the relative position of the 4.2 mm hole in the weld and 29 mm lubrication hole in the original FEM.

85. Electron beam welding of the two parts of the shaft generates compressive and tensile residual stresses in the area of the weld.

86. There are significant tensile residual stresses, at a depth of 60 µm, in the inner countersink on the 4.2 mm hole and the inner radius in the locations where the cracks initiated in the shafts fitted to G-REDW and G-CHCN.

87. The original fatigue substantiation document for the EC225 shaft made no allowance for the residual stresses.

88. From the data in the initial fatigue substantiation document (Issue A) it was calculated that the safety factor at the 4.2 mm hole in the EC225 shaft was 5.4.

89. Following the revision of the FEM, and incorporation of residual stress, the manufacturer calculated that there was a safety factor of 2.1 at the 4.2 mm hole and 2.3 at the inner radius.

90. The different methods used in the certification of the AS332 and EC225 shafts meant that it was not readily apparent that the maximum stress in the area of the weld had been underestimated.

91. The EASA considered a safety factor of 2.1 for the 4.2 mm hole and 2.3 for the inner radius to be acceptable, providing there is no corrosion in these areas.

Moisture in MGB

92. Low levels of water were found in the oil sampled from a small number of EC225 LP helicopters operating from Aberdeen.

93. Moisture can enter the MGB through the vents located in the gearbox and mast.

94. Moisture in the atmosphere was assessed as previously causing corrosion on the inside of the rotor mast fitted to the EC225 LP helicopters, an area that was not protected by the oil mist in the MGB.

95. The iron oxide generated by wear of the splines that drive the first stage sun gear was trapped at the inner radius on G-CHCN.

96. The MGB oil lubrication system was unable to remove the deposit containing the iron oxide from the inside of the shaft.

97. Moisture in the oil and gearbox became trapped in the deposit resulting in the formation of corrosion pits.

HUMS

98. As the cracks propagated, the load in the shafts was redistributed into the upper bearings, which increased the vibration levels detected by HUMS MOD-45 indicator.

99. The HUMS MOD-45 indicator amber threshold would not have been exceeded until the combined cracks in the bevel gear vertical shaft reached a length of between 87 and 100 mm.

100. The HUMS MOD-45 indicator exceeded the 'learned' amber threshold on both G-REDW and G-CHCN's penultimate flight.

101. The time from the MOD-45 indicator exceeding its amber threshold and the shafts failing was 4.62 hours for G-REDW and 4.75 flying hours for G-CHCN.

102. On identifying the MOD-45 exceedence, the operator of G-REDW followed the appropriate maintenance procedures. These procedures allowed the helicopter to continue flying under 'close monitoring'.

103. Analysis of the HUMS data from G-CHCN, prior to the start of the first flight on the day of the accident, would not have detected an increasing trend on the HUMS MOD-45 indicator.

Safety Recommendations and actions

Safety Recommendation 2012-034 issued on 17 October 2012

It is recommended that the European Aviation Safety Agency requires Eurocopter to review the design of the main gearbox emergency lubrication system on the EC225 LP Super Puma to ensure that the system will provide the crew with an accurate indication of its status when activated.

In April 2013 the EASA provided the following response to the Safety Recommendation:

'The root cause of the in-flight Emergency Lubrication (EMLUB) false alarm has been identified. For both helicopters (registered G-REDW and G-CHCN) events, it has been caused by wiring discrepancies found between the electrical outputs of the Air & Glycol pressure-switches of the EMLUB system and the helicopter wiring harness connecting the switches to the EMLUB electronic card. This design non-conformity only exists on helicopters equipped with pressure-switches manufactured by the sensor supplier Industria. The corrective actions have consisted in the following: Eurocopter have developed, through design change MOD 07.53028, a fix at aircraft wiring harness level for helicopters equipped with Industria pressure-switches. The retrofit of the fleet with this EASA approved design change is handled with Eurocopter's Alert Service Bulletin No.05A032, which EASA mandated with Airworthiness Directive (AD) 2013-0037.

From the extensive design review of the EMLUB system, components examinations, system testing and analysis completed during the investigation, it has been furthermore determined that the actual average engine bleed-air pressures for the EMLUB air circuit are lower than the certified design specifications, and indirectly it may also affect the pressures normally expected in the Glycol circuit of the EMLUB system. This brings the potential of triggering the thresholds of the Air and Glycol pressure-switches in some marginal flight conditions. To address this additional EMLUB system issue, Eurocopter are currently designing new pressure-switches with redefined lower pressure thresholds. After their approval, EASA will require Installation of these redesigned pressure-switches for the fleet by another AD.'

This has been assessed by the AAIB as 'accepted – closed'.

Safety Recommendation 2013-006 issued on 18 March 2013

It is recommended that the European Aviation Safety Agency requires the manufacturers of aircraft equipped with a Type 15-503 Crash Position Indicator system, or similar Automatically Deployable Emergency Locator Transmitter, to review and amend, if necessary, the respective Flight Manuals to ensure they contain information about any features that could inhibit automatic deployment.

In September 2013 the EASA provided the following response to the Safety Recommendation:

'EASA, in cooperation with the manufacturer, has re-examined the requirements of the Emergency Locator Transmitter EUROCAE ED-62 and studied the system specifications again and it was concluded that the equipment is not 100% compliant to the Minimum Operational Performance Standards (MOPS). The manufacturer is preparing an update to change the behaviour of the system to only allow deployment and activation as being one event. Once the Service Bulletin is available EASA will prepare a corresponding Airworthiness Directive to mandate the system update.

This proposed solution, meeting the intent of the requirements, is still under discussion with the applicant to reach a final design change as the ultimate fix for the problem.'

This has been assessed by the AAIB as 'partially accepted – open'.

Safety Recommendation 2013-007 issued on 18 March 2013

It is recommended that the Federal Aviation Administration requires the manufacturers of aircraft equipped with a Type 15-503 Crash Position Indicator system, or similar Automatically Deployable Emergency Locator Transmitter, to review and amend, if necessary, the respective Flight Manuals to ensure they contain information about any features that could inhibit automatic deployment.

In April 2013 the FAA provided the following response to the Safety Recommendation:

'Depending on the type of operation and operating airspace, the FAA may require rotorcraft to have an operating ELT. However, the FAA does not require the installation of a deployable ELT or CPI on helicopters; therefore, the loss of this function is not considered an unsafe condition. In addition, the FAA can only require a change to a design through an airworthiness directive, which requires the determination of an unsafe condition. As a result, the FAA lacks the justification to adopt safety recommendation 13.031, and we plan no further actions.'

This has been assessed by the AAIB as 'rejected'.

The following additional Safety Recommendations have been made:

Safety Recommendation 2014-013

It is recommended that the European Aviation Safety Agency provide Acceptable Means of Compliance (AMC) material for Certification Specification (CS) 29.1585, in relation to Rotorcraft Flight Manuals, similar to that provided for Aeroplane Flight Manuals in AMC 25.1581 to include cockpit checklists and systems descriptions and associated procedures.

Safety Recommendation 2014-014

It is recommended that the liferaft manufacturer, Survitec Group Limited, revises the Component Maintenance Manual for the Type 18R MK3 liferaft to include clear instructions and diagrams on how to route the rescue pack lines and mooring lines when packing the liferaft.

Safety Recommendation 2014-015

It is recommended that the aircraft manufacturer, Eurocopter Group, revise the Super Puma Aircraft Maintenance Manual Task 25-66-01-061 'Removal-Installation of the Liferaft Assembly' to include clear instructions and diagrams on how to route the rescue pack lines and mooring lines when installing the liferaft.

Safety Recommendation 2014-016

It is recommended that the European Aviation Safety Agency review the installation of the Type 18R MK3 liferaft in the EC225 sponson to ensure that there is a high degree of deployment reliability in foreseeable sea conditions.

Safety Recommendation 2014-017

It is recommended that the European Aviation Safety Agency develop certification requirements for externally mounted liferafts fitted to offshore helicopters which ensure a high degree of deployment reliability in foreseeable sea conditions.

Safety Recommendation 2014-018

It is recommended that the European Aviation Safety Agency amend the regulatory requirements to require that the long mooring line on liferafts fitted to offshore helicopters is long enough to enable the liferaft to float at a safe distance from the helicopter and its rotor blades.

Safety Recommendation 2014-019

It is recommended that the European Aviation Safety Agency commission research into the fatigue performance of components manufactured from high-strength low-alloy steel. An aim of the research should be the prediction of the reduction in service-life and fatigue strength as a consequence of small defects such as scratches and corrosion pits.

Summary of safety actions

Main gearbox bevel gear vertical shaft

On 18 May 2012, shortly after the accident to G-REDW, the EASA issued Emergency Airworthiness Directive 2012-0087-E. This required helicopters with certain bevel gear vertical shafts and equipped with the Eurocopter VHM system to download the VHM data and to review the MOD-45 and MOD-75 indicators every 3 flight hours. Helicopters fitted with the affected bevel gear vertical shafts and not equipped with VHM were restricted to day VFR flights when flying over water.

On 11 June 2012, the EASA issued Airworthiness Directive 2012-0104 which superseded 2012-0087-E. This altered the applicability of bevel gear vertical shafts and also increased the time between VHM downloads to 4 flight hours.

On 14 June 2012, the EASA issued Airworthiness Directive 2012-0107 which superseded 2012-0104 which retained the requirements but changed the effective date.

On 28 June 2012, the EASA issued Emergency Airworthiness Directive 2012-0115E which superseded 2012-0107. This retained the requirements of 2012-0107; however, it now required inspection of the VHM indicators in accordance with Eurocopter AS332 ASB No. 01.00.82 or EC225 ASB No. 04A009 both dated 27 June 2012. For the EC225 LP the download interval remained at 4 flight hours.

On 25 October 2012, shortly after the accident to G-CHCN, the EASA issued Emergency Airworthiness Directive 2012-0225E. This superseded the previous EAD 2012-0115E. This retained the requirements of 2012-0115E but increased the applicability to all bevel gear vertical shafts and reduced the interval between VHM inspections; this became 3 flight hours on the EC225. Helicopters with an unserviceable VHM were prohibited flight over water. This referred to changes in Revision 1 to Eurocopter AS332 ASB No. 01.00.82 and EC225 ASB No. 04A009 both dated 24 October 2012.

On 25 October 2012, the CAA issued a Safety Directive SD-2012/002 which stated that UK operators must not conduct a public transport flight or a commercial air transport operation over a hostile environment with any AS332 or EC225 helicopter to which European Aviation Safety Agency Emergency Airworthiness Directive 2012-0225-E dated 25 October 2012 applies. The Norwegian CAA also issued a similar Safety Directive 2012208342-1.

On 21 November 2012, the EASA issued Emergency Airworthiness Directive 2012-0250E which reflected Revision 2 of Eurocopter AS332 ASB No. 01.00.82 and EC225 ASB No. 04A009 both dated 21 November 2012. This required the amendment of the Emergency procedures of the Eurocopter RFM, which introduced the need to reduce engine power to *"MAXIMUM CONTINUOUS TORQUE LIMITED TO 70% DURING LEVEL FLIGHTS AT IAS≥ 60 KTS"* when operating over areas where emergency landing to ground was not possible within 10 minutes at V_y. It also required the continued monitoring of the VHM at regular intervals. For helicopters not equipped with VHM, the AD restricted operations which did not enable emergency landing on the ground within 10 minutes at V_y.

On 9 July 2013, the EASA issued Emergency Airworthiness Directive 2013-0138E, superseding 2012-0250E, which reflected modifications and procedures, introduced by Eurocopter Service Bulletins EC225 ASB No. 04A009 Revision 2 dated 21 November 2012, ASB No. EC225-04A009 Revision 3 dated 8 July 2013, ASB No. EC225-45A010 dated 8 July 2013, ASB No. EC225-05A036 dated 8 July 2013, AS332 ASB No.01.00.82 Revision 2 dated 21 November 2012, ASB No.AS332-01.00.82 Revision 3 dated 8 July 2013, and ASB No. AS332-05.00.96 dated 8 July 2013. These introduced several modifications including the M'ARMS MOD-45 monitoring system. Prior to installing the modified system, the requirement for a regular download of VHM data remained. Also, they required the cleaning of the bevel gear vertical shaft and installation of improved MGB oil jets. For helicopters without VHM or an unserviceable VHM, the power restrictions remained and it introduced an ultrasonic inspection at regular intervals.

On 10 July 2013, the CAA issued Safety Directive SD-2013/001 which removed the restrictions on carrying out public transport or commercial air transport flights over a hostile environment providing certain actions in EASA AD 2013-0138E had been complied with. An updated CAA Safety Directive SD 2013/002 was issued on 16 July 2013 to reflect a revision to EASA AD 2013-0138E dated 15 July 2013.

On 18 December 2013, the EASA issued Emergency Airworthiness Directive 2013-0301, superseding 2013-0138R1, which reflected that some of the requirements in AD 2013-0138R1 had expired, and that Eurocopter issued ASB No.AS332-01.00.82 at Revision 4 dated 17 December 2013 to introduce an Ultrasonic NDT method to detect vertical shaft cracks as alternative method to the only Eddy Current inspection available so far for the AS 332 helicopters.

Additional safety actions

The helicopter manufacturer undertook a number of measures and safety actions to detect damage and prevent corrosion in the area of the 4.2 mm hole in the weld during manufacturing of the shaft. These included new tooling, a final polishing operation, improved inspection techniques, a sealant to fill the gap between the PTFE plug and countersink, a 5 µm inspection criterion for defects and a more detailed inspection at the end of the manufacturing process.

During the investigation the helicopter manufacturer issued several Safety Information Notices and repair letters to operators and maintenance organisations.

The helicopter manufacturer is currently working on a redesigned bevel gear vertical shaft which takes into account the findings of the investigation. The EASA is reviewing this redesign as part of the certification requirements and applying the knowledge gained in the investigation to assess the various safety factors.

Emergency lubrication system

On 22 February 2013, the EASA issued AD 2013-0037 which relates to Eurocopter EC225 EASB No. 05A032 dated 22 February 2013. The AD requires the air and glycol pressure-switches in the emergency lubrication system to be identified. Depending on the type fitted, the switches may require replacing and the helicopter wiring harness may need to be modified (MOD 07.53028). In addition, this AD requires scheduled electrical functional testing of the emergency lubrication system.

On 28 May 2013, the EASA issued AD 2013-0113 which relates to Eurocopter EASB No.04A010 dated 27 May 2013. This updated the RFM by amending the emergency procedure to require an immediate landing as soon as the emergency lubrication system was activated.

On 18 July 2013, the EASA issued AD 2013-0156 which superseded AD 2013-0037 and 2013-0113. The requirements of the previous ADs were retained pending modifications to the emergency lubrication system within 4 months. The modifications are specified in Eurocopter ASB No EC225 05A033 dated 14 July 2013 and introduces new glycol pump, new pressure switches, check of the aircraft wiring and new PCB. Once these modifications are complete the RFM is amended to reintroduce the “land as soon as possible maximum flight time 30 min” to the emergency procedure after the emergency lubrication system is activated.

Crash position indicator

The CPI manufacturer amended the Type 15-503 CPI Operating Manual to reflect that the CPI system must be reset following a manual TRANSMIT selection, in order to restore full automatic functionality.

On 18 March 2013, Eurocopter issued Safety Information Notice No. 2567-S-25, dated 18 March 2013 and amended the Flight Manual for all Eurocopter helicopters equipped with a Type 15-503 CPI system.

On 17 January 2014, the EASA issued Airworthiness Directive 2014-0019, introducing a temporary amendment of the AFM and installation of a placard near the CPI cockpit control panel, to prevent use of the manual TRANSMIT function over water, for all aircraft equipped with a Type 15-503-134 or Type 15-503-134-1 CPI system. This AD also requires replacement of the SIU with a modified SIU incorporating automatic deployment following a manual activation, as a terminating measure for the temporary AFM amendment and placard installation.

On 27 February 2014 the CAA published CAP 1144 *'ADELT Review Report',* which contains a number of recommendations aimed at optimisation of ADELT installation and designs to maximise the likelihood of an ADELT deploying and transmitting correctly.

Liferafts

The liferaft manufacturer has stated that they will review the CMM and publish a Service Letter highlighting to liferaft maintenance organisations the importance of the lines exiting the rear of the valise and not the front.

The EASA RMT.0120 working group is aware of the issues relating to the liferafts found in the investigation and is considering proposing changes to certification requirements for externally mounted liferafts that would also take aircraft attitude into account.

Other survival equipment

The operator of G-REDW has changed the type of immersion suit used by pilots to an orange and black, closed-neck-seal design.

The supplier of immersion suits has added a further layer of tape over the seam for the toes of the sock to all of its suits to provide increased resistance to damage.

The EBS manufacturer is upgrading the existing re-breathers to include a new means of locating and opening the mouthpiece cover, as well as a retaining strap to hold the mouthpiece in place prior to use when the cover is open.

Information on the following areas affecting survivability was passed to the EASA RMT.0120 and the relevant manufacturers for consideration:

Seasickness
Jettison handle positioning and emergency egress
Safety knives and line cutters
Immersion suits
Emergency Breathing Systems

Checklists

Following the accidents the operator of G-REDW made changes to their checklists based on the findings of this investigation.

AAIB Field Investigation reports

ACCIDENT

Aircraft Type and Registration:	Airbus A320-214, G-OZBY
No & Type of Engines:	2 CFM56-5B4/P turbofan engines
Year of Manufacture:	2000 (Serial no: 1320)
Date & Time (UTC):	10 April 2013 at 1425 hrs
Location:	Prestwick Airport
Type of Flight:	Training
Persons on Board:	Crew - 14 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to the nose landing gear
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	15,085 hours (of which 2,791were on type) Last 90 days - 41 hours Last 28 days - 6 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was being operated on a flight crew 'base training' detail. While taking off after a touch-and-go landing, a takeoff configuration warning was generated. The commander rejected the takeoff and brought the aircraft to a halt on the remainder of the runway. The nose landing gear sustained some damage as the aircraft de-rotated on to the nosewheel during the manoeuvre. The crew did not consider the touchdown on the nose landing gear to be excessive and were not aware of the damage.

After a short delay, the training detail was continued. On the subsequent takeoff, with the co-pilot as PF, an ECAM message, L/G SHOCK ABSORBER FAULT was generated. This meant that the landing gear could not be retracted and that the autopilot and autothrust were unusable. During the climbout the aircraft started to descend so the commander took control and resumed the climb to circuit altitude.

After considering the status of the aircraft, the commander cancelled the training detail and the aircraft was diverted to a maintenance base.

History of the flight

Fourteen flight crew, comprising two training captains, 11 trainees and a safety pilot, reported for duty at Birmingham Airport at 0630 hrs, before departing for a flight crew 'base training' detail[1] at Prestwick Airport. A joint briefing was carried out, specifying that each trainee would carry out four circuits. The safety pilot was a company first officer, who would fulfil this role for the whole of the base training detail. The two training captains planned to share the instructional duties between them, one covering the first half of the training and the other completing the second half. The flight to Prestwick was uneventful and, on arrival, training circuits were carried out using Runway 13.

After the first half of the training detail, the training captains changed over and the second session began. Before each touch-and-go, the commander briefed the trainee on the specific actions to be carried out on the runway during the landing roll. No autobrake was to be set, no reverse thrust would be used, the trainee was to land on the centreline, then take their hand off the thrust levers while keeping the aircraft straight. The commander would disarm the spoilers, select flap 2, check the stabiliser trim was running, 'stand up' the thrust levers, check flap 2 was set and the trim was 'in the green', set TOGA thrust, check the speed and call rotate at $V_{APP.}$ The commander made these movements deliberate in order to avoid mistakes through rushing.

The fourth trainee of the second group, a co-pilot, was completing his final touch-and-go landing, with flap FULL. The landing and initial rollout were normal. The commander disarmed the spoilers, selected flap 2 and checked the trim and flap indications. He 'stood up' the thrust levers and, when the trim was set, selected MCT thrust and called "rotate". Shortly afterwards, there was a CONFIG warning. He glanced down and noted a red SPD BRK NOT RETRACTED message on the ECAM.

The commander decided to reject the takeoff and, with the aircraft rotating, he intervened on the controls. He closed the thrust levers and made a nose-down input on the sidestick but did not recollect calling "stop". There followed a period of a few seconds of dual inputs on the sidestick controls by the commander and co-pilot. Initially, both inputs were nose-down then, briefly, both were nose-up before stabilising around neutral. The commander applied the brakes hard but then reduced the brake pressure, once he judged that the aircraft would stop on the runway surface. After bringing the aircraft to a stop he taxied off the runway. The crew were aware of a hard touchdown on the nose landing gear but did not consider it was excessive.

Following the rejected takeoff (RTO) the crew was contacted by ATC to check whether any assistance was required. The crew advised that none was needed. The brake temperatures were checked and the brake fans selected ON. The commander then sought the assistance of the other training captain. They spent some time trying to determine the reason for the configuration warning but there were no indications as to the cause. So, believing that there might be a spoiler system fault, it was decided to continue the training but without arming

Footnote

[1] Circuits with touch-and-go landings.

the spoilers. Before continuing, the training captains discussed the firm nosewheel contact with several of the other crew members. None of them considered that it constituted a heavy landing and it was decided that an inspection was not required.

The training detail was resumed with the next trainee co-pilot occupying the right seat and acting as PF. The crew experienced difficulty entering a flight plan into the multi-function control display unit (MCDU), which appeared to have remained in go-around mode. They tried re-loading a flight plan using the secondary flight plan page and activating it, but were unable to do so. The commander eventually decided that a flight plan in the Flight Management System (FMS) would be unnecessary because visual circuits only were being flown. He also briefed that the landing gear should not be retracted immediately after the next takeoff, to aid brake cooling.

The aircraft took off from Runway 13 using TOGA thrust and, as soon as it had lifted off, the commander selected the thrust levers to MCT. During the initial climb, a L/G SHOCK ABSORBER FAULT message was displayed on the ECAM. The commander moved the thrust levers from the MCT detent to the CL detent, as the aircraft climbed through a height of 800 ft, and the thrust unexpectedly reduced to idle.[2] The safety pilot noticed the reduction in thrust and drew it to the commander's attention. The airspeed reduced and the aircraft started to descend. The commander took control, applied manual thrust and resumed the climb to circuit altitude. The crew requested, and were granted, an orbit in their present position. They then carried out the ECAM actions for L/G SHOCK ABSORBER FAULT, limiting the speed to a maximum of 280 kt and leaving the landing gear DOWN.

The trainee co-pilot was replaced in his seat by the other training captain and the two training captains reviewed the status of the aircraft. They determined that, with no landing gear retraction capability and the inability to engage the autothrust, autopilot or flight directors, the training should be discontinued and the aircraft flown back to Birmingham.

The crew transmitted a PAN call, advising ATC of their intentions, and an en-route clearance towards Birmingham was issued. After ATC had checked that a climb would be acceptable to the crew, the aircraft was cleared to climb to FL190.

En-route to Birmingham, the crew contacted the operator's engineering department to seek further guidance on the possible nature of the problem. A decision was made to divert the flight to Manchester, instead of continuing to Birmingham, and an uneventful landing was made at Manchester Airport following a VOR/DME approach.

The commander reported afterwards that, following the RTO and despite the lack of automation, the aircraft handled normally and, in the conditions, he had not found it especially demanding to fly. However, he also commented that the workload had been increased by the lack of information about the status of the aircraft's systems. He believed they had experienced a speedbrake fault and did not necessarily associate the shock absorber fault

Footnote

[2] The manufacturer provided the following explanation for the observed thrust behaviour: *'The auto-thrust (A/THR) engaged automatically when the thrust levers were retarded to CL. As the current speed was around 180kt and the selected speed was 130kt, the A/THR commanded a thrust reduction.'*

message with a hard landing. He could not understand why the autopilot and autothrust were not available and stated that the relevant information was not provided either by the ECAM or in the Flight Crew Operating Manual (FCOM).[3]

Meteorological information

The METAR for Prestwick issued at 1450 hrs was:

> surface wind from 120º at 6 kt, visibility 9,000 m, temperature 10ºC, dewpoint -2ºC and pressure 1003 hPa

The METAR for Manchester issued at 1550 hrs was:

> surface wind from 150° at 7 kt visibility 4,000 m in haze, few cloud at 4,600 ft, temperature 10ºC, dewpoint 1ºC and pressure 1002 hPa

Airport information

Prestwick Airport Runway 13 has a displaced threshold and an LDA of 2,743 m (8,999 ft).

Aircraft information

Configuration warning

The thrust levers can be moved into one of four detents for forward thrust. They are: 0 (idle thrust), CL (climb thrust), FLX/MCT and TOGA (both takeoff power settings). The takeoff configuration (CONFIG) warning becomes active when the thrust levers are set at or above FLX/MCT. There are eight red configuration warnings, of which speedbrake lever position is one, and four amber configuration cautions. If the speedbrake lever is out of its detent, the CONFIG SPD BRK NOT RETRACTED red warning will appear on the ECAM display when takeoff power is set.

Speed control

The aircraft may be operated in either managed or selected speed. Managed speed targets are computed by the Flight Management Guidance Computer (FMGC). When the speed target is managed, the SPD/MACH window of the Flight Control Unit (FCU) shows dashes and the Primary Flight Display (PFD) speed scale shows the speed target in magenta. To use a selected speed/Mach target, the flight crew uses the knob on the FCU to set the target speed, which is then displayed in the FCU window. It is also displayed in blue on the PFD speed scale.

During the pre-flight phase the flight crew has to insert V_1, V_R, and V_2 in the PERF TO page of the MCDU manually. These speeds are then displayed on the PFD during takeoff. If the speeds are not inserted in the MCDU before takeoff the FCU will show the last selected target speed.

Footnote

3 The manufacturer stated that autopilot and autothrust would be displayed in the INOP SYS list on the ECAM.

Landing gear shock absorber fault

The ECAM message L/G SHOCK ABSORBER FAULT is generated when the shock absorber does not extend after the aircraft becomes airborne. Additional information is provided on the ECAM Status page, advising that the landing gear must remain DOWN, if it has not been retracted, and the speed limit is 280 kt. The crew are also advised that the fuel consumption will be increased. In the INOP SYSTEMS field of the Status page the L/G RETRACT is listed, indicating that landing gear retraction is not possible.

The manufacturer advised:

> *'In case of a failure or a mis-rigging of both NLG [Nose Landing Gear] proximity sensors or if the NLG did not fully extend due to some mechanical damage, the Nose Shock-Absorber discrete associated with the proximity sensor, and directly connected to the FAC* [Flight Augmentation Computer] *(from each LGCIU* [Landing Gear Control Interface Unit]*), will be set to the Nose Shock-Absorber 'ON GROUND' state. As a result, the FAC will detect a mismatch between the NLG and the MLG [Main Landing Gear] and will inhibit the AP* [Autopilot]*, FD* [Flight Director] *and A/THR* [Autothrust] *engagement. In this case, AP1+2 and ATHR will be displayed in the INOP SYS list on the ECAM.'*

and

> *'There are several mechanical problems that may lead to a proximity sensor position failure, and therefore to a L/G SHOCK ABSORBER FAULT. Depending on the number and location of the failed proximity sensor(s), the consequences are different but whatever the failure scenario; the ECAM display will be correct and will reflect the real situation of the aircraft.'*

The manufacturer also advised that, in order to keep the FCOM as simple as possible, only the most frequent failure is covered (single failure of a shock absorber proximity sensor on a single landing gear leg). In this case, auto-pilots, flight directors and auto-thrust are available. For the situation where multiple proximity sensors fail, the FCOM does not provide guidance on the status of the aircraft systems.

Landing gear

The landing gears on A320 series aircraft are equipped with target proximity sensors, which effectively function as weight-on-wheels switches. Operation of the landing gear is controlled via two LGCIUs, with the proximity sensor outputs being used by a number of aircraft systems, including autoflight and autothrust. Data from most aircraft systems is collected by a Data Management Unit (DMU) which forms part of an Aircraft Integrated Data System (AIDS) and is used for condition monitoring and the generation of associated reports. A LOAD <15> report is automatically generated in the event of normal 'g' exceeding pre-determined values on landing and/or the radio altimeter descent rate exceeding a threshold value. The report, which is available on the flight deck printer, is to ensure the appropriate inspections are carried out by reference to the Aircraft Maintenance Manual (AMM). However, nose gear strut compression is not used within the landing gear detection logic.

Speed brake/ground spoiler control

The speed brake control lever is located on the left side of the flight deck centre pedestal and, when lifted into the ARMED position, arms the ground spoilers such that they deploy automatically on landing. When the control lever is pushed down into a detent at the front of the slot, movement in an aft direction results in proportional deployment of the speed brake surfaces. The control lever is connected to a series of transducers which send the command to the three spoiler-elevator computers (SECs), which in turn signal the spoiler servo controls that move the surfaces. These servos are equipped with linear variable displacement transducers (LVDTs) which provide position feedback to the SECs and ECAM indication.

Examination of the aircraft

Examination of the aircraft revealed no visible evidence of any damage to the nose landing gear or adjacent structure. However, on jacking the nosewheel off the ground it was apparent that the oleo would extend only 50 mm or so from its 'on ground' position. This resulted in the proximity sensors, which were attached to a linkage operated by the scissors assembly, remaining in the 'ground' as opposed to 'air' position.

With electrical power applied to the aircraft the operation of the speed brake lever was checked. It was found that when the lever was pushed down and moved aft from the front end of the gate, an ECAM indication of inboard spoiler operation appeared after the lever had moved approximately 2 mm. This was in accordance with correct operation of the system and indicated that spoiler deployment was initiated after a relatively small movement of the lever.

A copy of the Post-Flight Report (PFR) was obtained from the printer on the flight deck pedestal. This provided a record of faults logged by the Central Fault Display System (CFDS), showing both the ECAM messages, together with any associated failure messages. giving diagnostic information to maintenance personnel. The first pertinent fault report was 'BRAKES HOT', timed at 1428 hrs, together with a Flight Phase and ATA chapter reference. This reflected the time the takeoff was aborted following the configuration warning. The next message was 'L/G SHOCK ABSORBER FAULT' at 1447 hrs, followed by 'AUTO FLT A/THR OFF', also timed at 1447 hrs. The final relevant ECAM message was another 'L/G SHOCK ABSORBER FAULT', at 1448 hrs. The time-stamps of the final three messages indicated the elapsed time of approximately 19 minutes from the rejected takeoff to the subsequent departure, while the aircraft was taxied back to the start of Runway 13.

The PFR contained two relevant maintenance messages, which were associated with the 'L/G SHOCK ABSORBER FAULT' messages. Both were timed at 1447 hrs and referred to the two nose landing gear proximity sensors, '25GA' and '24GA', one message for each sensor. The source (ie component) for each message was identified as LGCIU 2 and LGCIU 1 respectively. This indicated that neither LGCIU had received valid 'air mode' signals from the proximity switches after takeoff. As a result a baulk signal was generated that would have prevented retraction of the landing gear following a gear UP selection. This feature is designed to prevent potential additional damage arising from retracting a damaged landing gear.

The nose leg was subsequently removed and sent to the manufacturer's overhaul facility for further examination. This revealed that a degree of distortion had occurred to the inner oleo cylinder, such that it could no longer move freely relative to the outer cylinder; it was this feature that had prevented the strut extending, under the oleo gas pressure, to the 'air' position. The damage was less severe than that which has been seen in previous A320 damaged nose landing gear events, notably that to registration G-MARA, which was published in AAIB Bulletin 6/2009. In this incident the aircraft touched down in a flat, perhaps slightly nose down attitude. Apart from the damage to the cylinder, part of the linkage that moved the target proximity sensor was noted to be distorted. This had occurred as a result of the landing gear geometry, which was such that it caused distortion in the linkage at full strut compression.

One of the AAIB Safety Recommendations (2009-047) made in the G-MARA report, recommended that Airbus include a specific reference in the AMM to inspecting the nose landing gear proximity target link rod for damage, as this could be a likely indicator of full strut compression and thus potential additional damage. Airbus stated they would change their procedures to be followed in the event of abnormal landings in a manner that effectively introduced the intent of the Recommendation. In the event, the amended AMM did not include any reference to the gear proximity target link rod. However, Airbus did update the relevant subtask for nose landing gear inspections (ref 05.51.11.210.091) to inspect the aircraft *"…if the hard or hard overweight landing was on the nose gear only (high pitch rate)…."* The required tasks in this event include lifting the aircraft on the forward jacking point.

Additional information

Information from the aircraft manufacturer indicated that if the compression status of the nose landing gear differs from that of the main gears for more than 20 seconds, the LGCIU is considered invalid. Since both sets of proximity switches failed to register 'air mode', both LGCIUs were considered failed by the Flight Augmentation Computers (FACs) with the result that 'L/G SHOCK ABSORBER FAULT' messages were generated approximately 20 seconds after the main landing gears uncompressed.

The aircraft manufacturer additionally stated that the invalid LGCIU status meant that the FACs, which, among other functions, provide flight envelope protection, would have no indication of landing gear position. This information is used in complex configuration and operational speed computations so the lack of it reduces the integrity of these calculations. This in turn can lead to errors in the weight and selectable speeds and is the reason why the autopilot/autothrust and flight directors cannot be engaged.

Recorded data

The aircraft was fitted with an FDR and a CVR. Before the event was notified to the AAIB the operator initiated an internal investigation. The FDR was downloaded and the data was supplied to the manufacturer, to help determine the appropriate maintenance actions. Subsequently, a copy of the data was obtained by the AAIB investigation.

The CVR was a two-hour recorder. The circumstances surrounding the RTO were overwritten and the CVR recording began during the flight to Manchester.

Other on-board sources of data were the EGPWS and an in-cockpit video of part of the RTO sequence, captured using a handheld smart phone. The smart phone captured three minutes and nine seconds of high definition video and audio recording, filmed from the rear left section of the flight deck by a fourth pilot, a trainee secured in a crew jump seat, and directed mainly towards the trainee in the right seat. The recording started early in the approach and was stopped during the RTO.

Other evidence included RTF, radar and CCTV recordings.

The following information is an amalgamation of the recorded data. Figure 1 shows the pertinent extracts from the recordings leading up to and including the RTO.

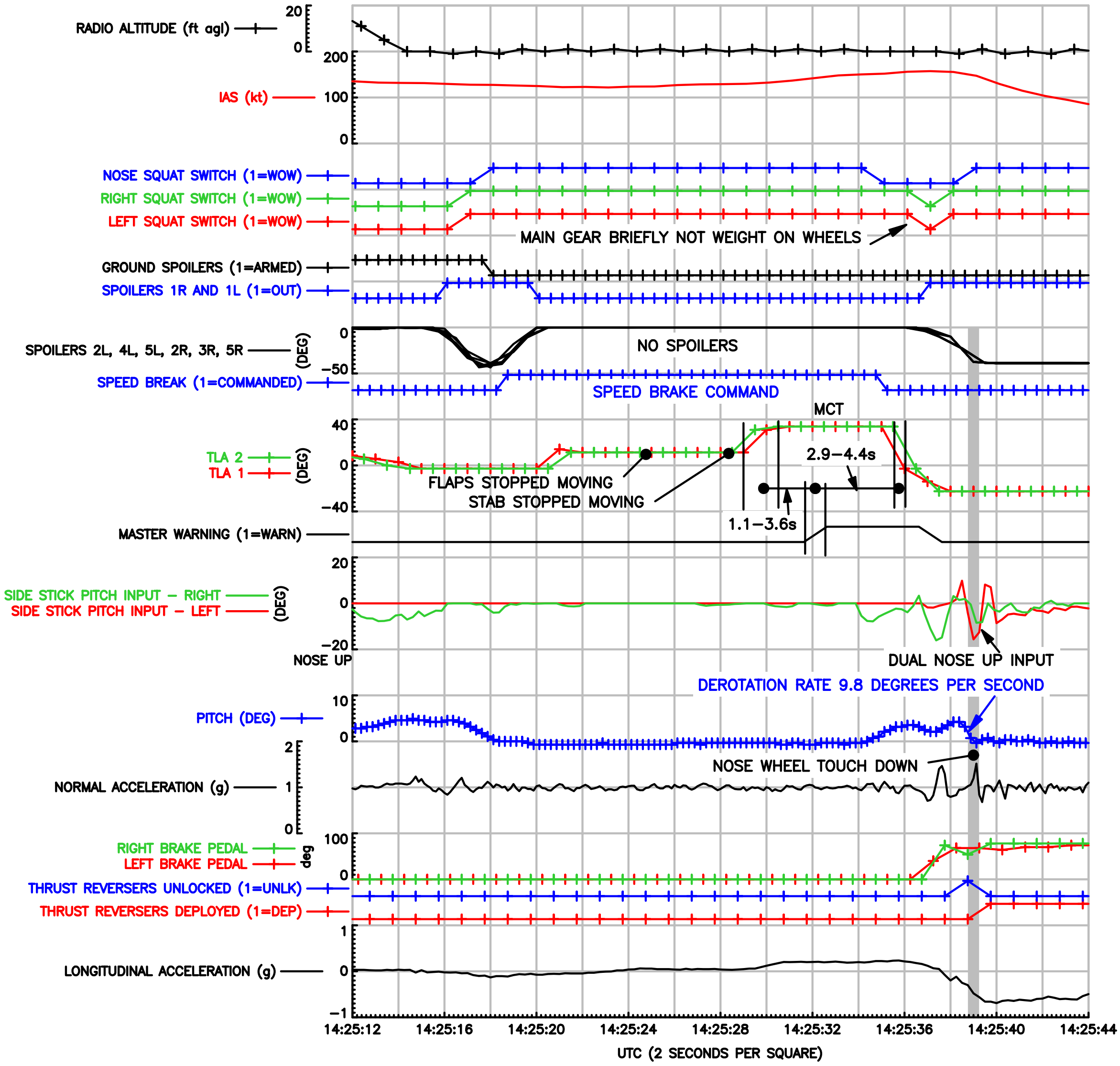

Figure 1

Touch-and-go rejected takeoff

Prior to landing, the ground spoilers had been ARMED and, on landing, they deployed as intended. As the nose landing gear proximity switch registered weight-on-wheels, the ground spoiler system transitioned to NOT ARMED and the speed brake parameter transitioned to COMMANDED. Within the following two seconds the spoilers retracted. During this period the flaps started to move. Shortly after that, the throttle levers were advanced to a position half way to the CLB detent and the stabiliser trim started moving.

When the stabiliser trim stopped moving the throttles were moved to the MCT detent. The in-cockpit video indicates that approximately 1.8 seconds after thrust levers reached MCT, the master warning was triggered. Approximately 2.5 seconds after the onset of the warning, the speed brake command parameter reset to NOT COMMANDED. This was followed by the thrust levers being retarded to idle and then reverse thrust. Meanwhile, the pilot in the right seat had started to rotate the aircraft. With the nose landing gear in the air, the spoilers started to deploy and the brake pedals were applied. The main landing gear proximity switches indicated they were in the 'air' (landing gear uncompressed) position for one sample (the sample rate was 1 per second) and then showed weight-on-wheels, again, shortly following which the thrust reversers unlocked. The aircraft then derotated, nose-down, reaching a rate of 9.8 °/s at the same time as both side stick controls were commanding a pitch-up. A normal acceleration spike of 1.52g was recorded at the centre of gravity as the nose landing gear touched down.

The aircraft came to a stop with approximately 560 ft of runway remaining and immediately turned on to Runway 21, then on to Taxiway R.

Between the onset of the master warning and the first recorded movement of the thrust levers to reject the takeoff, the aircraft had accelerated from a ground speed of 131 kt to 147 kt.

Subsequent flight

The subsequent flight departed at 1446 hrs. The data recorded at the start of the flight is shown in Figure 2. The nose landing gear proximity switches continued to indicate weight-on-wheels after takeoff and the flight directors were engaged at 200 ft agl. At 800 ft agl, the autothrust engaged in 'speed' mode after the thrust levers were retarded to CLB. With the aircraft speed above the selected speed of 130 kt, the engine target N_1 and, subsequently, achieved N_1 values reduced. The flight director and autothrust systems then disengaged as the aircraft passed 1,200 ft agl, with the aircraft decelerating. Five seconds later, the selected speed was increased to above the aircraft speed. A further five seconds later the thrust levers were advanced and subsequently the sidestick control inputs switched from the right to the left. Shortly afterwards, an EGPWS mode 3 (altitude loss after takeoff), warning was triggered.

The aircraft climbed to 1,600 ft agl and remained at this height whilst carrying out a number of orbits. At 1501 hrs, the aircraft initiated a climb to FL190 and flew to Manchester, landing at 1550 hrs. The landing gear remained DOWN throughout the flight. The autopilot was not recorded as engaged during any part of this flight and the aircraft used normal control laws.

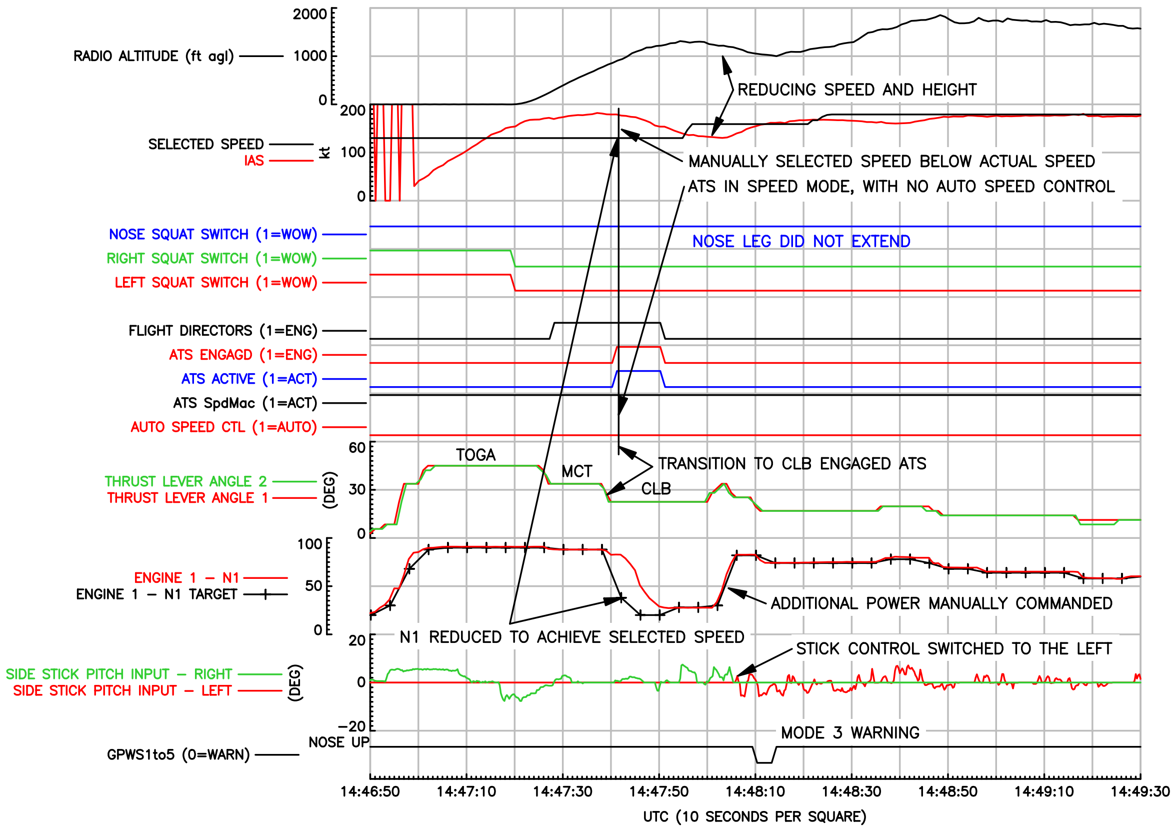

Figure 2

Subsequent takeoff

The CVR recording started 27 minutes prior to the touchdown at Manchester Airport. It included information on the ECAM messages relayed to the operator's engineering department by the crew. They related to: autopilots 1 and 2, autothrust, landing gear retraction, a HOT AIR INOP caption and the aircraft being Category 2 status only. The crew suspected damage to the landing gear proximity sensors and reported three green indicator lights for the landing gear.

Manufacturer's comments

During the investigation, the manufacturer was consulted on the recorded behaviour of the flight director and autothrust modes. They provided the following explanation:

> *'After the rejected touch and go, the FD were engaged in Go Around modes. Then they were disengaged at approximately 14:28:00. The most probable hypothesis for this disconnection is that the crew selected them OFF trying to exit the MCDU Go Around phase. When they have been selected OFF, there is no automatic engagement of the FD except during a go around in flight. Therefore, the FD were not engaged during the takeoff. At 14:47:27, FD2 was engaged followed, 1 sec later by FD1. This engagement cannot be automatic and must have been commanded by the crew. The FD engaged in basic modes, V/S and HDGM, then ALT* mode engaged as the aircraft was approaching the selected altitude.'*

and

> *The auto-thrust (A/THR) engaged automatically when the thrust levers were retarded to CL. As, at that time, the Flight Directors (FD) were engaged in ALT* mode, the A/THR engaged in SPEED mode. As the current speed was around 180 kt and the selected speed was 130kt, the A/THR commanded a thrust reduction.*

Previous touch-and-go takeoffs

The previous touch-and-go takeoffs were compared to the takeoff on the final flight that eventually landed in Manchester. The final takeoff was the only one with the AUTO SPD CNTRL parameter not indicating AUTO.

Flight data monitoring

The investigation prompted two questions:

1. How often has the speed brake command been triggered inadvertently when the ground spoilers have been disarmed?

2. Was the derotation rate during the RTO distinct enough from normal operations to trigger an indication that maintenance action may be required?

The operator's Flight Data Monitoring (FDM) program provided the statistical background to these questions. This was achieved using a combination of data from current event triggers and data from new event triggers.

Speed brake command

An FDM trigger event was created for a speed brake command generated within five seconds of the ground spoilers being disarmed. The approach phase of a flight was excluded from this study to avoid distorting the figures with intentional use of the speedbrake controls, which also met the trigger criteria.

The occurrence rate of this event during the landing roll on the operator's A321 and A320 fleet were 2.47 and 2.24 occurrences per 1,000 landing rolls, respectively. No common trends were identified. This event is benign during the landing roll on a full-stop landing. However, the occurrence rate is indicative of how often there is an unintended consequence when disarming the ground spoilers.

Derotation rate

The operator's FDM program has three derotation rate triggers per fleet, measured during landing. They are referred to as Minor, Major and Critical, and correspond to the trigger values given in Table 1.

	Derotation rate events		
	Minor	Major	Critical
Trigger derotation rates (°/s) – A320	-4	-5	-7
Occurrences in 9,787 landings	2	0	0

Table 1

The operator's derotation rate trigger levels and triggered occurrences during normal A320 operations

In the 12 months of operation to the end of August 2013, covering nearly 10,000 A320 landings, there were 2 triggers of the Minor event and no Major or Critical derotation rate triggers. This indicated a clear distinction between normal operations and the derotation that caused the damage to G-OZBY.

Training procedures

The aircraft manufacturer provides guidance on touch-and-go landings in the *Base Training Syllabi* for their aircraft, including specific task sequence and allocation. Spoilers are expected to be ARMED for landing and DISARMED during the touch-and-go landing roll. Additional advice on emergencies states:

> *'The decision to discontinue a touch and go after the application of TOGA must only be taken if the instructor is certain that the aircraft cannot safely fly.*
>
> *Remember there is no V_1 on a touch and go.'*

The operator's Type Rating Training Organisation (TRTO) manual provides specific guidance on the procedures to be used during base training including the sequence of actions during a touch-and-go landing. The procedures reflect those in the manufacturer's guidance, with the exception of the following statement: *'the spoilers will not be armed'* for landing. The manual recommends a minimum LDA of 8,000 ft (2,438 m).

The AAIB was advised that the manufacturer had, in the past, required the spoilers not to be ARMED for a touch-and-go landing but had revised the procedure.

A number of the operator's training captains had been instructed by a third party provider on how to conduct aircraft base training. The procedures for arming and disarming the spoilers, as taught by that provider, differed from the manufacturer's and those described in the operator's TRTO manual. They recommended that spoilers should be ARMED for landing and should remain ARMED for the takeoff phase. The operator reported that their training personnel had standardised amongst themselves and adopted the manufacturer's procedure, namely, to arm the spoilers for landing and disarm them during the ground roll.

Analysis

The available evidence suggested that the configuration warning resulted from the speed brake lever being inadvertently placed in the speed brake range, during the touch-and-go landing, in such a position that it did not command spoiler surface deflection. The timing of this selection indicated that it occurred when the ground spoilers were being disarmed by the commander pressing the lever downwards. This then caused the takeoff CONFIG warning to be activated after takeoff power was set, and the commander rejected the takeoff.

The manufacturer's syllabus, the operator's TRTO manual and a third party training provider each specified different procedures for arming and disarming of the ground spoilers. The commander was using the technique recommended by the manufacturer and adopted by the operator's training personnel.

The decision to reject a takeoff is normally a rule-based decision with clearly defined failure events and a calculated V_1 decision speed. The manufacturer advises that a touch-and-go should not be rejected once TOGA is set, unless the commander is certain the aircraft will not safely fly, and notes that there is no V_1 decision speed on a touch-and-go.

The takeoff CONFIG warning is not activated until the thrust levers reach takeoff power. Therefore, during a touch-and-go the warning will always occur after MCT or TOGA is set and at a higher speed than for a normal takeoff. On this occasion, after setting MCT, the commander believed that the safety of the aircraft might be compromised if they continued, so he rejected the takeoff. During the RTO there was a period of dual inputs on the pilots' sidestick controls, lasting for a few seconds. The absence of a STOP call probably contributed to this.

The commander brought the aircraft to a stop before the end of the runway, which was 305 m (1,000 ft) longer than that recommended in the TRTO manual for touch-and-go landings, and was able to reduce the braking effort during the deceleration.

The two training captains considered the status of the aircraft after the RTO and came to a decision that the touchdown of the nose landing gear during the RTO was not hard enough to merit any further action. They discussed the event amongst those on board and it was not considered that the touchdown of the nose landing gear had been excessive.

Thrust reduction after takeoff

An explanation for the reduction in thrust to idle was provided by the aircraft manufacturer. When CLB thrust mode was engaged the selected target speed was 130 kt, which was below the aircraft's current speed of 180 kt. The selected speed of 130 kt may have corresponded to the approach speed from the previous approach. The observed thrust behaviour was not expected by the crew but appears to have been as a result of crew selection and not related to the damage sustained by the aircraft.

Recorded data

Inadvertent speed brake command

The operator created an FDM trigger for capturing speed brake commands that became active within five seconds of the ground spoilers being disarmed. The occurrence rate on the operator's A321 and A320 fleet were 2.47 and 2.24 occurrences per 1,000 landing rolls, respectively. This provides an indication of the rate at which an inadvertent speed brake command occurs on the operator's A321 and A320 fleet as a consequence of disarming the ground spoilers. It also shows that the probable reason for the configuration warning, and the subsequent RTO, on this investigation is not unique. This has little consequence during a normal, full-stop landing but becomes an issue during touch-and-go landings.

Combining the operator's A320 fleet rate and the number of touch-and-go landings carried out during this training detail, indicates that there was an approximately 8% probability that the inadvertent speed brake command would have occurred that day.

Hard landing/ high derotation rate

Over a 12 month period, on its A320 fleet, the operator did not detect any derotation rates during landings of -5 °/s or greater. The derotation rate during the RTO, which resulted in damage to the nose landing gear, was calculated as -9.8°/s.

No LOAD <15> report was generated as none of the Normal 'g' or radio altimeter descent rate thresholds were exceeded during the RTO. The aircraft manufacturer stated that the LOAD <15> algorithms are not capable of detecting all cases of abnormal landings and that the detection of this kind of occurrence is outside the scope of the LOAD <15> report. The detection of possible nose landing gear damage remains the pilots' assessment of the touchdown. On this occasion, the crew did not consider the touchdown on the nose landing gear to be excessive and there was no indication of damage or fault with the aircraft until the subsequent takeoff.

Safety pilot

Each training captain was scheduled to carry out some 24 takeoffs and landings, assuming that no additional training was required. A safety pilot is required to be on board to monitor the safety of the aircraft during base training as an 'extra pair of eyes' in case of errors or distractions. Therefore, the safety pilot for this detail was responsible for monitoring the safety of at least, 48 takeoffs and landings. For a single crew member to remain alert throughout this whole period would be demanding. During the ground roll in a touch-and-go landing there are a number of actions for the safety pilot to monitor. From the jump seat position, though, it is unlikely that he would have been able to see clearly if the speedbrake lever was slightly out of its detent. During the subsequent takeoff he drew the commander's attention to the unexpected behaviour of the thrust.

Safety actions

The operator carried out a review of its crew training programme following this incident and made a number of changes to their procedures and manuals. These included:

- The operator's Safety Department created a Flight Data Monitoring event to highlight any inadvertent movement of the speedbrake lever during both line and training operations.
- A revised and definitive procedure for base training has been included in the operator's Type Rating Training Organisation (TRTO) Manual.
- The operator has revised its crewing requirements, and documented them in their TRTO Manual, such that the maximum number of trainees/circuits per training captain is limited. Furthermore, one safety pilot is rostered for each training captain, in order to reduce workload and possible fatigue of the safety pilot.

SERIOUS INCIDENT

Aircraft Type and Registration:	Eurocopter EC155B1, OY-HJJ
No & Type of Engines:	2 Turbomeca Arriel 2C2 turbine engines
Year of Manufacture:	2003 (Serial No: 6662)
Date & Time (UTC):	6 November 2013 at 2023 hrs
Location:	Clipper Gas platform, North Sea
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - 8
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	41 years
Commander's Flying Experience:	2,240 hours (of which 1,160 were on type) Last 90 days - 120 hours Last 28 days - 44 hours
Information Source:	AAIB Field Investigation

Synopsis

Shortly after takeoff from an off-shore platform at night, the helicopter entered a series of extreme pitch excursions which resulted in the airspeed reducing below 20 kt, followed by a descent. The flight crew were eventually able to recover to normal flight. The helicopter had descended to within approximately 50 feet of the sea surface. It was found that the helicopter's flight path was consistent with inappropriate control inputs. The investigation concluded that a combination of technical and organisational factors had pre-disposed the flight crew to believing that the helicopter was not performing correctly, which led them to depart from normal operating parameters. This resulted in the crew rapidly becoming disorientated to the extent that their ability to control the helicopter safely was compromised. Several safety actions have been taken by the helicopter operator.

History of the flight

The helicopter was operating a personnel transfer flight to the Clipper gas production platform in the southern North Sea. It departed on the outbound flight from Norwich Airport at 1925 hrs with two flight crew and five passengers on board. The 1848 hrs weather report from the platform gave a wind of 190º at 14 kt, FEW clouds at 500 ft and SCT cloud at 1,100 ft. The visibility was reported as 6,675 m with recent light drizzle; QNH was 996 hPa.

The outbound flight was unremarkable. The weather on arrival was slightly worse than forecast, with a visibility of 3,000 m, FEW clouds at 400 ft and SCT clouds at 800 ft. The actual wind was largely unchanged. The commander, acting as Pilot Flying (PF), flew the majority of the sector including the approach. However, the physical characteristics of the helideck and the prevailing wind direction necessitated that the co-pilot, who flew the majority of the sector as Pilot Not Flying (PNF), take control for the landing.

Ten passengers boarded the helicopter for the return flight to Norwich. The calculated takeoff mass was 37 kg below the calculated performance limited takeoff mass of 4,870 kg. However, when the commander, acting again as PF, attempted to lift the helicopter from the helideck, he could achieve only a low hover with the power available. He therefore had to land back on the helideck.

During the first takeoff attempt, an amber TRIM caution illuminated on the Caution Advisory Display (CAD), with an associated amber C legend on each pilot's Primary Flight Display (PFD). This indicated that a problem existed with the collective channel of the Automatic Flight Control System (AFCS). The crew carried out a reset of the AFCS which cleared the caution, although it reoccurred several times (along with other AFCS related indications, as described in more detail later in this report) while the helicopter was on the helideck. The commander briefed the co-pilot that automatic control of the collective might not be available after takeoff.

One passenger and his luggage were off-loaded and the crew prepared for a second attempt at takeoff. The second attempt to take off also encountered performance issues, even though the calculated takeoff mass was now 134 kg below the performance limited maximum. The commander decided to land again to off-load a further passenger, reducing the total to eight. A combination performance issues and the need to deal with repeated AFCS cautions prolonged the departure. With generally poor weather in the operating area, the crew became concerned that the fuel state was reducing towards minimum for their flight to Norwich.

After 28 minutes on the helideck, the commander carried out a successful takeoff and, as the helicopter accelerated, he engaged the autopilot in Go-Around (GA) mode. Almost immediately, the crew sensed that the helicopter was not transitioning to a climb as they expected, but was in fact still descending and accelerating. With the autopilot still engaged, the commander made manual control inputs in an attempt to ensure the desired climb profile was followed. Recorded flight data showed that the helicopter transitioned to a climb but that pitch attitude continued to increase steadily to 18º nose-up and the airspeed reduced to near zero. Soon afterwards, with the helicopter still in a nose-high attitude and at low speed, the co-pilot, in response to a request for assistance from the commander, made an input on the collective lever which resulted in an over-torque. The nose-up pitch continued to increase, reaching 23.5º nose-up before recovery action was taken. In recovering from the pitch excursion, the helicopter reached a 36º nose-down pitch attitude with the subsequent high rate of descent being arrested approximately 50 ft above the sea surface. A further nose-high pitch excursion followed, during which the helicopter reached 20º nose-up. The commander subsequently recovered the helicopter to normal flight parameters and established a climb to cruise altitude. The crew reported initial difficulties engaging autopilot modes during the climb, but normal functionality was recovered prior to a safe approach and landing at Norwich, 47 minutes after takeoff.

Flight crew reports

The flight crew were interviewed separately on the morning of 8 November 2013.

AFCS abnormal indications

Both pilots described repeated indications of abnormal AFCS operation before the final takeoff, which occurred while the helicopter was on or just above the helideck. Although the pilots differed somewhat in their recall, in general terms both described repeated amber TRIM captions on the CAD, with an associated C legend on their PFDs. These captions generally appeared just as the collective lever was first moved upwards for liftoff.

According to the pilots' reference cards, these indications represented '*loss of collective trim or stick position sensors*'. The associated actions were applicable only in flight, and consisted of notes that flight could continue, but that certain autopilot functions would not be available. The crew therefore responded to the cautions by carrying out repeated re-sets of the AFCS, which in each case were successful. The commander also noted that he had to adjust the collective friction control as the lever felt stiff to move and did not seem to move smoothly.

From the pilots' combined accounts, it is possible that there was also an ACTUATOR caption on the CAD which may have illuminated briefly, after one of the resets, before clearing. The cause of this condition was described in the reference cards as '*loss of series actuator*'. The associated actions for this condition, which again were related only to flight, consisted of assuming manual control and carrying out a reset of the AFCS. The commander also thought (and confirmed by later comment on the voice recording) that an amber COLL LINK (collective link) legend had appeared on his PFD in association with a CAD caution. Both pilots were certain that resets had been successful and that no abnormal indications were present when the helicopter eventually took off.

Takeoff and accelerating transition

With the helicopter climbing vertically and maximum takeoff power applied, the commander committed to the takeoff by moving the cyclic control forward to commence the transition. He was concerned about the hitherto unexpected poor performance, and selected a greater nose-down pitch attitude than normal in order to ensure that the helicopter cleared the helideck as swiftly as possible; flight data showed the helicopter reached an 18° nose-down attitude. The commander recalled thinking that the helicopter's cyclic control felt unusual, and that pitch control was more sensitive than usual. He was aware of a descent and thought the performance was still not as expected.

At about 40 kt, in response to a standard "airspeed alive" call from the co-pilot, the commander reduced power to maximum continuous in accordance with normal procedures. He thought the helicopter had levelled or began a shallow climb by about 55 kt airspeed. However, the commander still felt that performance was poor and so, possibly slightly earlier than usual, he engaged the autopilot GA mode, which was confirmed by correct indications on his PFD. However, he soon felt that the helicopter was not responding as expected, which was to climb away at the current airspeed. Instead, he believed it pitched nose-down slightly and was still descending and accelerating. In an effort to arrest the perceived speed excursion and assist the autopilot to transition to a normal climb, he thought he may have temporarily made an aft input on the cyclic control.

The co-pilot had a similar impression and recalled calling "still descending". The commander did recall making an aft cyclic input at this stage. The autopilot remained engaged in the GA mode, and the commander was aware of overriding it for a short while. He recalled seeing the pitch attitude increasing to about 20º nose-up and a significant rate of climb, although he perceived the helicopter to be still descending with maximum power applied. He heard the automatic aural alert 'ONE HUNDRED FEET' and called for the co-pilot (who was aware of the pitch excursion and had been calling out parameters) to assist him. The commander believed that this occurred at about the lowest height reached during the incident.

The co-pilot saw the pitch attitude increasing and thought the commander was making control inputs in the correct sense, although they appeared exaggerated, resulting in a degree of 'over controlling'. He was aware of the reduced height (he thought about 50 ft) and airspeed reducing through about 20 kt. He thought the commander wanted him to assist on the controls, so placed his hands on them and made a forward input on the cyclic and an upward movement of the collective lever. The commander retained control but reduced power slightly before establishing what he believed was a normal accelerating transition. He did recall disengaging the autopilot at some stage in the event, but was unsure exactly when. The co-pilot recalled a further pitch oscillation before recovery to normal flight was achieved.

The commander reported that the helicopter's cyclic control felt unusual throughout and that it was akin to flying the helicopter in a degraded control mode, whereby only basic stability augmentation is available. Although not a normal condition, it was one which he practised routinely in the simulator. The co-pilot, from his observation of the commander's control inputs, was of the same opinion. The commander recalled disengaging the autopilot, but thought it was probably late in the sequence of events.

The commander reported difficulty in engaging some autopilot modes during the subsequent climb until ALT mode (altitude hold) was selected for cruise flight. A successful 3-axis coupled[1] ILS was flown at Norwich.

Footnote

[1] 'Coupled' refers to the process of coupling the autopilot to one or more upper modes.

Helicopter description

The Eurocopter EC155B1 is a twin-engined helicopter that can carry up to 13 passengers with 2 crew (Figure 1). It has an AFCS, also known as the autopilot (AP), that can control the four axes of pitch, roll, yaw and collective.

Figure 1
Eurocopter EC155B1 OY-HJJ

Automatic Flight Control System (AFCS)

System overview

The helicopter's AFCS is intended to improve stability and handling qualities with 'basic modes' functioning continuously in normal operation. Additionally, a number of 'upper modes', which are guidance modes, are selectable by the pilots as desired. The 'upper modes' include airspeed hold (IAS), altitude hold (ALT), vertical speed hold (VS) and go-around mode (GA).

Controls and indications

'Upper modes' are engaged and disengaged by pushbuttons on a control panel or on the cyclic and collective controls. Indications of mode engagement status are displayed on each pilot's PFD (green for engaged modes). Indications of failures, transient conditions or degraded modes are also displayed on the PFD, sometimes accompanied by caution messages on the CAD. Reference or target values are displayed on the PFD and navigation display (ND), and a failure of the autopilot to achieve a reference value for any reason is also indicated on the PFD. Indication that a control is being moved manually while upper modes are engaged is indicated to the flight crew by the engaged mode legend on the PFD flashing green/amber.

The commander recalled seeing indications of correct GA mode engagement. However, neither he nor the co-pilot were aware of any other AFCS related indications on their PFDs during the incident.

AFCS Go-Around (GA) mode

Engagement of the GA mode is achieved by pressing a button on the collective lever. In this mode the autopilot initially maintains the airspeed at time of engagement and a vertical speed of 1,000 ft/min up or current vertical speed, whichever is higher. The airspeed and vertical speed can then be adjusted by the pilot if desired. Unless other modes were selected beforehand, GA mode would automatically revert to separate IAS and VS modes after 15 seconds. In GA mode or IAS / VS mode, the autopilot controls vertical speed through the collective control and airspeed through cyclic pitch control.

Technical description of the AFCS

The AFCS consists of an Automatic Pilot Module (APM) which controls the helicopter via four series actuators and four parallel actuators. The series actuators provide small but rapid control inputs on the roll, pitch and yaw axes (two on the roll axis). The parallel actuators, also known as trim actuators, provide slower control inputs over the full control range. These control the roll, pitch, yaw and collective axes and also provide control feel. The pilot can override the parallel actuators by force or can press the relevant trim release button to disengage them.

The APM receives a number of inputs from air data systems, gyroscopes, cyclic positions sensors, a yaw lever position detector and a collective lever position detector (CLPD). The CLPD is mounted to the airframe below the left collective and has a link that connects to the collective push-pull tube. As the collective is moved, the link moves and its linear displacement is converted to an angular displacement which is measured by an RVDT[2] and a potentiometer installed inside the CLPD (Figure 2). The RVDT provides collective position to the APM, while the potentiometer serves to monitor the RVDT. If the two disagree a TRIM and C caption will be illuminated in the cockpit, as well as a COLL LINK caption. If these captions remain on, the collective channel will not be available to the AFCS.

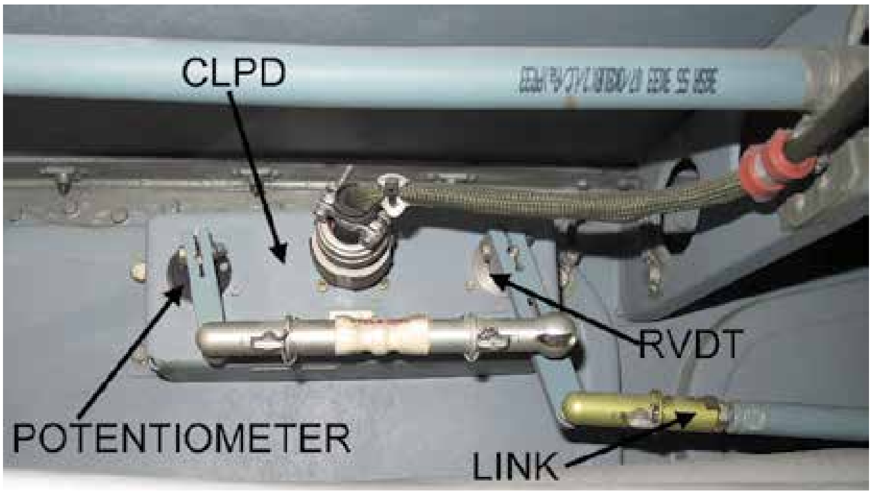

Figure 2

Collective Lever Position Detector (CLPD)

Footnote

2 Rotary Variable Differential Transformer, used for accurate measurement of angular displacement.

Recorded flight data

The helicopter was fitted with a combined cockpit voice recorder and flight data recorder that contained one hour of cockpit recordings and over 12 hours of flight data respectively. This was removed from the helicopter following the incident for the data to be downloaded and analysed. Electrical power to the flight recorder was not isolated after landing, so the unit continued to record until the helicopter's main power was turned off. Consequently, for the voice recordings, activities on the helideck and the first part of the takeoff were over-written. The main flight data parameters for the incident are shown at Figure 3.

Recorded flight data

Recorded flight data showed the transition commencing with a progressive forward movement of the cyclic control and a corresponding decrease in pitch attitude from the hover attitude of 2 to 3º nose-up to 18º nose-down (Figure 3 - time 39400 seconds). The cyclic then moved back to just forward of neutral and nose-down pitch started to reduce. As the helicopter accelerated and power was reduced to maximum continuous (not shown), the pitch attitude was still significantly below 10º nose-down. The helicopter's flight path changed from level flight to a descent. At about 70 kt, as the helicopter pitched up through 10º nose-down, the cyclic control moved further back to about the neutral position and the rate at which the helicopter was pitching up increased, although it continued to descend with a maximum rate of 860 ft/min for two or three more seconds before a climb was established. At this point, as the pitch attitude passed 0º, and at 76 kt airspeed, autopilot GA mode was engaged (time 39409).

About two seconds after mode engagement, with vertical speed increasing towards (and eventually exceeding) the target of 1,000 ft/min, the collective and engine torque began to reduce under the control of the autopilot collective channel as it tried to limit the vertical speed to 1,000 ft/min. Vertical speed reached a maximum of 1,500 ft/min.

The cyclic control remained at about neutral as the pitch continued to increase. Although the autopilot GA mode remained engaged, force 'breakout' sensors on the cyclic control detected continued pilot manual control inputs, primarily in pitch but also in roll, which continued until the point of eventual recovery. The helicopter continued to pitch up and climb, reaching 18º° nose-up pitch at about 240 ft radio height[3] and with speed reducing through about 45 kt. At this point, total engine torque, which had reduced to below 50% (time 39415), started to increase again, reaching about 80% over 6 seconds.

With increasing forward cyclic inputs, the pitch attitude then decreased over the next 8 seconds (although with oscillations) to reach 10º nose-up, by which time the helicopter had climbed to 400 ft radio height with airspeed reducing to below 20 kt. The collective lever was raised, to give about 88% torque. About two seconds later, there was a noticeable forward movement of the cyclic and the collective was further raised (believed to be the inputs made by the co-pilot). Engine torque increased briefly to 109%, representing the point at which the over-torque occurred. Radio height at this point was about 410 ft.

Footnote

[3] Radio height is recorded at a low sample rate of once per four seconds.

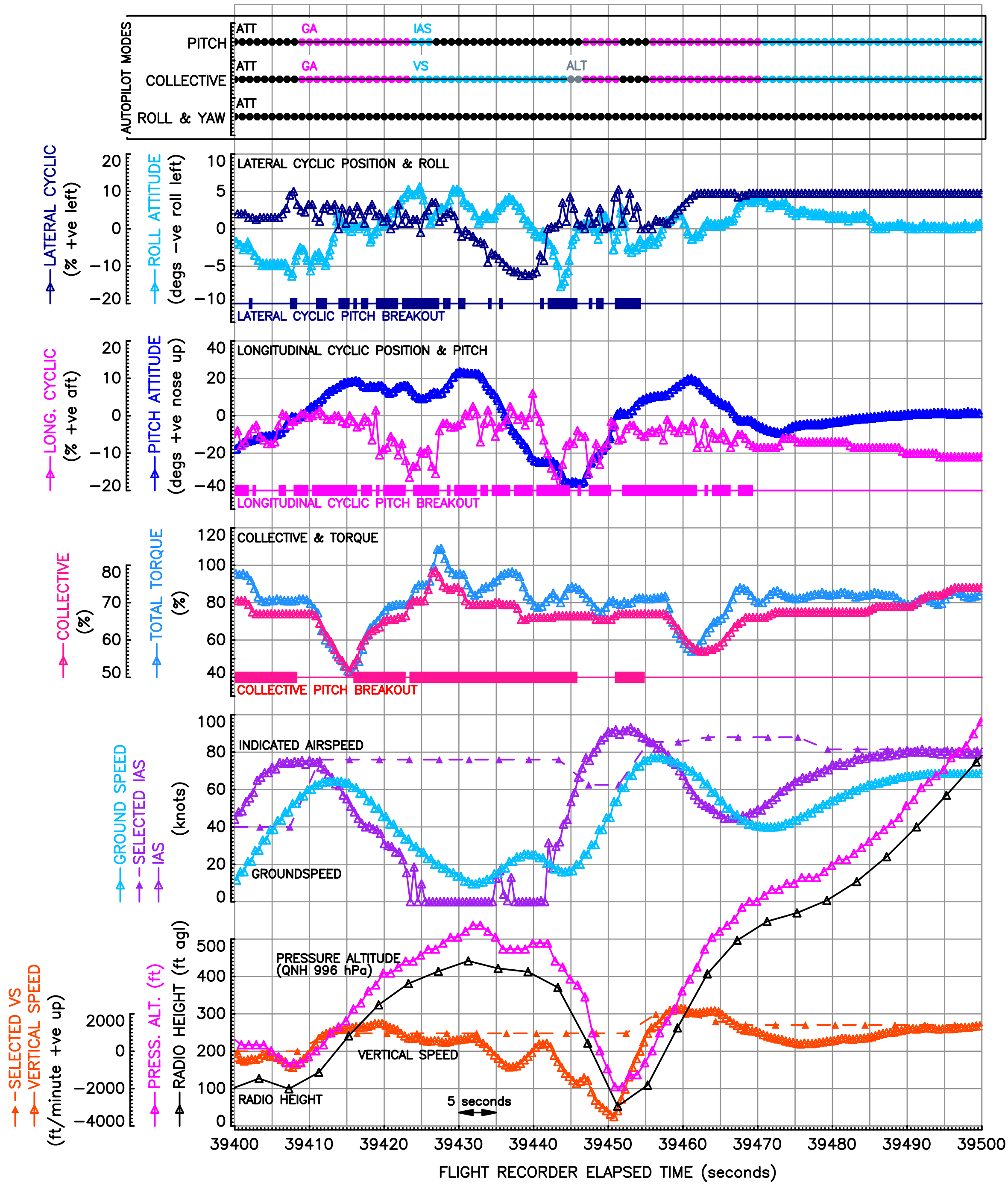

Figure 3

Salient recorded flight data for the incident to OY-HJJ

With data indicating zero airspeed[4], the cyclic control then moved significantly aft again, initially to just forward of the neutral position, and pitch attitude started to increase again (time 39426). This was coincident with operation of the cyclic trim release button (not shown), which allowed the pilot to disengage the trim actuators temporarily on the cyclic control, allowing it to be repositioned to a new datum without the artificial load applied (the commander remembered repositioning the cyclic rearwards, although he thought this occurred earlier in the sequence, in response to his initial perception that the helicopter was not responding correctly to GA mode engagement). The helicopter reached 25º nose-up pitch over the next 3 seconds (time 39430). It remained at this value for a further 3 seconds, with the helicopter at 460 ft radio height and indicating zero airspeed, before a noticeable forward cyclic input was made. The helicopter then pitched nose-down and started to descend.

The helicopter reached 24º nose-down pitch in about 7 seconds. After a brief pause at this value, the helicopter responded to increasing forward cyclic input by pitching down further, to 36º nose-down. This was accompanied by a rise in airspeed and descent rate calculated from the pressure altitude as 2,900 ft/min at a height of about 100 ft. After about a second, the helicopter pitched up again, reaching zero pitch angle just before it reached the lowest recorded radio height of 53 ft.

There followed a similar pitch up excursion, to 20º nose-up, but with a more obvious and controlled recovery. This time, the airspeed did not fall below 40 kt and the helicopter maintained a climb throughout.

AFCS mode behaviour

When the commander engaged GA mode, it engaged as expected. Current airspeed (76 kt) became the autopilot speed target, with a vertical speed target of 1,000 ft/min up. As vertical speed increased towards the target and then exceeded it, collective and engine torque reduced, as would be expected. The GA mode remained engaged for 15 seconds before reverting to IAS and VS modes. However, as IAS decayed to zero, due to the aft cyclic inputs, the IAS mode disengaged automatically, being replaced with a basic attitude mode; the VS mode remained engaged.

There was a brief GA mode re-engagement as the helicopter descended towards its lowest altitude, but both pitch and collective channels disengaged simultaneously after 2 or 3 seconds, probably the deliberate disengagement by the commander. A further 2 seconds later, the mode was again engaged. As with the first engagement, the helicopter was by this time climbing under pilot input and collective and engine torque again reduced as the vertical speed increased. The GA mode remained engaged, reverting to IAS and VS modes for the subsequent climb. Pilot manual input continued in cyclic pitch but ceased as the recovery and climb became established.

Footnote

4 The recorded airspeed is unreliable below 20 kt.

Data comparison with earlier flights

The flight recorder contained data for 17 earlier takeoffs, being a mix of shore-based and platform departures. The weight and balance conditions for each flight were not established, nor were environmental conditions, so only a general comparison between the earlier flights and the incident flight was made. Nevertheless, the following observations were made:

1. The nose-down pitch attitudes for initial transitions were all between -5º and -9º.

2. The cyclic pitch control position in the early stages of transition always remained significantly further forward than on the incident flight and never as far back as the neutral position. The most rearwards position was typically achieved just after maximum nose-down pitch, and appeared to be a short term corrective input. Cyclic positions then moved gradually forward with increasing airspeed.

3. The average pitch attitude at 70 kt on transition was 4.4º nose-down.

4. The final pitch attitudes for most transitions were only 2º to 4º above the initial pitch attitude, with only small variations in actual cyclic pitch positions.

5. Stabilised climb pitch attitudes varied between +2º and -2º, depending on airspeed, the actual values remaining largely stable.

6. There were no other instances of manual inputs occurring with autopilot upper modes engaged, either on earlier flights or later on the accident flight. All observed returns of manual inputs in cyclic pitch were consistent with the phase of flight.

7. Autopilot GA mode was used on takeoff on 53% of previous flights.

Cockpit voice recordings

The recording started with the commander's call to the co-pilot for assistance. Immediately afterwards, the over-torque warning chime sounded and it was evident that it had been noticed by the commander. The co-pilot announced that the speed was zero, and called out the applied power. Eight seconds later he announced "FOUR TWENTY FEET RADALT, SPEED COMING UP". Four seconds later he called "WE'RE DESCENDING", repeating the warning immediately after, although the commander did not acknowledge the calls. The aural voice alert "ONE HUNDRED FEET" sounded three seconds after, and the co-pilot said "CHECK HEIGHT". The commander made a short exclamation. The next call was the co-pilot calling out airspeed and attitude as the helicopter climbed through 200 ft, after reaching its lowest point.

Subsequent conversation between the pilots included discussion about apparent problems engaging autopilot heading mode (although it did subsequently engage) and what had occurred on takeoff. Each pilot voiced confusion over what had occurred, and each appeared to identify the point that GA mode was engaged as being a key area: the commander said that the helicopter didn't respond as he thought it would do and the co-pilot remarked that the helicopter was still descending.

Loss of relevant voice recordings

Voice recordings from the ground phase and early flight phase were overwritten because power to the flight recorder was not isolated immediately after landing and shutdown, allowing the unit to continue to run. The operator included the following in its Operations Manual part A, paragraph 2.5.13, being an extract from JAR-OPS procedures:

> *'To prevent the data of the FDR/CVR to be erased, the power supply to the FDR/CVR should be disconnected until the data has been preserved.'*

It was apparent at interview that, in the absence of further guidance or explicit instructions to flight crews, the commander believed that isolation of the recording equipment was an engineering function.

Helicopter examination

An autopilot self-test was carried out by the crew after landing and there were no faults. Additional self-tests were carried out by the operator's engineer and by the AAIB, and again there were no faults. Interrogation of the APM did not reveal any fault codes for the incident flight.

Examination of the collective control system revealed that the potentiometer inside the CLPD had become loose. When the collective was moved the body of the potentiometer moved slightly. The CLPD was removed which revealed that one of the three tongues which secured the potentiometer to the casing had become loose (Figures 4 and 5). This tongue should have engaged into the slot at the base of the potentiometer, but it had become loose and rotated out, enabling the body of the potentiometer to rotate slightly during collective movement. The other two tongues were still securely engaged in the slot.

Figure 4
Inside the CLPD

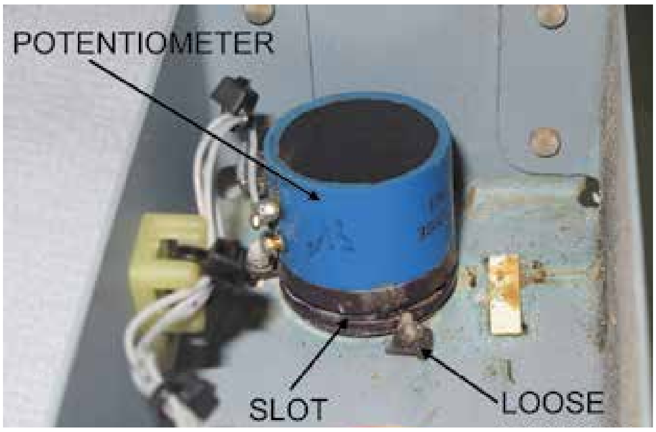

Figure 5

Close-up of potentiometer inside CLPD

The APM and CLPD were removed from the helicopter for further examination and replacement parts were installed. The operator carried out further checks on the flight control system and AFCS and no faults were found. All control movements were found to be smooth without binding. The over-torque checks were also completed with no faults found. The helicopter then underwent a test flight during which no anomalies or AFCS faults occurred; this flight included a departure with GA engagement in a similar flight condition to the incident flight. The helicopter was subsequently released back to service.

Further faults following OY-HJJ's release back to service

On OY-HJJ's third flight in operational service, during pre-taxi checks, the ACTUATOR caption illuminated on the CAD accompanied with C and R captions on the PFD. These cleared when the AP was reset. During the last phase of the flight, while raising the collective in the flare, the TRIM caption with C illuminated. Additionally, the pilot reported that the collective was harder to move than normal. The collective system was inspected and tested for full movement and no faults were found. Two flight tests were carried out, during which the TRIM and Y captions illuminated. The yaw parallel actuator was replaced and a further test flight was carried out without incident. During departure of the next operational flight, the TRIM and Y captions illuminated as well as YAW on the AP control panel. These occurred multiple times and were cleared by switching the yaw channel on and off six times. The helicopter was subsequently withdrawn from service for further investigation with the assistance of the helicopter manufacturer.

To address the collective TRIM with C fault, the bearings in both collective mixing units were replaced although they showed no binding during tests. The fault in the yaw channel was traced to a bellcrank in the aft end of the tailboom which had a worn guide that could cause binding in the yaw controls. The bellcrank was replaced and the helicopter was returned to service but the TRIM with C captions illuminated again.

Further investigation revealed that wiring around the collective control was tight so this was re-routed. In addition, the grounding block 10N2 was found to be soiled with dirt and oil. This grounding block serves to ground three wires for the YAW TRIM discretes.

The resistance between the yaw parallel actuator plug and these three ground pins was measured and found to be high. The ground wires were removed from the block and found to be slightly corroded, so were cleaned and replaced. In the operator's experience corrosion on wirepins for discrete signals could cause false captions on the CAD.

Given these findings, the TRIM with Y caption was probably caused by either the worn bellcrank in the tailboom or the corroded wires in the 10N2 grounding block, or a combination of both.

As a further preventative measure the collective, roll, pitch and yaw parallel actuators were replaced.

Examination of the stationary swashplate revealed chafing where the main servo rod end was attached to the swashplate (left image in Figure 6). This area of the swashplate should have been protected by a 'stirrup guide' (right image in Figure 6), but this guide was missing. Because the servo rod is a hydraulic actuator, any resistance, due to chafing between the rod end and swashplate, would not have been felt in the pilot controls and would not have affected the AFCS. The swashplate was replaced with a new part with a stirrup guide fitted.

Following the aforementioned rectification action the helicopter was returned to service with no further reported AFCS faults.

Figure 6

Left image: fixed swashplate from OY-HJJ with missing stirrup guide;
Right image: stirrup guide on another swashplate

Autopilot module examination

The APM was removed from the aircraft and sent to the helicopter manufacturer for testing under the supervision of the BEA[5]. The APM should have recorded fault codes in its non-volatile memory (NVM) in relation to the AP captions witnessed by the flight crew, but no such fault codes were stored. The manufacturer connected the APM to another helicopter and repeated the interrogation of the NVM but no fault codes were stored. The manufacturer's investigation into the cause of the lack of fault code recording is continuing.

Footnote

5 The BEA is the Bureau D'Enquêtes et D'Analyses – the French equivalent of the AAIB.

Maintenance history

OY-HJJ was manufactured in 2003 and bought by the current operator in 2007. At the time of the incident it had accumulated 4,962 hours and 8,595 cycles. There was no significant recent maintenance or significant deferred defects. The CLPD and the potentiometer inside the CLPD had not been replaced since the operator acquired the helicopter in 2007. Maintenance documentation from the helicopter's previous owner could not be obtained, so it could not be established if the potentiometer had been installed by the manufacturer or by the previous owner's maintenance organisation. The helicopter manufacturer stated that this was their first known occurrence of a loose potentiometer in the CLPD.

The stationary swashplate (also known as the non-rotating star) had been installed on OY-HJJ in June 2011. This swashplate had been repaired and overhauled by the helicopter's maintenance and repair organisation (MRO) in February 2011. During overhaul the stirrup guide was not replaced, and this was due to the repair worksheet not including an instruction to replace this guide. The helicopter manufacturer has initiated an internal investigation and has published a revised repair worksheet which includes an instruction to install the stirrup guide. It also intends to publish a Safety Bulletin to require operators of the EC155 to inspect the stationary swashplate for stirrup guide fitment.

Flight crew information

The commander joined the operator as a co-pilot in July 2012 with 1,780 hours total flying time. He completed type conversion training with his previous company and had flown 570 hours on type. His most recent recurrent simulator check was completed successfully on 4 October 2013. The commander's training records reflected successful completion of all required training with no weaknesses noted.

The co-pilot joined the operator in September 2012. He had also previously qualified on type, with 1,300 hours total and 550 hours on type. His most recent recurrent simulator check was completed successfully on 13 July 2013. Like the commander, his training records reflected successful completion of all required training with no weaknesses noted.

On the day of the incident, the two pilots reported for their duty at 1515 hrs. Both pilots had returned to duty after scheduled days off and each considered himself well rested and fit.

Helicopter performance

Helicopter mass

The helicopter was weighed by the manufacturer in 2007 at the time of its delivery to the operator. In 2011, it was dry-leased to a company in Africa, where it was re-painted and re-weighed. On return to the operator in 2013, a new weighing record was produced on the basis of the 2011 weighing record. However, there was a misunderstanding over the configuration of the helicopter at the time of its weighing in 2011; the cabin seating had not been included in the new figures, whereas the operator believed that it had been. When the helicopter was re-weighed after the incident, it was found to be 82 kg heavier than that stated on its weighing record.

In line with the provisions of JAR-OPS 3[6], the operator's OM Part A stated:

> *'The mass and centre of gravity (C of G) of each Company helicopter shall be established by actual weighing before it is used for the purpose of commercial air transportation. All helicopters are to be reweighed thereafter at intervals of four years.'*

JAR-OPS 3 further stated:

> *'Helicopters transferred from one JAA operator with an approved mass control programme to another JAA operator with an approved programme need not be weighed prior to use by the receiving operator unless more than 4 years have elapsed since the last weighing.'*

The company to which OY-HJJ was dry leased did not meet the above criteria, so a re-weighing would have been required on the helicopter's return in 2013. At that time, as part of the operator's application to the Danish Transport Authority (DTA) for an Airworthiness Review Certificate (ARC), the 2011 weighing report was among documents presented to a DTA official for inspection. The operator regarded the issue of the ARC as an acceptance by the DTA of its non-compliance with JAR-OPS 3. However, there was no documented evidence of such.

When the helicopter was drained of fuel for weighing, it was also established that a calibration error in the right hand fuel system resulted in an extra 38.5 kg of fuel being carried in the right hand tank than was indicated to the flight crew. The combined effect of these two factors was to produce an error or 120.5 kg in the calculated takeoff mass; the helicopter being heavier than the flight crew believed.

The reason for the fuel calibration error was subject to separate investigation. The helicopter operator undertook to analyse historical flight information to establish if and when the helicopter may have been unwittingly flown outside the applicable mass and balance limitations.

Helicopter performance

Using a performance table appropriate for the Clipper platform, the flight crew derived a performance limited maximum takeoff mass of 4,870 kg. For their initial departure, takeoff mass was calculated to be 4,833 kg, 37 kg below this maximum, while the second takeoff attempt, with 9 passengers, was calculated to be 134 kg below maximum. The final takeoff, with 8 passengers on board and an appropriate fuel adjustment, was calculated to be at 4,573 kg, or 297 kg below the performance limited takeoff mass.

During the investigation, takeoff performance figures were recalculated using the revised, higher weight. This established that the first two takeoff attempts were above the

Footnote

6 JAR-OPS Part 3 prescribes requirements applicable to the operation of any civil helicopter for the purpose of commercial air transportation by any operator whose principal place of business is in a JAA Member State.

performance limited takeoff mass, by 114 and 17 kg respectively (the second attempt may have been slightly under the maximum if fuel burnt while on the heli-deck is taken into account).

The final takeoff mass (including an adjustment for additional fuel burnt) was 146 kg below the maximum. The helicopter remained below the absolute maximum all-up mass of 4,920 kg throughout. Actual centre of gravity position was calculated to be at 3.92 m aft of datum, which was slightly forward of mid position and within prescribed limits.

Company information

Takeoff profile

The normal takeoff profile detailed in the operator's Operations Manual (OM) was based on one developed by the helicopter manufacturer with a view to reducing exposure to risk during the takeoff phase. The procedure was termed PC2DLE: *Performance Class 2 – Defined Limited Exposure*. It entailed a vertical climb using no more than maximum takeoff power to a decision point 20 ft above the helideck, at which point the helicopter was rotated to a maximum of 10º nose-down (the Eurocopter Complimentary Flight Manual for the EC155B1 gave this as 15º nose-down, the reduced value being a company maximum). As the helicopter reached takeoff safety speed of 40 kt, power was to be reduced to maximum continuous, the nose-down attitude reduced and a smooth accelerating climb initiated.

The company's training philosophy on AFCS use after takeoff was that autopilot upper modes would only be selected via the autopilot mode selector panel, and only once the helicopter's flight path was stable. GA mode was not regarded as a normal mode to be used after takeoff. However, it was known that other operators of the type routinely used GA mode after takeoff, and that pilots joining from those operators may revert to using it during normal takeoffs. The commander was one of these pilots, and it was evident at interview that he regarded GA mode as a valid mode for use after takeoff. The operator's OM did not prohibit the use of GA mode for takeoff, it only stated:

> *'Climb may be flown manually or in 3 or 4 axis CPL mode. Normally 4 axis coupled.'*

In a Notification to Pilots issued after the incident, the operator issued specific instructions that the GA mode may only be used during a missed approach and not during takeoff. Engagement of upper modes was not to be made below 70 kt and 200 ft, and only in a 'wings level' climb of not more than 1,000 ft/min.

Procedure, deviation and attention calls

In its OM Part B (applicable to the EC155B1), the operator detailed its requirements for standard communication calls between pilots under normal and abnormal conditions. *Procedure* calls were applicable to routine procedures on a particular helicopter type. *Attention* calls were primarily for use in the approach phase, to enhance safety and guard against an undetected pilot incapacitation; they required a clear response from the PF, with a requirement that the PNF take control of the helicopter if the PF twice failed to respond to a call. *Deviation* calls by the PNF were intended to alert the PF to deviations from the normal or intended flight path.

The OM Part B did not stipulate any requirements for the PF to acknowledge deviation calls, or state what actions the PNF should take if the deviations continued. The OM Part A (General) did include a 'Two Communication Rule'. This was also intended to guard against incapacitation, stating that a crew member should suspect incapacitation any time a pilot did not respond appropriately to a second call associated with deviation from normal procedures or flight profile.

After the incident, the operator revised its instructions to crews, requiring a positive response from the PF in case of a deviation call being made. Additionally, it required the PNF to take control in case of an incorrect or absent response to any standard call during a critical phase of flight.

Operator's internal recommendations

Following its own investigation into the incident, the helicopter operator made a number of internal safety recommendations. Areas addressed included: guidance and advice to flight crews regarding automation and the AFCS, improved flight crew training programmes, the introduction of defined flight parameters to assist PNF monitoring and the Flight Data Monitoring programme, a review of the PC2DLE based company takeoff procedure and measures to improve the company's procedures for mass and balance arrangements.

Analysis

Prior to departure from the platform, the flight crew received a number of abnormal AFCS indications. These captions were not captured in the APM's NVM, the cause of which is subject to ongoing investigation by the helicopter manufacturer. There was no evidence that these captions reoccurred during the incident and the AFCS was assessed to have operated correctly during this phase of the flight. After the CLPD was replaced, the COLL LINK caption did not recur; it was probably caused by the loose potentiometer inside the CLPD providing a different collective position reading to the RVDT. The cause of the loose potentiometer inside the CLPD could not be determined, but the helicopter manufacturer had not received any other reports of loose potentiometers. Since the potentiometer is only used to monitor the RVDT, the worst-case effect of a loose potentiometer is a loss of the collective AFCS channel with accompanying captions.

The TRIM with 'C' caption could also have been caused by the loose potentiometer. However, this caption recurred after CLPD replacement, so it may also have been caused by the restriction caused by the tight wiring around the collective control which was later discovered (and may have also caused the later ACTUATOR with C captions on further flights). The tight wiring may also explain why the commander reported that the collective felt stiff to move. No reason for the commander's report of the cyclic controls feeling unusual could be determined, nor for the ACTUATOR caution. The helicopter manufacturer stated that the ACTUATOR caution can sometimes briefly appear following an autopilot reset, and the crew's accounts support this explanation.

Despite the technical issues experienced by the crew, the helicopter nevertheless appeared serviceable and within applicable operating limitations immediately before the final takeoff. The flight crew were both early in their duty period, properly qualified and well rested. However, the takeoff was preceded by performance, technical and weather issues which would have combined to place an additional pressure on the flight crew for what was already a demanding takeoff profile.

Almost immediately after takeoff, both pilots perceived that the helicopter was not performing correctly and that the AFCS was not responding as expected, neither of which is borne out by the flight data. Their perception of the helicopter's flight path rapidly diverged from what was actually occurring, to the extent that their ability to control the helicopter within safe limits was compromised. The only unusual event that occurred between the helicopter lifting from the helideck and the onset of the crew's perception errors was the initial pitch down, which was significantly greater than both the operator's stipulated maximum and typical values seen elsewhere on the recorded flight data. It is thus likely that the initial pitch down, together with the lack of external visual cues, was the triggering event for this incident.

Flight data showed that the effect of the exaggerated nose-down attitude, when combined with the power reduction which started at 40 kt, was to cause the helicopter to descend, at a point in the transition when the crew would normally be expecting to establish in a climb. This descent continued until about the time the commander engaged GA mode, and is apparently what prompted him to start making aft cyclic inputs. The commander's assessment that the helicopter was not performing correctly was a factor in his decision to engage the autopilot slightly early, but it also meant that the autopilot was engaged before a stable, climbing flight path was achieved. This situation would have taken the autopilot a finite time to resolve, which probably conflicted with the commander's perception of the time available, hence the desire to 'assist' the autopilot with a manual control input.

As the helicopter pitched up the rate of climb increased quickly, causing the autopilot to reduce collective and engine torque significantly. This may have contributed to the crew's perception of a continued descent, which was so powerful that both pilots believed the helicopter to have descended directly to its lowest point, despite their instrumentation indicating a very different flight profile.

Recorded flight data showed that the AFCS system performed as expected, but was overridden by manual control inputs throughout much of the incident. As no other instances of manual input with autopilot upper modes engaged were detected in the recorded data, and the indications ceased coincident with recovery, the indications were believed to be valid. As far as could be determined, there were no cockpit indications of abnormal AFCS operation during the incident. Indications alerting the crew to the abnormal situation are presumed to have occurred, but were not recalled. However, the crew clearly believed that the autopilot was not functioning correctly, both during and after the event. This is most likely due to the repeated abnormal AFCS indications which occurred whilst on the helideck, which would have predisposed them to this view.

The concept of deviation calls in standard procedures is intended to alert all crew members to a developing undesirable situation. In this case, the situation developed so rapidly after takeoff that the pilots quickly became overloaded, to the extent that even basic flight parameters were incorrectly perceived. The opportunity for standard calls to prevent the situation developing was therefore limited, and only early in the incident, at a time for which there was no voice recording. However, the voice recording does show some verbal communication taking place during the most extreme manoeuvres, which probably contributed to the crew's successful recovery of the situation.

The commander's decision to select an exaggerated nose-down attitude was made out of concern for the helicopter's apparently poor performance. This arose because of the weighing and fuel gauging errors which had existed undetected for some time. Their direct effect was to cause the flight crew to believe that the helicopter was underperforming and therefore were a major influence on the commander's subsequent actions. The provisions of JAR-OPS 3 in respect of the weighing requirements would, if followed, have removed this contributory factor and the incident may not have occurred.

Safety actions

Following the incident, the operator carried out a review of the instructions and guidance given to flight crews in its Operations Manual and the content of recurrent simulator training programmes. The following safety actions were carried out:

1. Pending amendment of the Operations Manual, a Notice to Crew (NTP) was issued, covering:
    a. A revised, more conservative method of applying wind corrections to performance calculations,
    b. A limit on the number of resets that may be carried out on a malfunctioning or degraded system, with the requirement that autopilot resets must be followed by a successful system self-test,
    c. A prohibition on the use of GA upper mode after takeoff,
    d. Additional company requirements for engagement of autopilot upper modes after takeoff,
    e. An expansion of the Procedure, Deviation and Attention call-outs to introduce a formal response from PF and widen the requirement for PNF to take control of the helicopter in case of an incorrect or missing response by PF.
2. Recurrent simulator training programmes were expanded to include:
    a. A review of autopilot upper modes, including the potential for excessive deviations arising from manual control inputs while upper modes are engaged,

b. A greater emphasis on manual handling skills,

c. Increased frequency of 'recovery from unusual attitude' training.

The missing stirrup guide in the stationary swashplate resulted in chafing damage to the swashplate, but this was not related to any of the AFCS captions. The helicopter manufacturer has revised their repair worksheet to include instructions to fit the stirrup guide and intends to publish a Safety Bulletin requiring operators of the EC155 to inspect the stationary swashplate for stirrup guide fitment.

BULLETIN CORRECTION

Prior to publication it was noted that this report was incorrectly classified as an INCIDENT.

The occurrence was in fact classified as a **SERIOUS INCIDENT**.

BULLETIN CORRECTION

The report incorrectly stated the location as **Clipper South Gas Field, North Sea.** The correct location is **Clipper Gas platform, North Sea**.

The online version of the report was on corrected on 8 August 2014.

ACCIDENT

Aircraft Type and Registration:	Bell 206B Jet Ranger III, G-BPWI
No & Type of Engines:	1 Allison 250-C20B turboshaft engine
Year of Manufacture:	1980 (Serial no: 3087)
Date & Time (UTC):	4 October 2013 at 1610 hrs
Location:	Upper Edgebold, near Shrewsbury, Shropshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Substantial
Commander's Licence:	LAPL (H)
Commander's Age:	61 years
Commander's Flying Experience:	445 hours (of which 18 were on type) Last 90 days - 21 hours Last 28 days - 9 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot noticed that the engine turbine temperature had increased to close to its maximum limit and prepared to make a precautionary landing. During the approach the indication returned to normal, so he decided to continue the short distance to his destination. As the helicopter climbed away, the engine failed. The pilot carried out a forced landing during which the tail boom struck the ground. He candidly commented that, on reflection, it would have been better to continue with the precautionary landing, rather than having to attempt a forced landing without power from low altitude.

History of the flight

The pilot, who had recently converted onto the type, was returning to the helicopter's home base after visiting a maintenance organisation. No maintenance had taken place; the purpose of the visit was for the pilot to receive refresher training on performing the daily inspection. The start and pre-flight checks were normal. After departure the pilot climbed to 2,000 ft and set up a cruise using 70% torque, giving an indicated airspeed of 100 kt.

When the helicopter was about 5 nm south-west of Shrewsbury, the turbine temperature increased to 812°C, but all other engine indications were normal. The pilot decided to carry out a precautionary landing and reduced the power to approximately 40% torque and descended. The turbine temperature then decreased, so he increased torque to 60% and levelled off.

As the engine now appeared to be operating normally, the pilot decided to abort the precautionary landing and continue the short distance to his destination. When he increased the torque to 70% to climb, the turbine temperature increased to above the top of the scale on the gauge. The torque indication fluctuated and the engine sounded as if it was "hunting". The helicopter was about 800 ft agl at this point. The pilot entered an autorotation and declared a MAYDAY to Sleap Radio. During the ensuing forced landing the helicopter rolled over, coming to rest on its side. The pilot, who sustained a minor injury, was able to escape through the broken front windscreen and called the emergency services by mobile telephone.

Helicopter examination

The helicopter was recovered from the accident site by the maintenance organisation visited by the pilot prior to the flight. They reported that they had drained a significant quantity of fuel from the main tank to prevent it leaking into the ground. The engine oil tank had ruptured in the impact, but they reported evidence of residual oil in the vicinity consistent with the quantity expected to be in the tank. The helicopter was examined once it had been recovered to the maintenance organisation and no pre-existing defects were identified with the airframe, drivetrain or control systems. The engine controls were all connected and operated normally. The engine was removed and transported to an overhaul facility for detailed inspection.

Engine inspection

Prior to dismantling the engine, the engine control air tubes were checked for leaks; none were found. The compressor bleed valve was checked and operated normally. The thermocouple harness for the turbine temperature gauge was removed and bench-tested. It was found to be within normal limits.

Examination of the oil system revealed metal chips in the oil taken from the main oil filter housing and that the O-ring on the oil filter spigot was missing. The upper magnetic chip detector had collected debris, including metal chips; the lower magnetic chip detector was covered in a paste-like residue. The No 6 and 7 main bearing scavenge sump was dry, but contained metallic debris, as did the oil scavenge pipes.

On disassembly, the No 7 main bearing was found to be disintegrated, with evidence of severe heat damage and metal splatter on the turbine disc and casing, Figure 1. The failed parts were returned to the engine manufacturer for a detailed failure analysis. Any significant findings will be dealt with through their normal continued airworthiness processes.

A check valve situated in the output flow from the oil filter was found to contain a foreign body which appeared to be an O-ring similar to that fitted to the oil filter spigot, Figure 2. The O-ring had become lodged in the valve opening, preventing the check valve from operating. The check valve is designed to open whilst the engine is running, to provide a flow of filtered oil from the filter housing to the bearings, and to close on engine shutdown, to retain oil in the filter housing and prevent it leaking into the engine internal cavities.

Figure 1
Failed No 7 bearing

Figure 2
Oil filter housing check valve (disassembled) with foreign O-ring found inside

Relevant maintenance history

In July 2013, the engine had undergone a scheduled 300-hour inspection and new compressor casings were installed. As part of this inspection an oil flow check was carried out and a figure of 260 cc of oil in the specified time period was recorded. The engine maintenance manual specifies a minimum amount of 90 cc, but no maximum. The maintenance records show that the oil filter was not disturbed at this time.

In May 2013, 56.6 engine hours earlier, a 100-hour/12 month inspection was carried out. The engine oil was replaced and the oil filter was inspected and cleaned, before being refitted. An oil flow check was carried out and a figure of 120 cc of oil in the specified time period was recorded.

In November 2012, a further 9.4 hours earlier, the engine was removed from the helicopter and sent to an overhaul organisation to remedy an oil leak from the torque meter. After installation in the helicopter an oil flow check was carried out and a figure of 130 cc of oil in the specified time period was recorded.

The pilot reported he had noticed that blue haze/smoke was visible from the engine exhaust for several minutes after every engine shutdown. This was to be investigated at the next maintenance input.

Discussion

Engine failure

The engine failure appears to be as a result of the disintegration of the No 7 bearing, which was most likely caused by oil starvation. This bearing supports part of the turbine assembly and therefore relies on oil flow for cooling, as well as lubrication. Any reduction in oil flow could lead to the bearing overheating and ultimately failing.

The foreign O-ring found in the oil filter housing check valve was probably the one missing from the oil filter spigot. The O-ring is likely to have caused a restriction to the oil flow around the engine, which may also account for the fluctuating torque indication, as the torque meter uses engine oil pressure for its operation. It also seems likely that this O-ring prevented the check valve from closing on engine shutdown for the previous few flights. With the engine shut down and the check valve still open, oil could leak from the oil filter housing into the hot parts of the engine and then vaporise, producing a blue haze/smoke in the exhaust similar to that reported by the pilot.

The oil flow check after the last filter disturbance indicated the oil system was operating normally. A subsequent oil flow check 56.6 engine hours later showed a much higher than normal oil flow, but still within maintenance manual limits. It was not possible to determine how or when the O-ring entered the check valve.

Precautionary landing

Following the first indications of high turbine temperature the pilot decided to conduct a precautionary landing, but when he saw the indications return to normal during the approach he decided to continue the flight to his destination only a few miles away. The engine failed shortly after he added power to climb away.

The pilot, on reflection, candidly commented that he would have been better to continue with the precautionary landing rather than having to attempt a forced landing without power from a low altitude. He added that in the final stages of the approach he probably flared too much, causing the tail boom to strike the ground.

AAIB correspondence reports

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

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

The accuracy of the information provided cannot be assured.

ACCIDENT

Aircraft Type and Registration:	Aero AT-3 R100, G-SACY
No & Type of Engines:	1 Rotax 912-S2 piston engine
Year of Manufacture:	2007 (Serial no: AT3-029)
Date & Time (UTC):	9 March 2014 at 1515 hrs
Location:	Sherburn in Elmet, Leeds
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose leg collapsed and two propeller blades damaged
Commander's Licence:	Student
Commander's Age:	50 years
Commander's Flying Experience:	31 hours (of which 31 were on type) Last 90 days - 6 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The student had not flown for 60 days and therefore flew for 35 minutes, with his instructor, during which time he successfully completed three circuits. The instructor briefed the student to continue flying solo touch-and-go circuits and to ensure that the aircraft was returned to the airfield fuel pump by 1530 hrs.

The student successfully flew three circuits, but due to activity in the circuit conducted a go-around on the third circuit. While downwind on the fourth circuit the student noted that it was now 1515 hrs and therefore elected to make this his last landing. The student reported that he realised late on the approach that he was too high and fast and consequently touched down beyond his normal aiming point. He thought the aircraft had made a firm touchdown and did not immediately recognise that it had in fact bounced until it started 'porposing', by which time it was too late to initiate a go-around. The aircraft landed on its nosewheel causing the nose leg to collapse and detach from the aircraft. Two of the propeller blades were also damaged and engine was shock-loaded.

Following the accident the CFI of the flying club carried out a review of the revision training that instructors should carry out if a student has not flow for a significant period.

ACCIDENT

Aircraft Type and Registration:	CAP 10B, G-BKCX
No & Type of Engines:	1 Lycoming AEIO-360-B2F piston engine
Year of Manufacture:	1982 (Serial no: 149)
Date & Time (UTC):	16 March 2014 at 0701 hrs
Location:	Private airstrip near Swansea
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Substantial damage to engine and cowlings, propeller, fuselage, canopy, tail and wings
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	642 hours (of which 538 were on type) Last 90 days - 8 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and photographs of the accident site

The aircraft was on final to land at a private grass airstrip when it encountered a flock of geese and suffered several bird strikes. There was severe engine vibration and evidence of other damage to the airframe. The pilot selected a field adjacent to the intended landing strip and carried out a forced landing. The aircraft landed tailwheel first, followed by the mainwheels, which rolled for a short distance before digging in to the soft surface. This caused the aircraft to pitch nose-down and invert.

The pilot considered that he avoided serious injury by the use of his five-point safety harness. He released it and escaped from the aircraft by breaking the canopy and pulling himself out. He telephoned the emergency services and was later taken to hospital with head and neck injuries.

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BIDH
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1981 (Serial no: 152-80546)
Date & Time (UTC):	11 April 2014 at 1715 hrs
Location:	Beverley (Linley Hill) Aerodrome, Yorkshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose leg collapse and bending damage to propeller tips, engine frame, cowling and firewall
Commander's Licence:	Student Pilot's licence
Commander's Age:	42 years
Commander's Flying Experience:	23 hours (of which all were on type) Last 90 days - 9 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries made by the AAIB

Synopsis

During a solo circuit the student pilot made an approach and was observed to flare the aircraft high. The aircraft descended and bounced on touchdown. The nose then dropped and the nose landing gear collapsed on impact with the ground. The aircraft came to a stop resting on the underside of the engine cowl, having sustained damage to the airframe, propeller and nose landing gear. The pilot was uninjured and vacated the aircraft without further incident. The accident was caused by mishandling after the bounce on touchdown.

History of the flight

The weather conditions on the day of the incident were good, with a 9-10 kt wind directly down the runway and clear visibility. The pilot had performed two satisfactory circuits under dual instruction with no intervention. He was then sent to perform a pair of solo circuits, consisting of a touch-and-go followed by a full-stop landing, and then to repeat the exercise. He completed the first pair of solo circuits satisfactorily.

On the first of the second pair of solo circuits his instructor watched him fly the correct circuit pattern before the student made an RTF call to confirm which flap setting he should use. The instructor advised him to select either 20º or 30º according to his judgement. On approach the pilot flared the aircraft slightly higher than normal and bounced on touchdown. The nose then dropped, the aircraft descended and on impact with the ground the nose landing gear collapsed. The aircraft came to a stop resting on the underside of the engine cowl with the nose gear still attached but bent and twisted beneath the aircraft. The propeller tips were distorted and the aircraft had sustained structural damage to the engine frame and firewall. The pilot vacated the aircraft uninjured.

Pilot's observations and discussion

The pilot's previous solo flights and landings had all gone very well so on this occasion he was disappointed in his performance. Afterwards he carried out his own analysis of the accident:

> After his RTF call he had selected what he believed to be 20º of flap; the aircraft was actually set at 30º of flap. This flap setting, along with wind speed and direction on the day, may have contributed to the high flare on approach as he compensated for the nose-down attitude caused by this flap setting. He also considered he had not recognised that he had flared high and, because he not previously experienced a poor landing, was unable to identify the deteriorating situation.

He also discussed the outcome with his instructor and concluded that after the first bounce he had felt he was losing control and thus did not attempt a go-around, as he had been taught. As a result he had opted for a more determined attempt to land the aircraft by lowering the nose, which created an excessive rate of descent onto the nose landing gear.

BULLETIN CORRECTION

Following reassessment, prior to publication on 10 July 2014, this report has been corrected for a factual error on the number of circuits flown. The original version of the report appears in the hard copy version of Bulletin 7/2014; the online version has been corrected.

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BYMH
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1981 (Serial no: 152-84980)
Date & Time (UTC):	14 January 2014 at 1205 hrs
Location:	Stapleford Aerodrome, Essex
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, engine mount, nose landing gear and surrounding structure.
Commander's Licence:	Student
Commander's Age:	66 years
Commander's Flying Experience:	81 hours (of which 81 were on type) Last 90 days - 6 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The student pilot had undertaken several touch-and-go landings with his instructor before being sent to practise them solo. On his second approach, he flared the aircraft too high and it stalled several feet above the runway. The ensuing very heavy landing buckled the nose landing gear and mounting structure, causing the propeller to strike the ground. The student pilot, who was uninjured, believed that a lapse of concentration or a sudden lack of confidence may have been responsible for the accident.

ACCIDENT

Aircraft Type and Registration:	Cirrus SR20, N781CD	
No & Type of Engines:	1 Teledyne Continental Motors IO-360 piston engine	
Year of Manufacture:	2004 (Serial no: 1423)	
Date & Time (UTC):	15 March 2014 at 1430 hrs	
Location:	Sleap Airfield, Shropshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 3
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to landing gear, tail surfaces and propeller	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	57 years	
Commander's Flying Experience:	212 hours (of which 14 were on type) Last 90 days - 13 hours Last 28 days - 4 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The aircraft took off at a relatively high weight with a gusty 20 kt wind blowing directly across the runway from left to right. Shortly after lift off, the aircraft rolled sharply right and entered a series of oscillations. The pilot, feeling that his control effectiveness was reducing, landed the aircraft on rough ground within the airfield boundary.

History of the flight

The pilot prepared for a local flight with three passengers, expected to last between 60 and 75 minutes. The weather conditions were fine, but the westerly wind of about 20 kt plus occasional gusts was blowing directly across Runway 36, which was in use. The pilot provided a copy of a completed weight and balance loading form for the flight, which showed a takeoff mass of 2,845 lb; the maximum permitted was 3,000 lb.

Runway 36 was 775 m long. The pilot recalled wondering why Runway 23 was not in use, and assumed it was not available at that time. With all pre-takeoff checks complete, the aircraft commenced its takeoff run. Shortly after lift off, the aircraft banked sharply right, which the pilot attributed to a gust of wind. As the aircraft deviated away from the runway centreline, the pilot attempted to correct, but the aircraft entered a series of oscillations. The pilot felt the controls were becoming less responsive and later thought this may have been due to the aircraft becoming subject to a tailwind component as it deviated to the right.

The pilot felt his only option was to land the aircraft. He believed it touched down on a section of disused runway before crossing onto farmland, still within the airfield boundary. As the aircraft passed over the rough ground, it sustained damage to the propeller and tail. The aircraft was brought to a stop and secured, before the airfield fire truck arrived on scene.

ACCIDENT

Aircraft Type and Registration:	Hughes 369D, G-CCUO	
No & Type of Engines:	1 Allison 250-C20B turboshaft engine	
Year of Manufacture:	1980 (Serial no: 400711D)	
Date & Time (UTC):	27 January 2014 at 1300 hrs	
Location:	Near Stonebridge Cross Business Park, Droitwich, Worcestershire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Minor)	Passengers - N/A
Nature of Damage:	Substantial	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	62 years	
Commander's Flying Experience:	18,000 hours (of which 40 were on type) Last 90 days - 3 hours Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

Shortly after takeoff the pilot experienced yaw control difficulties, resulting in the loss of control of the helicopter and a subsequent crash landing. The pilot escaped with minor injuries. In the absence of any mechanical abnormalities, the most likely cause of the accident is a loss of tail rotor effectiveness.

History of the flight

The pilot arrived to position the helicopter back to its normal operating base following its annual maintenance inspection. He reported that the weather was good and the surface wind was from 250° at 15 kt. After a short delay, whilst some outstanding items from the maintenance were resolved, the flight was commenced. The helicopter was facing into wind and after takeoff, lifted into a high hover. The pilot reported that he did not appear to have directional control with the yaw pedals and after a few seconds, the helicopter "started spinning". As the spin accelerated, the pilot became disorientated and he lowered the collective lever to land. The helicopter drifted to the right into a wooded area beside the apron and it collided with trees. It came to rest on its side, partly submerged in a pond. The pilot was briefly rendered unconscious and woke to find that he was immersed in water. He was able to unfasten his harness and escape through the shattered windscreen. Witnesses to the accident arrived to offer assistance.

Background information

During the annual inspection the only work affecting the yaw control system was the routine replacement of the tail rotor gearbox oil. A post-accident inspection of the yaw control system confirmed continuity between the yaw pedals and the tail rotor blades, with no defects apparent. The damage to the helicopter indicated that it had been turning to the right.

Loss of tail rotor effectiveness

Loss of tail rotor effectiveness (LTE) is a critical low-speed aerodynamic flight characteristic that can result in rapid, uncommanded yaw. If not corrected promptly, this can result in a loss of control. It is not related to a technical malfunction and may occur to varying degrees in all conventional single main rotor helicopters at airspeeds below 30 kt.

LTE occurs when the airflow through the tail rotor is altered or disturbed, rapidly altering the thrust produced by the tail rotor. The disturbance to the airflow can be caused by the downdraft from the main rotor, the main rotor blade tip vortices, or by naturally occurring turbulence or wind.

Flight conditions more likely to induce LTE include: high power settings and or slow forward airspeeds, typically where translational lift is in the process of change[1] and where the relative airflow is within plus or minus 15° from the 10 o'clock position for helicopters with anti-clockwise main rotors. For these types there is a greater susceptibility to LTE during turns to the right. (Helicopters with clockwise main rotors are more susceptible to LTE when the relative airflow is within plus or minus 15° from the 2 o'clock position and during turns to the left.)

Discussion

In order to climb vertically into a high hover, a relatively high power setting would have been required. The windspeed of 15 kt was sufficient to cause the onset of translational lift whilst in the hover and any shift in the relative wind direction towards the 10 o'clock position could have caused the vortices from the main rotor blade tips to impinge on the tail rotor airflow. With the presence of these adverse conditions and in the absence of any mechanical abnormalities, it seems most likely that a loss of tail rotor effectiveness led to the loss of control. The pilot candidly commented that he was not aware of the LTE condition and when he gained his PPL (H) in 1984 and during subsequent training, which included practical and written tests, he did not recall it being covered in the training syllabus.

Following a fatal accident in 2003 attributed to LTE, the AAIB made Safety Recommendation 2003-126 to the CAA. It recommended that the CAA should publish, as widely as possible within the UK, information on the loss of tail rotor effectiveness. The CAA published this information and included it in training material for helicopter instructors and examiners. An article was also published in GASIL 1 of 2004 and FODCOM 1/2004 was issued.

Footnote

[1] Translational lift occurs when the vertical airflow induced by the main rotor is affected by horizontal airflow across it. It is most noticeable when the horizontal airflow, due to helicopter movement or wind, is around 15 to 25 kt.

Current education and training on LTE

The CAA advised that the current education and training that addresses LTE as a subject includes:

- The relevant EASA Part-FCL training syllabus; PPL(H) Ex 18(d) and the Theoretical Knowledge requirements.
- AIC Pink 066/2013 strongly recommends flight and theoretical knowledge awareness training for all light helicopter pilots and lists LTE as a subject that should be covered. (http://www.nats-uk.ead-it.com/public/index.php%3Foption=com_content&task=blogcategory&id=161&Itemid=58.html)
- Type-rating training covers individual LTE characteristics which depend on the type of anti-torque rotor design. The flight manual usually gives recommendations or limitations related to the type.
- The European Helicopter Safety Team (EHEST) has ongoing work to raise safety awareness and education. EHEST provides a number of downloadable high-quality training materials; their current HE1 Training Leaflet – 'Safety Considerations' has a section dedicated to LTE. (http://easa.europa.eu/essi/ehest/2010/10/leaflet-safety-considerations/)

Safety action

The CAA intends to review and expand Safety Sense Leaflet 17, '*Helicopter Airmanship'*, to include information about loss of tail rotor effectiveness and how to avoid and recover from the condition.

ACCIDENT

Aircraft Type and Registration:	Luscombe 8E Silvaire Deluxe, G-BTCH	
No & Type of Engines:	1 Continental Motors Corp C85-12F piston engine	
Year of Manufacture:	1948 (Serial no: 6403)	
Date & Time (UTC):	22 December 2013 at 1315 hrs	
Location:	Popham Airfield, Hampshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to wings, propeller and wing spar carry-through structure in cabin	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	64 years	
Commander's Flying Experience:	555 hours (of which 389 were on type) Last 90 days - 0 hours Last 28 days - 0 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The pilot was attempting to hand-swing the propeller to start the engine after refuelling the aircraft. When it fired, he became aware that the aircraft was starting to move and ran towards the open cockpit door. However, he slipped over and was unable to prevent the aircraft from moving away and striking some hangar doors at slow speed. The pilot cited a number of causal factors for the accident.

History of the flight

The pilot had driven to Popham with the intention of undertaking some local flying. However, he saw that there was insufficient fuel onboard for what he planned to do and so would need to visit the fuel pumps. He was unable to start using the aircraft battery but did so successfully using external power and then taxied to the fuel pumps. As he arrived, he found another aircraft already on the concrete slab which served as a hardstanding for aircraft refuelling and he lined up and waited behind it. The parked aircraft was facing east as opposed to what the pilot understood was the more normal westerly orientation, but he also parked G-BTCH facing downwind in what he described as "relatively strong but also gusty" wind conditions after he had taxied onto the slab.

Having refuelled the aircraft to about two thirds full, he attempted to start the engine but there was again insufficient battery charge and he got out of the aircraft to hand-swing the propeller - a procedure with which he was very familiar, having performed it often. He set the parking brake and cracked the throttle open the usual amount before the first of several attempts to start the engine. When it finally fired and kept running, he walked around the wing strut towards the left door but became aware that the aircraft was starting to move. He now ran towards the open door but slipped and fell to the ground; by the time he got up, he could only watch as the aircraft moved away towards some closed hangar doors. It struck a door with its right wingtip at an estimated speed of 5 mph, which yawed the aircraft to the right, causing the propeller and then the left wingtip to strike the door and frame.

After securing the aircraft, the pilot reported the damage to the hangar owner, but there had been no injuries or other third party damage incurred. He stated that he did not feel that, when the engine had started, it had run up to an abnormally high rpm but rather that a number of other factors had conspired to cause the accident:

- He should have chocked the wheels, knowing that the cable-operated disc brakes fitted to this elderly aircraft were not particularly effective. The group-owned aircraft did not routinely carry chocks.
- Parking with the aircraft facing downwind and with the door open, acting as a "sail", probably allowed a gust of wind to start it moving on the relatively low rolling-resistance concrete surface. There was also a slight downslope in the easterly direction.
- Although he described the concrete surface as "damp and slimy", he was of the opinion that he could have been wearing more suitable footwear than the leather-soled shoes he had worn on the day.
- Although the aircraft was known to have battery charging problems and was scheduled to have its worn generator replaced with an alternator at the next annual inspection, the aircraft should have been taken out of service until this work had been done.

A detailed account of the events provided by the pilot together with a photograph and comments from the Light Aircraft Association (LAA) appeared in the April 2014 edition of the LAA magazine *Light Aviation*.

BULLETIN CORRECTION

Following publication of this report, the subsequent correction will be issued in the September Bulletin. The online version of the report was corrected on 22 July 2014.

> In the **History of the flight** it was stated that the pilot had flown to Popham Airfield. This is incorrect; he had in fact **driven** there.

ACCIDENT

Aircraft Type and Registration:	Pierre Robin DR400/180 Regent, G-JMTS
No & Type of Engines:	1 Lycoming O-360-A3A piston engine
Year of Manufacture:	1991 (Serial no: 2045)
Date & Time (UTC):	19 January 2014 at 1230 hrs
Location:	Stow Maries Aerodrome, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Engine detached, damage to right wing and nose landing gear
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	16,400 hours (of which 60 were on type) Last 90 days - 48 hours Last 28 days - 11 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was taking off from grass Runway 20 when it suffered an uncommanded wing drop just after lift off. Whilst the pilot attempted to correct this, the aircraft touched down again and rolled off the end of the runway into a ploughed field, where it was severely damaged. The pilot believes a number of performance factors acted together to cause the accident.

History of the flight

The aircraft was taking off from Runway 20 at Stow Maries Aerodrome, which is grass and has a declared length of 650 m. The wind was estimated to be from 250° at 5 to 7 kt and the surface condition was described as "wet". The aircraft was about 113 kg below its maximum takeoff weight.

The initial acceleration was described by the pilot as "slow", but he stated that he had expected this, and the aircraft became airborne after about 450 m (measured subsequently from ground marks). However, as it passed a line of trees at the end of the runway, the aircraft experienced a severe uncommanded roll to the left which the pilot attempted to correct. This caused a roll to the right and "lift was lost and the aircraft touched the ground", running across the overshoot and into a recently ploughed field. The nosewheel collapsed and the right wing contacted the ground, causing a violent yaw in that direction before the aircraft came to a rapid halt with the engine detached from the fuselage. The occupants were uninjured and evacuated the aircraft normally.

The pilot believes that a combination of the following factors probably played a part in the accident:

- The aircraft was "heavy" but within limits
- It was fitted with spats and a coarse pitch propeller
- The runway length was sufficient, but an airfield brief had not been obtained in person by the commander
- The airfield was wet and the effect of possible wind curl-over from the trees had not been anticipated

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-181 Cherokee Archer II, G-BHWZ
No & Type of Engines:	1 Lycoming O-360-A4M piston engine
Year of Manufacture:	1978 (Serial no: 28-7890299)
Date & Time (UTC):	19 March 2014 at 1200 hrs
Location:	Compton Abbas Airfield, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nosewheel spat and propeller damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	77 years
Commander's Flying Experience:	419 hours (of which 85 were on type) Last 90 days - 5 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was landing on the grass Runway 26 at Compton Abbas when the accident occurred. The weather conditions were fine, with a light westerly wind. The pilot reported flying a normal approach with full flap, achieving a smooth touchdown about 100 m beyond the runway numbers. During the rollout the aircraft suddenly pitched nose-up, followed by three further pitch oscillations of reducing severity. The pilot described the motion as being as if the aircraft had encountered a bump and he thought that an unseen undulation, associated with a footpath that crosses the runway, may have contributed to the event.

ACCIDENT

Aircraft Type and Registration:	Pitts S-2S Special, G-EWIZ	
No & Type of Engines:	1 Lycoming AEIO-540-D4A5 piston engine	
Year of Manufacture:	1981 (Serial no: S18)	
Date & Time (UTC):	7 March 2014 at 1611 hrs	
Location:	Gloucestershire Airport	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Lower left wing, propeller, wheel and spat	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	51 years	
Commander's Flying Experience:	15,297 hours (of which 230 were on type) Last 90 days - 85 hours Last 28 days - 22 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

After making a normal touchdown on Runway 27 at Gloucestershire Airport, the aircraft began to turn right as it slowed through 40 kt. Despite the application of full left rudder and brake, the pilot was unable to stop the right turn. The aircraft then departed the paved surface and nosed over in the grass beside the runway. The wind was from 360° at 6 kt.

The pilot reported that a subsequent examination of the aircraft found that the left brake was not working correctly.

ACCIDENT

Aircraft Type and Registration:	Reims Cessna FA152 Aerobat, G-BFRV
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1978 (Serial no: 345)
Date & Time (UTC):	5 March 2014 at 1229 hrs
Location:	Shoreham Airport, West Sessex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller strike, damage to leading edge of right wing
Commander's Licence:	Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	n/k hours (of which 217 were on type) Last 90 days - 3 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Following an uneventful flight, the pilot was cleared for a touch-and-go on Runway 20 (asphalt) at Shoreham. The surface wind was reported as 190° at 5 kt. At 500 ft the pilot selected full flap and the aircraft crossed the runway threshold at about 65 kt airspeed. He pulled the throttles back to idle at touchdown but, as he reached down to retract the flaps, the aircraft veered to the left of the centreline, and he was unable to correct with rudder inputs. The airspeed at this point was between 35 and 40 kt. The aircraft left the runway onto waterlogged grass into which the left wheel immediately dug in. This caused the aircraft to spin around and, as the nosewheel became embedded in mud, stop abruptly and the right wing contacted the ground.

The aircraft came to rest, upright, about 5 m from the edge of the runway. The Shoreham rescue and firefighting service attended the scene by which time the pilot, who had been wearing a full harness, had vacated the aircraft unhurt.

ACCIDENT

Aircraft Type and Registration:	Robinson R22 Beta, G-BYCF
No & Type of Engines:	1 Lycoming O-360-J2A piston engine
Year of Manufacture:	1998 (Serial no: 2866)
Date & Time (UTC):	29 March 2014 at 1734 hrs
Location:	Elstree Aerodrome, Hertfordshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Substantial
Commander's Licence:	Student pilot
Commander's Age:	45 years
Commander's Flying Experience:	39 hours (of which 39 were on type) Last 90 days - 15 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The student pilot was attempting a solo lift from a grass surface. Whilst applying left cyclic input to correct a right side low condition, the helicopter rolled rapidly to the left in what was reported as a dynamic rollover incident.

Description of the event

The student pilot completed a dual lesson, in fine weather conditions, before his instructor vacated the aircraft so that the student pilot could fly a solo circuit. It was to be the student's second solo on type. The student began raising collective to lift from the grass surface, but felt the helicopter was right side low. He attributed this to the absence of the instructor in the left seat. He corrected with left cyclic input and continued to raise the collective. The helicopter suddenly and rapidly rolled to the left, causing the main rotor blade to strike the ground. Once the helicopter came to a rest on its side, the student made the helicopter safe before vacating. The student pilot's instructor commented that the accident had been caused by dynamic rollover.

AAIB comment

Dynamic rollover occurs when a sideways force, provided by a horizontal component of the total rotor thrust, is applied at the rotor mast while a skid or wheel is touching the ground or other fixed object. The helicopter pivots around the fixed point and rolls. Any attempt to raise the collective to fly away from the problem increases the horizontal component and exacerbates the situation.

ACCIDENT

Aircraft Type and Registration:	Vans RV-4, G-NADZ	
No & Type of Engines:	1 Lycoming O-360-A1F piston engine	
Year of Manufacture:	1983 (Serial no: 3)	
Date & Time (UTC):	31 March 2014 at 1435 hrs	
Location:	Tibenham Airfield, Norfolk	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Minor)	Passengers - N/A
Nature of Damage:	Beyond economic repair	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	65 years	
Commander's Flying Experience:	596 hours (of which 78 were on type) Last 90 days - 1 hour Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Since 13 October 2013, the pilot and G-NADZ had only flown for 45 minutes when three days before the accident the pilot carried out the annual air test on the aircraft during which he flew a number of circuits.

On the day of the accident the pilot intended to fly a number of circuits at Tibenham Airfield before repositioning the aircraft to another airfield. The aircraft had sufficient fuel onboard and prior to the first takeoff, from Runway 08, the engine power check was carried out and found to be satisfactory. The first circuit, which culminated in a full stop landing, was completed without incident. The pilot back-tracked down the runway and took off to fly a second circuit. The acceleration was normal and as the aircraft reached a height of approximately 100 to 150 ft the pilot raised the flaps and at about the same time the engine stopped, though the propeller continued to windmill. Immediately ahead of the aircraft was a field containing crops, with the furrows at approximately 90º to the runway heading. The pilot was concerned that if he attempted to land in this field the aircraft might flip onto its back and given that the aircraft had a bubble canopy he risked being trapped with the possible danger of the aircraft catching fire. He therefore made a left turn with the intention of landing on the grassed area of the airfield. The pilot completed the turn, and the wings were level, when the aircraft struck the ground with a high sink rate sufficient to cause the accelerometer on the aircraft to register 8 g. The aircraft bounced once and came to rest approximately 25 ft from the initial touchdown point. The pilot was assisted from the aircraft by a number of individuals at the airfield and taken to hospital by ambulance where he was found to have sustained extensive bruising.

The aircraft was extensively damaged with both mainwheels having been pushed into the lower surface of the wings, the engine and propeller were also damaged and the skin in the fuselage was creased. The damage was assessed as being beyond economic repair. The cause of the engine failure was not established.

ACCIDENT

Aircraft Type and Registration:	Quik GT450, G-JULE
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2006 (Serial no: 8219)
Date & Time (UTC):	18 April 2014 at 1655 hrs
Location:	Mayfield Airstrip, Ormskirk, Lancashire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Wing broken and pod cracked
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	204 hours (of which all were on type) Last 90 days - 9 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was landing on Runway 02 at a private airstrip in surface wind conditions that he later estimated to be north-westerly at 10 kt. During the landing roll, approximately halfway along the grass runway, the pilot described the crosswind lifting the left wing, causing the right wing to strike the ground. The right wing was damaged by the ground impact and the aircraft rolled onto its right side, damaging the pod. The pilot assessed the cause of the accident to be his underestimation of the crosswind during the landing roll.

ACCIDENT

Aircraft Type and Registration:	Rotorsport Cavalon gyroplane, G-RDNY
No & Type of Engines:	1 Rotax 914-UL piston engine
Year of Manufacture:	2013 (Serial no: RSUK/CVLN/004)
Date & Time (UTC):	5 March 2014 at 1512 hrs
Location:	Lydd Airport, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Substantial to airframe, rotor strike marks on runway
Commander's Licence:	Student Pilot
Commander's Age:	56 years
Commander's Flying Experience:	122 hours (of which 95 were on type) Last 90 days - 10 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and ATS Occurrence Report

Synopsis

The student pilot used an incorrect takeoff technique and lost control of the gyroplane as it became airborne. The gyroplane struck the runway and came to rest on its side, suffering extensive damage. The student pilot, who was uninjured, vacated the gyroplane without assistance.

History of the flight

The student pilot was undertaking a cross-country training exercise from his home base at North Weald Airfield. Weather conditions were fine, with light south-westerly winds. He flew three visual circuits with his instructor before departing North Weald for Holmbeck Farm Airfield near Leighton Buzzard. The plan was then to fly on to Lydd Airport before returning to North Weald.

The first two flights were uneventful. The student pilot took a short break while on the ground at Lydd before preparing for the flight back to North Weald. Start-up and taxi were normal, as were pre-takeoff checks.

The aircraft entered Runway 21 for departure. The student pilot set 2,000 engine rpm, pre-rotated the rotor to 220 rpm and increased engine rpm to 4,000 before releasing the wheel brakes. He then increased power and monitored the airspeed, which increased rapidly. At 50 kt, he initiated a rotation with a small rearward movement of the control stick. However, the gyroplane pitched up severely, causing the keel and tail to strike the ground and detach. The rest of the gyroplane became airborne for a short while before rolling to the right, causing first the rotor blades, then the fuselage, to strike the runway. The gyroplane came to rest on its right side. The pilot made the switches safe before vacating through the right hand side door to await the airfield emergency services.

Assessment of cause

The student pilot identified a handling error, in that he had not moved the control stick aft before starting the takeoff run. He attributed this to a reversion to a fixed wing takeoff technique, but could not identify a potential reason for the lapse. His instructor commented that the control stick should have been eased aft once the rotor rpm had been achieved during pre-rotation, and before applying the required power for takeoff. He noted that the student had never previously failed to use the correct technique and that there had been no indication that he was at risk of doing so.

BULLETIN CORRECTION

The tabled information at the beginning of the report incorrectly stated that the injuries to the pilot were **minor** whereas, as correctly described in the synopsis, **no injuries** were sustained.

The online version of this report was corrected on 24 July 2014.

ACCIDENT

Aircraft Type and Registration:	Rotorsport UK MTOsport, G-GSMT
No & Type of Engines:	1 Rotax 914-UL piston engine
Year of Manufacture:	2008 (Serial no: RSUK/MTOS/001)
Date & Time (UTC):	28 February 2014 at 1600 hrs
Location:	South-east of Stonehill Farm, Crawfordjohn, Lanarkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	435 hours (of which 155 were on type) Last 90 days - 7 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

One or more seagulls struck the propeller when the aircraft was flying at a height of 500 ft agl. The propeller was damaged and this caused severe vibration, which necessitated a reduction to idle power. During the subsequent forced landing, avoiding action had to be taken when wires were spotted just prior to touchdown. The aircraft landed upright in a shallow river but the rotors struck the far river bank and the aircraft rolled onto its side. The occupants made their own escape and were not injured.

History of the flight

The aircraft was on a return flight to its home airfield at Stonehill Farm, near Crawfordjohn, Lanarkshire after a visit to Kirkbride Airfield in Cumbria. Apart from some isolated showers, it was a sunny day with good visibility and a light south-westerly breeze. The pilot was following the valley of the Snar Water river in a north-easterly direction, at a speed of approximately 85 mph and at a height of 500 ft agl, when he saw a few seagulls close to the aircraft. He was unable to avoid the birds and at least one of them struck and damaged the propeller. This caused a loud bang and a great deal of vibration was felt through the airframe and the control stick. The pilot selected the throttle to idle and the vibration reduced but he was forced to land immediately. He chose a field in front of the aircraft and just to the right of the river. However, as he approached the field, he spotted low-level electricity cables, which he had insufficient height or speed to fly over. The pilot turned left and attempted to cross the river but, again, the aircraft did not have enough energy and he was forced to make a controlled landing in the water, at low speed.

The river had a water depth of between 1 ft and 2 ft but the far bank was steep and around 8 ft high. The rotor blades impacted the earth bank and the aircraft immediately rolled violently to the right. It came to rest partially submerged, lying on its right side. The passenger, who was a trainee gyroplane pilot, turned off the duplicate magneto switches, which remained above the water, on the left side of the rear seat. This stopped the engine and the pilot then managed to turn off the ignition. Neither occupant was injured and they both unstrapped and escaped the aircraft without difficulty. They later manoeuvred the aircraft upright and, with some local assistance, dragged it from the river.

ACCIDENT

Aircraft Type and Registration:	Team Minimax 91, G-BZOR
No & Type of Engines:	1 Rotax 447 piston engine
Year of Manufacture:	2001 (Serial no: PFA 186-13312)
Date & Time (UTC):	16 March 2014 at 1150 hrs
Location:	Farley Farm Airstrip, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to landing gear, propeller, left wing, wing struts and cowling
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	127 hours (of which 2 were on type) Last 90 days - 2 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot intended to fly a circuit prior to landing. On the approach, he felt that his glidepath was somewhat flat, so he applied power to climb a little before reducing it for touchdown. During this process, he states that he became distracted by the gusty conditions and closed the throttle too early. The airspeed decayed and led to a stall about 6 ft from the ground. The subsequent heavy landing caused the landing gear to collapse.

The pilot cites inattention and a lack of familiarity with the aircraft as the main causal factors in the accident.

ACCIDENT

Aircraft Type and Registration:	Zenair CH 601UL Zodiac, G-FAOH	
No & Type of Engines:	1 Rotax 912-UL piston engine	
Year of Manufacture:	2005 (Serial no: PFA 162A-14406)	
Date & Time (UTC):	9 March 2014 at 1200 hrs	
Location:	Hunsdon Airfield, Essex	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Minor)	Passengers - 1 (Minor)
Nature of Damage:	Aircraft substantially damaged	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	52 years	
Commander's Flying Experience:	756 hours (of which 417 were on type) Last 90 days - 31 hours Last 28 days - 12 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The microlight aircraft was landing on Runway 26 at Hunsdon Airfield when the accident occurred. The weather was fine, with a local surface wind forecast from 140° at 8 to 13 kt; the wind at Stansted Airport (8 nm to the north-east) at the time of the accident was from 180° at 9 kt. Shortly before touchdown, the aircraft appeared to experience a gust of wind, causing the left wing to lift. The pilot was unable to stop the aircraft rolling right and reported a "sudden heavy sinking". The aircraft struck the ground short of the runway, coming to a stop inverted. Local club members assisted the pilot and his passenger, who both sustained minor injuries. The aircraft was substantially damaged but there was no fire.

Miscellaneous

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

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

BULLETIN CORRECTION

AAIB File:	EW/G2014/01/08
Aircraft Type and Registration:	Airbus A320-214, EI-EZV
Date & Time (UTC):	16 January 2014 at 1505 hrs
Location:	London Heathrow Airport
Information Source:	Aircraft Accident Report Form

AAIB Bulletin No 5/2014, page 24 Figure 1 refers

The scale for the parameter SIDE STICK PITCH – First Officer in Figure 1 is incorrectly labelled. The scale should show that positive values greater than zero indicate the side stick has been moved forward and that negative values of less than zero indicate that side stick has been moved aft. A revised plot is attached below. The analysis is unchanged.

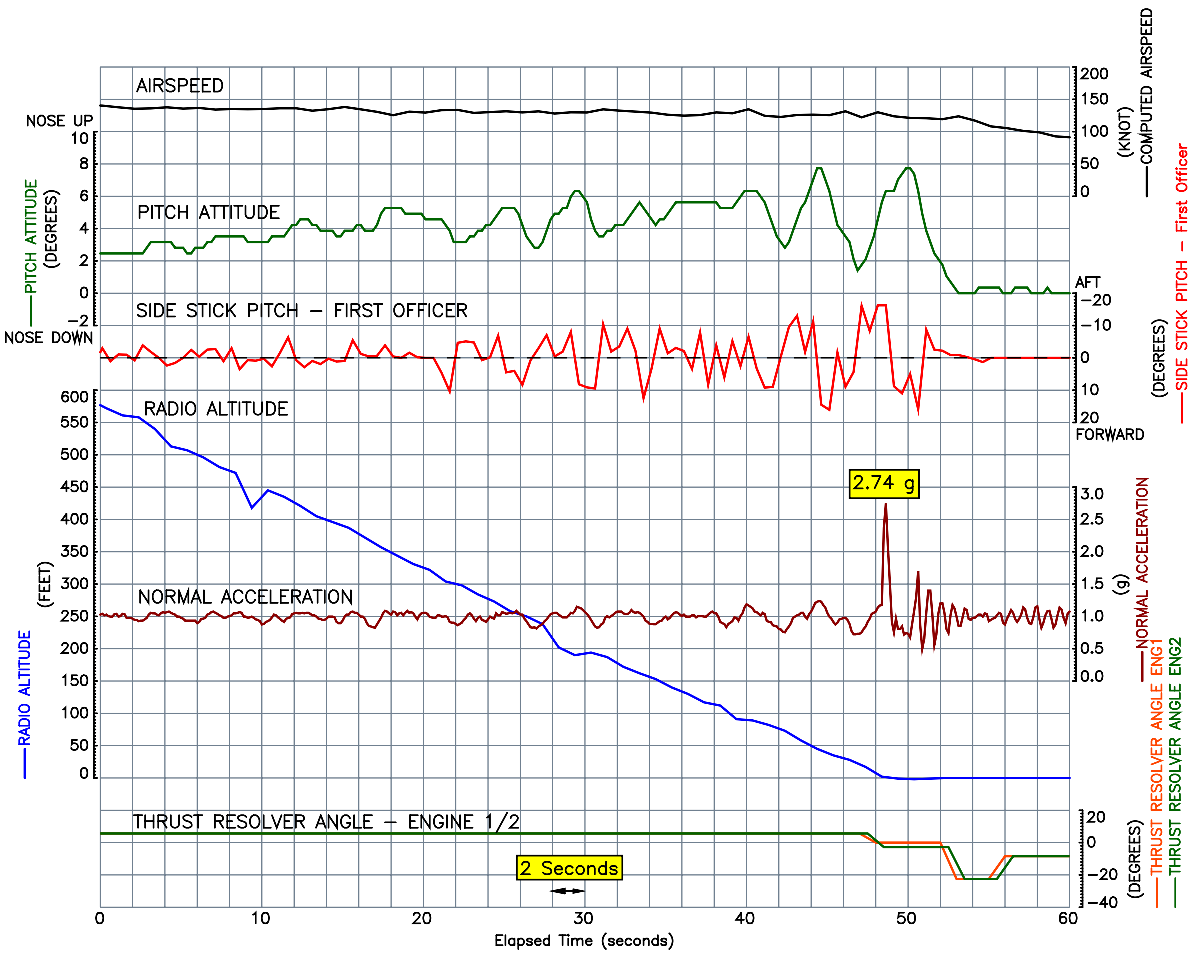

Figure 1

Flight data from the landing

This correction was issued online on 17 June 2014.

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

3/2010 Cessna Citation 500, VP-BGE
2 nm NNE of Biggin Hill Airport
on 30 March 2008.

Published May 2010.

4/2010 Boeing 777-236, G-VIIR
at Robert L Bradshaw Int Airport
St Kitts, West Indies
on 26 September 2009.

Published September 2010.

5/2010 Grob G115E (Tutor), G-BYXR
and Standard Cirrus Glider, G-CKHT
Drayton, Oxfordshire
on 14 June 2009.

Published September 2010.

6/2010 Grob G115E Tutor, G-BYUT
and Grob G115E Tutor, G-BYVN
near Porthcawl, South Wales
on 11 February 2009.

Published November 2010.

7/2010 Aerospatiale (Eurocopter) AS 332L
Super Puma, G-PUMI
at Aberdeen Airport, Scotland
on 13 October 2006.

Published November 2010.

8/2010 Cessna 402C, G-EYES and
Rand KR-2, G-BOLZ
near Coventry Airport
on 17 August 2008.

Published December 2010.

1/2011 Eurocopter EC225 LP Super
Puma, G-REDU
near the Eastern Trough Area
Project Central Production Facility
Platform in the North Sea
on 18 February 2009.

Published September 2011.

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

Published November 2011.

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

Published February 2014.

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

Published June 2014.

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

http://www.aaib.gov.uk

GLOSSARY OF ABBREVIATIONS

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

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