AAIB
Air Accidents Investigation Branch

AAIB Bulletin 3/2020

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AAIB CORRESPONDENCE INVESTIGATIONS Cont

(ALL TIMES IN THIS BULLETIN ARE UTC)

AAIB Field Investigation Reports

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

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

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

ACCIDENT

Aircraft Type and Registration:	Sikorsky S-61N Sea King, G-ATBJ
No & Type of Engines:	2 General Electric Co CT58-140-2 turboshaft engines
Year of Manufacture:	1965 (Serial no: 61269)
Date & Time (UTC):	1 February 2018 at 1100 hrs
Location:	Marchwood, Hampshire
Type of Flight:	Commercial Air Transport (Non-Revenue)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damaged beyond economical repair
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	11,233 hours (of which 1,501[1] were on type) Last 90 days - 26 hours Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

The helicopter was being transferred from Marchwood, Hampshire, to a maintenance base having been transported, by sea, from the Falkland Islands. As the helicopter took off for a hover check it pitched nose-down. The commander promptly lowered the collective and the helicopter struck the ground on its nose, before coming to rest on its landing gear.

The investigation found that the spherical bearing within the swashplate had seized as a result of corrosion, compounded by inactivity during the voyage from the Falkland Islands. The checks prior to the flight did not identify the control restriction.

Safety action has been taken by the helicopter manufacturer to highlight the correct pre-flight procedures to follow after prolonged aircraft inactivity, and by the operator to remind flight crews to conduct flight control servo system[2] checks to the maximum extents of control movement.

Footnote

[1] The commander also had 2,809 hours on the Westland Sea King (WS-61).
[2] The flight control servo system checks are also referred to as the full and free checks.

History of the flight

Background information

G-ATBJ had previously been operating in the Falkland Islands for four years until its last flight on 31 December 2017. It was then prepared for return by sea to the UK; this included having its main[3] and tail rotor blades removed; no covers were used to protect the rotor head and transmission. On 8 January 2018, the helicopter was moved onto a roll-on/roll-off sealift ship and transported from the Falkland Islands to Marchwood Sea Mounting Centre, Hampshire, where it was unloaded on 29 January 2018. G-ATBJ was transported below decks during the voyage. The following day, the helicopter was prepared for flight which included having its main and tail rotor blades fitted; a ground run was then performed by flight crew[4].

Accident flight

On 1 February 2018, the flight crew planned to perform a hover check. If successful, the helicopter was to be flown to Bournemouth Airport, Dorset, before refuelling and continuing to the operator's base at Cornwall Airport, Newquay.

Upon arrival at the helicopter, the co-pilot performed the external checks while the commander commenced the internal checks. Two of the operator's engineers were also in attendance and remained outside the helicopter throughout.

The crew discussions indicated the need to progress quickly due to limitations associated with having to rely on a limited number of external batteries as no external power cart was available.

After the first and second attempts to start engine 1 failed, the crew noted that the bus voltage, to which the main, alternate and external batteries were connected, was 23V, so they swapped the external battery for another one. The third attempted start was also unsuccessful and the crew, noting that this battery voltage was down to 23V, elected to try to start engine 2. They commented that there were two external batteries in the aft hold but that they would need those later at Bournemouth.

The engine 2 start was successful but, because the subsequent checks required the rotors, and hence the hydraulic pumps and electrical generators, to remain disengaged, the commander commented that they needed to be "AS QUICK AS WE CAN" to minimise the use of the battery to pressurise the hydraulics from the DC motor-generator (motorising).

The recordings indicate that the low pressure warning for the primary hydraulic system extinguished soon after they were pressurised. However, the auxiliary hydraulic system took a further 18 seconds, during which the commander stated, "WE'RE NOT GOING TO GET

Footnote

3 Whilst operating in the Falkland Islands G-ATBJ utilised composite 'Carson' main rotor blades but, prior to the accident flight, steel blades had been fitted.

4 The commander was the same for the ground run on 30 January 2018 and the accident flight the following day, but the co-pilots were different for each flight.

it [auxiliary hydraulic pressure] we haven't got enough oomph in the systems now". During the after-start checks, a flying controls servo system check was completed, but not to the full extent of control movement[5]. During these checks the Pilot Flying (PF) stated "…and they [main rotor blades] are moving in the right sense…I'm not doing full and free, we haven't got time."[6]

The checks were completed before the helicopter's rotors were engaged. When the rotors were engaged, the crew noted that the auxiliary hydraulic pressure dropped to about 1,000 psi (normal pressure range is 1,300 to 1,500 psi) but then started increasing and reached its normal level as the rotor speed increased. With rotors running, the mechanical hydraulic pump, driven from the main gearbox, provided sufficient pressure to extinguish the auxiliary hydraulic system low pressure warning. No other warnings were recorded during the accident flight. The crew then started engine 1.

Before takeoff, pre-flight checks were completed and clearance to lift and depart was received from ATC. The commander released the parking brake and unlocked the tailwheel. The co-pilot then advanced the engine speed select levers to achieve 104%, monitoring the triple tachometer as he did so. While the co-pilot monitored the engine instruments, the commander started to raise the collective until the helicopter was light on its wheels.

Initially the helicopter started to move forward, so the commander arrested this movement with the cyclic and trimmed out the aft cyclic input; he then continued to raise the collective. As the helicopter lifted it started to move forward again and the co-pilot caught the movement in his peripheral vision. As the commander continued to raise the collective, the helicopter pitched nose-down and started to climb. As it started to pitch the co-pilot observed a large amount of aft cyclic being applied by the commander.

The helicopter did not respond to the aft cyclic input, so the commander promptly lowered the collective to land the helicopter. The crew felt a "thump through the seats" as the helicopter struck the ground with its nose. The mainwheels made ground contact causing the tail to pivot downwards onto the tailwheel. The time between the last wheel leaving the ground and the initial impact was less than three seconds.

Despite the co-pilot being slightly dazed he commenced the emergency shutdown checklist and called to the commander to apply the rotor brake. Both pilots then evacuated the helicopter and, once outside, went to check that the engineers were unhurt. There were no injuries.

Footnote

[5] The pilots believed that a full and free check to the extremities of the controls' movement was not possible as the helicopter's electrically-driven hydraulic pumps would have disengaged under a high demand as they were being powered by the battery. However, the helicopter manufacturer has advised that, if the controls are moved slowly, full movement could be obtained without the pumps disengaging.

[6] Both pilots highlighted that they did not intend to avoid full and free checks, but they felt that they were not achievable in the circumstances having previous experience on the S-61 after failed attempts using batteries.

Both pilots stated that everything appeared normal up until the moment when weight came off the wheels. The commander also stated that he believes the cyclic forces were unusually light when moved fore and aft during the takeoff but the sidetoside movement forces felt normal.

Accident site

The accident site was close to a helipad within a loading area at Marchwood Sea Mounting Centre, Hampshire. The helicopter had come to rest, on its landing gear, on an approximate heading of 270° with the tailwheel about 10 m from the centre of the marked helipad.

The front of the helicopter had struck the ground during the accident sequence. The front equipment bay was crushed, (Figure 1) resulting in the detachment of the bay door. Scuff marks on the concrete surface, 9.5 m from the centre of the helipad, indicated the location that the helicopter initially struck the ground (Figure 2). The tailwheel strut had been driven through the upper stops, with buckling of the skin around frame 493 at the rear of the fuselage.

Figure 1

G-ATBJ after accident (transport ship in background)

Figure 2

G-ATBJ impact mark (note: cones positioned after accident)

Meteorology

Observations from Southampton Airport, 4 nm north-north-east of Marchwood, indicated that there were FEW amounts of medium to high based cloud and good visibility, no showers were reported at the Airport. At the time of the accident, the surface wind was predominately from 310°, varying between 260° and 360°, at about 11 kt. The temperature was 6°C and the QNH was 1005 hPa.

Weight and balance

The aircraft had a takeoff weight of 15,805 lb; this included 1,500 lb of fuel. Its maximum certified takeoff weight was 20,500 lb. Its Centre of Gravity (CG) was -8.5 in aft of datum, which is within the flight limits of +12 in and -16 in at this takeoff weight.

Recorded information

The helicopter was fitted with a Multi-Purpose Flight Recorder (MPFR). This retained the last two hours of audio and 78 hours of data. The audio included the ground run carried out on the helicopter two days prior to the accident. Pilot control inputs were recorded but the data did not include any parameters relating to actuator or swashplate positions. The states of the primary and auxiliary hydraulic systems low pressure warnings (triggered below 1,000 psi) were recorded but not the actual hydraulic system pressures. The MPFR operates whenever the dc essential bus is powered.

The event was also captured on a recording from a CCTV camera which was monitoring the helicopter prior to takeoff.

Recorded cyclic control position

The MPFR recorded cyclic as a nominal percentage of movement from the rigged position, a negative percentage value equates to pulling the cyclic rearward to pitch the helicopter up and a positive percentage relates to forward cyclic. The last three MPFR annual calibration checks were reviewed to establish the range of control input movement. The results showed that there were variations of only a few percent over the years for the values associated with the extreme control positions. The range of values for the cyclic pitch covered by the checks were between -44% and 26% for fully aft and fully forward respectively and these are the limits shown on Figures 3 and 4.

Pre-flight checks – accident flight

Figure 3 shows the limited extent of the cyclic inputs made by the crew during the pre-flight *Flight control servo system* check.

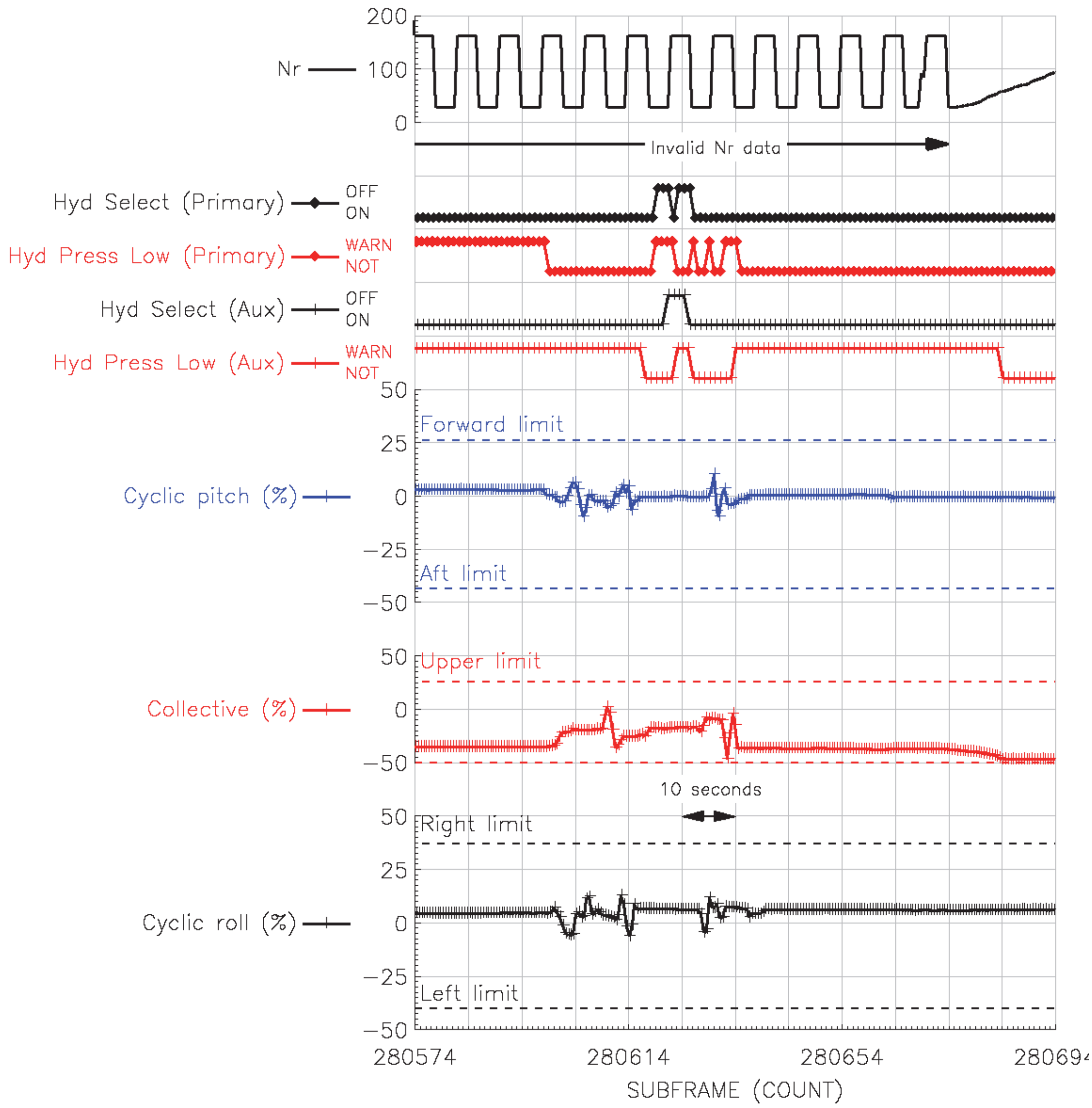

Figure 3

Flight control servo system check from the accident flight

Accident flight

Figure 4 is a plot of pertinent parameters recorded during the takeoff. Just after takeoff, the helicopter started to pitch nose-down, reaching a pitch rate of approximately -7 °/s. The commander applied aft cyclic but, even at the full aft limit, there was no significant effect on the pitch rate. He rapidly lowered the collective and the helicopter struck the ground at a pitch attitude of approximately 20° nose-down.

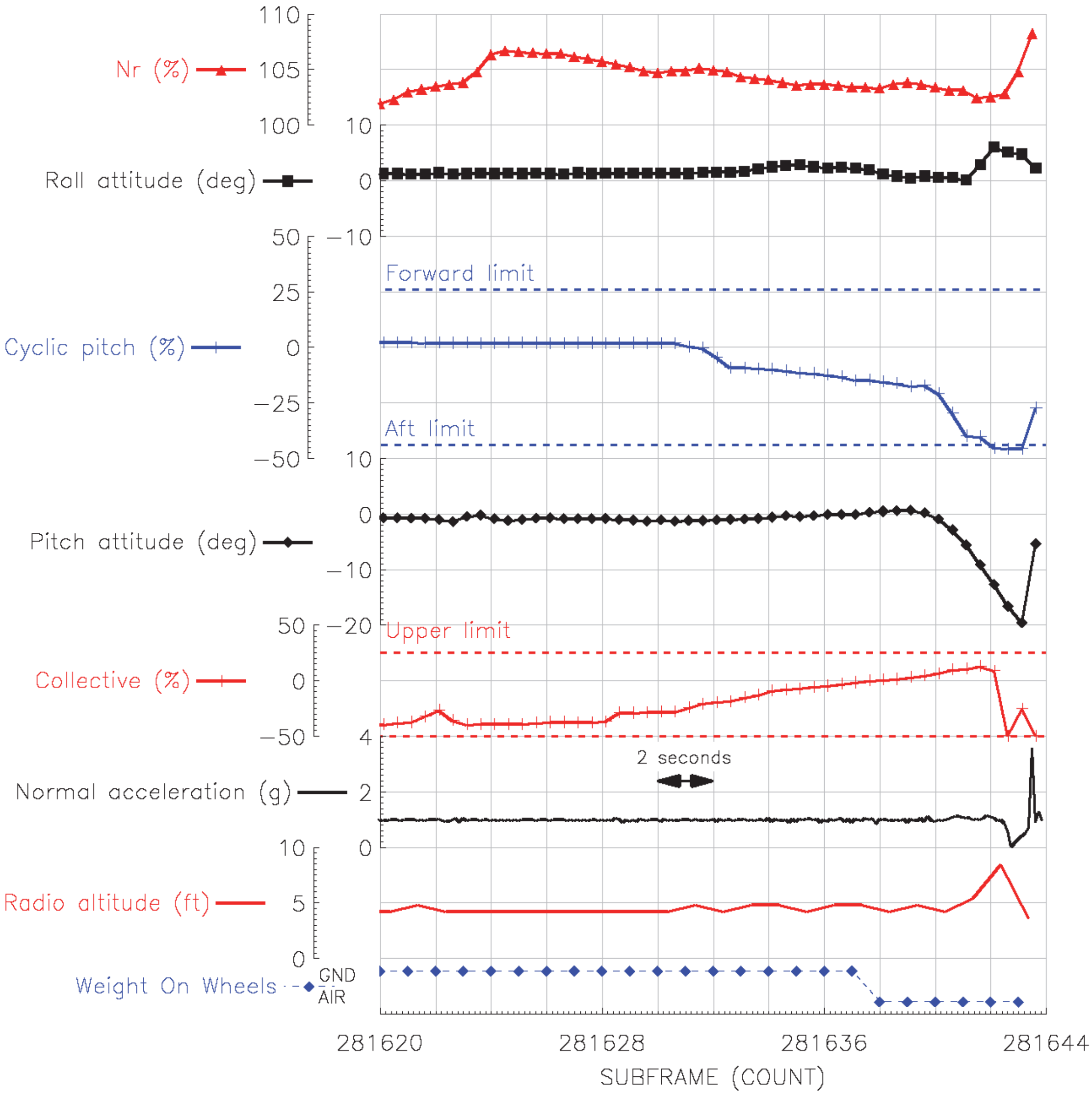

Figure 4

Pertinent recorded parameters for the accident flight

Figure 5 is a snapshot from the CCTV recording. This shows the main rotor disk did not appear to have any significant rearward component given the full aft cyclic input which was being made at that time.

Figure 5
CCTV snapshot at the point of impact

Ground checks two days earlier

The audio and data associated with the ground run carried out two days before the accident were reviewed. As on the day of the accident, time pressure due to the limited battery power was apparent from the crew conversations. While motorising under battery power and carrying out the flight control servo system check with the auxiliary low pressure warning initially active, the crew commented that there was "NO AUX PRESSURE THERE OF ANY SORT, IT'S KIND OF WORKING". Comment was also made to just check that the blades were moving in "THE RIGHT SORT OF WAY". During the check, the range of cyclic pitch movement recorded was between -12% aft and 18% forward as opposed to the full range of movement required by the procedure of approximately -44% aft to 26% forward.

Range of cyclic control movement used

During the investigation, G-ATBJ's historic data was reviewed to determine the use of the full range of cyclic movement. In the 78 hours of recorded data there was only one check where the controls were fully exercised.

During the period between being unloaded from the ship and lifting off during the accident flight and when the MPFR was operating, the data indicates that cyclic pitch inputs were exercised over less than half of the full available range. This includes periods during which operational procedures were carried out which required full cyclic inputs to be made.

The recorded data included multiple flights on 15 separate days prior to the helicopter's return to the UK. Flight control servo system checks were carried out prior to the first flight of each day, using varying amounts of control inputs, but none exercised the full range of the controls required by the procedure.

The operator advised that it was possible that the engineers had pulled the MPFR circuit breaker during daily checks, and this could explain the lack of recorded full range checks. However, no documentation was provided to explain why this action might have been taken.

The operator was asked to review the full and free checks from previous recordings in its flight data monitoring programme. A sample of these recordings indicates that the full and free check was not always conducted to the full extent of control movement available. The operator noted that observations in simulator checks and during flights also indicated that the check was not always completed to the full range.

Safety action by the operator

On 20 June 2018, the operator issued Flying Staff Instruction (FSI) 2018-35 to remind all crews to conduct the flight controls servo system check, which includes a full and free check, as required by the Operations Manual Part B, Section 02, Appendix 2. The FSI contained the detailed check as an Appendix.

After FSI 2018-35 was issued, the operator carried out a review of compliance on a sample of flights. This review identified that the control extremes were mostly but not always being reached; the majority of deviations being associated with a lack of full travel of aft cyclic. The operator considered that this may have been associated with seating positions and physical body shape, and that it would review this possibility in more detail.

The operator has advised that it will continue to monitor that its pilots perform the check, to the extremities, through routine simulator checks and, through its flight data monitoring programme, during operational flying.

Helicopter information

General

The Sikorsky S-61N helicopter Mk 1 is a single main rotor helicopter with a torque-correcting tail rotor. The main rotor has five blades, which can either be of composite or steel construction. The fuselage is an aluminium alloy monocoque design with a boat-type hull.

Two General Electric CT 58-140-2 series turboshaft engines, mounted on the top of the fuselage, drive the main and tail rotor transmission through the main gearbox, which is positioned aft of the engines.

G-ATBJ was configured with 19 seats and was being used for personnel and cargo transportation within the Falkland Islands prior to being shipped back to the UK for maintenance. It held a valid Certificate of Airworthiness and Airworthiness Review Certificate.

Flight controls

The pilot's and co-pilot's flight controls are mechanically linked, and their inputs are transmitted mechanically through control rods and bellcranks from the collective, cyclic and tail rotor control pedals to four auxiliary hydraulic servos. These servos, situated in a control compartment behind the aft cockpit bulkhead, power the controls via a mixing unit and the primary servos.

The mixing unit consists of bellcranks and connecting links which proportion and transmit the control movements to the main rotor primary servos and to the tail rotor pitch change mechanism. The three primary servos are mounted on the main gearbox and transfer control movements to the main rotor swashplate. The control configuration of the S-61N is shown in Figure 6.

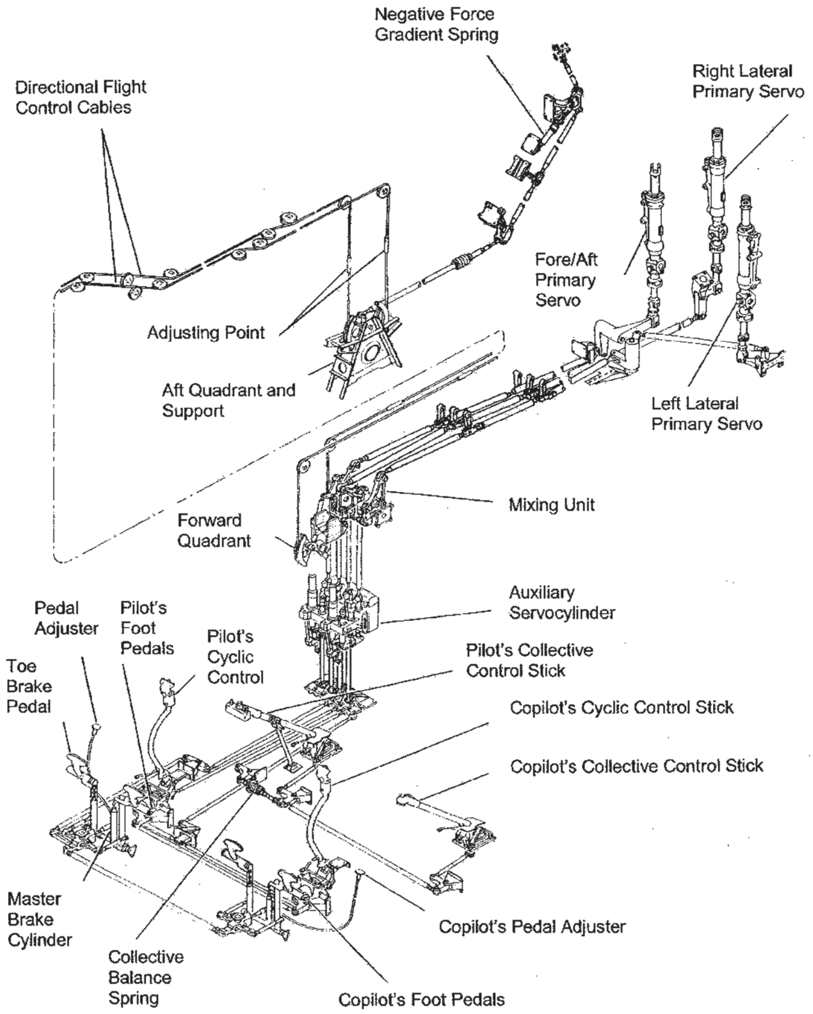

Figure 6

S-61N flight control general layout (reproduced with permission)

During normal operation, both the primary and auxiliary hydraulic servo systems are used, but the helicopter can be flown with one of the systems inoperative. The main rotor forces are too great to allow the helicopter to be flown manually without hydraulic assistance.

Each servo, when hydraulically powered, receives control inputs through a 'sloppy link'. As the sloppy link is moved, it opens a pilot valve within the servo. This diverts hydraulic pressure to the piston within the servo allowing it to extend/retract as commanded. Once the linkage is in the desired position, the pilot valve seals the flow to the hydraulic piston causing the movement to stop. If the servo is not hydraulically powered, a spring-loaded bypass valve opens allowing the upper and lower chambers of the actuator to be connected. This allows the servo power piston to move freely without hydraulic assistance whenever force is applied to the power piston, as fluid can flow freely between the chambers.

The hydraulic pumps are driven by the main gearbox whenever the main rotors are running or by a DC motor-generator which is electrically powered from batteries when on the ground, known as motorising the system. Although the full range of swashplate and cyclic/collective control movement is possible while operating using the DC motor-generators, due to limitations in hydraulic pressure available when motorising, the rate at which the hydraulics servos can respond to control inputs without stalling is reduced.

To allow the helicopter to be started at locations such as Marchwood, which did not have an available ground power cart, G-ATBJ carried two external batteries which were to be used as an external power supply. The S-61N is fitted with two batteries the main (connected to the essential bus) and the alternate (connected to the emergency bus). The external battery also connects to the essential bus and during start the 'start switch' is made which connects the emergency bus to the essential bus. This means that all three batteries are connected during start and, being the same nominal voltage, will share the load roughly equally. With limited battery charge available and no means of charging the batteries in flight, ground operations under battery power were minimised to maintain battery charge.

Swashplate

The main rotor head is splined onto the main gearbox output, its principal components are the hub, swashplate and bifilar vibration absorber. The swashplate transmits movement of the flight controls to each main rotor blade through pitch control rods. A spherical bearing, sometimes referred to as a ball-ring socket, allows the swashplate to be tilted off its horizontal plane and moved on its vertical axis. The rotating swashplate is connected to the rotary wing hub by rotating scissors and the pitch control rods. The stationary swashplate is connected to the main gearbox by stationary scissors and the primary servo cylinders. The rotating swashplate can rotate around the stationary swashplate. When the servo cylinders are actuated, movements of the stationary swashplate are transmitted to the rotating swashplate and then to the main rotor blades via the pitch control rods (Figure 7).

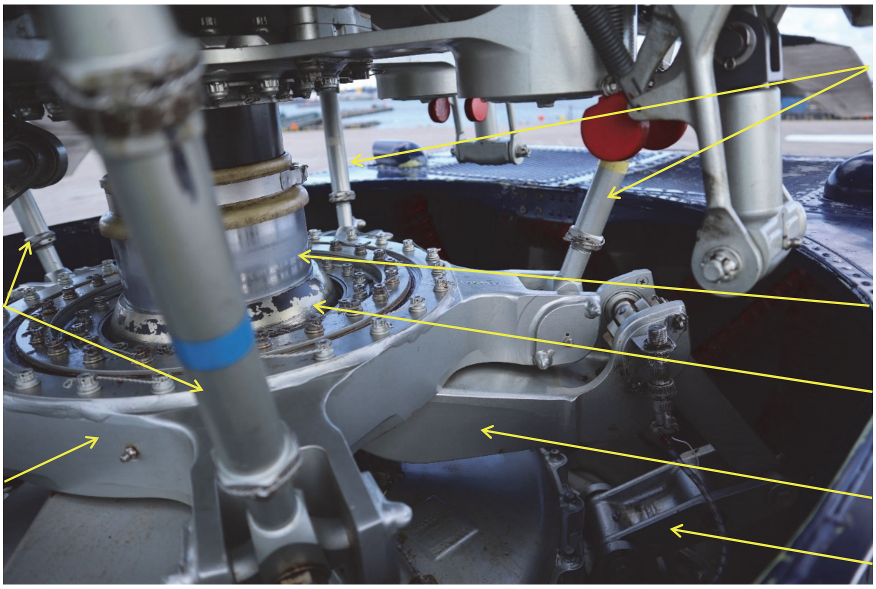

Figure 7

S-61N swashplate configuration

The anodised aluminium spherical bearing is held in position by two opposing phosphor bronze sockets which are inserted into the stationary swashplate housing. The lower socket is located on a flange at the bottom of the housing. The upper socket is held in place by a retainer and spacer. An adjustable shim is used to set the height of the retainer and hence the amount of clamping it provides to the spherical bearing (Figure 8). In-service adjustment of the shim can be made if the vertical play of the bearing exceeds 0.070 in. The bearing is packed with grease when assembled and cannot be replenished during normal maintenance.

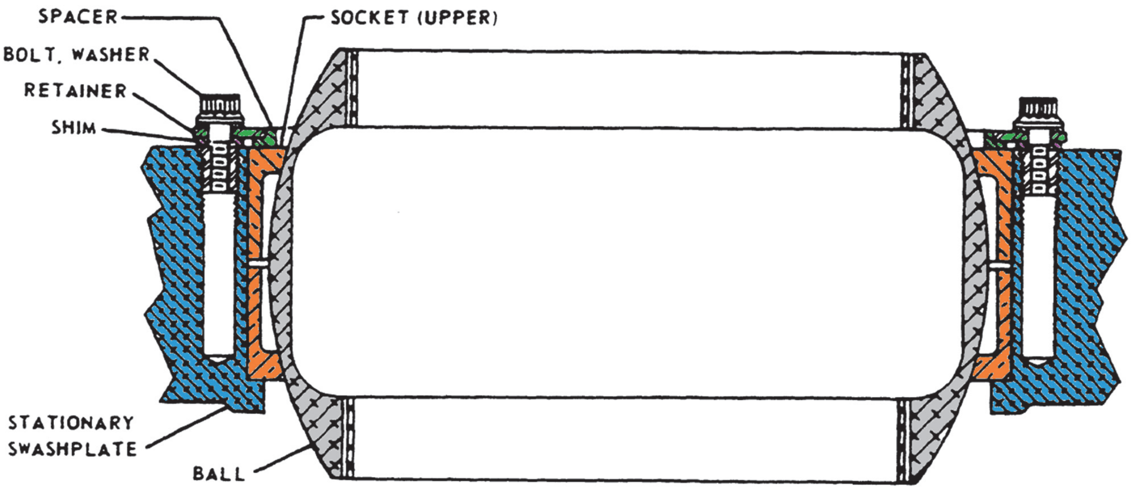

Figure 8

Arrangement of S-61N swashplate spherical bearing (reproduced with permission)

Manufacturer's S-61N flight manual

The S-61N flight manual contains details of the procedures to be followed at helicopter start. In particular, with regard to the checks required of the flight control servo system, Part 1, Section II, *Normal Procedures* of the S-61N Flight Manual states:

'<u>EXTERNAL POWER ENGINE STARTS AND ROTOR ENGAGEMENT</u>

…

4. Flight control servo system – CHECK fully as described below prior to first flight of the day, optionally or partially as desired for subsequent flights.

a. Auxiliary and primary servo hydraulic pressure indicators – Normal range.

a.1. Copilot's flight control servo switch – momentarily select PRI OFF and AUX OFF in turn and confirm respective pressure indicator drops to zero and caution light illuminates.

b. Pilot flight control servo switch – PRI OFF. Primary servo pressure indicator should indicate a drop to zero and caution light should illuminate. Momentarily select AUX OFF using copilot servo switch and confirm auxiliary pressure is normal and caution light remains off.

NOTE
There should be no measurable control jumps when securing or restoring primary servo hydraulics. Some main rotor blade pitch motion is to be expected.

c. Trim release button (on cyclic stick) – Depress. Collective pitch lever – Actuate full up.

d. Actuate cyclic stick from one extreme to the other in lateral, then fore-and-aft directions. Repeat cyclic stick movements with collective down.

e. Flight control servo switch – ON. Primary servo hydraulic pressure normal; caution light OFF.

…'

An abridged version of this procedure was available to the crew in the operator's Normal Checklist and Operation Manual Part B, Section 02, Appendix 2:

'HYDRAULIC SYSTEMS

Motor Generator .... MOTORIZE

Flying Controls .... Check Full and free movement

Hydraulic Switches: Check Interlocks as below

***PF** - Servo Switch .... PRI OFF*

***PM** - Servo Switch .... AUX OFF Check Auxilliary system remains in Green Arc, Primary system goes to zero pressure.*

***PF** - Controls .... ALL FULL & FREE*

***PF** - Servo Switch .... AUX OFF Check systems change over with no delay*

***PM** - Servo Switch .... PRI OFF Check no change over occurs*

***PF** - Controls .... CYCLIC/COLL FULL & FREE*

***PF** - Servo Switch .... BOTH Check systems change over with no delay*

***PM** - Servo Switch .... BOTH Check both systems restored*

***Note**: Liaise with start crew during full and free checks to ensure Main and Tail Rotor Blades responds* [sic]*. When checking for full and free movement with each system selected off, ensure that no coupled indications are evident.'*

Helicopter examination

To facilitate road transport, the main and tail rotor blades, tail pylon and sponsons were removed and the helicopter was transported to the AAIB, where a detailed examination of the helicopter control system could be carried out. All control linkages were intact, continuous and correctly installed.

The auxiliary and primary servos were examined for leakage or damage and then removed. Computed Tomography scanning was completed prior to being transported to the helicopter manufacturer's facility for testing and disassembly; no anomalies were identified.

The investigation also considered other areas that could have contributed to the nose-down pitching movement including the Auto-Flight Control System (AFCS) or trapped water affecting the Centre of Gravity. However, these were discounted as possible causes.

During the removal of the primary servos it was identified that the spherical bearing within the stationary swashplate assembly was seized. The swashplate was able to translate up and down the guide tube but could not tilt. There was evidence that the guide tube had deflected during operation as grease on the mast had come into contact with the inner surface of the guide tube (Figure 9); however, there was no evidence of metal-to-metal contact between the mast and guide tube. Once it had been removed, examination of the swashplate assembly confirmed that the spherical bearing could not articulate in any direction. The swashplate (Figure 10) was transported to the manufacturer's facility for further disassembly.

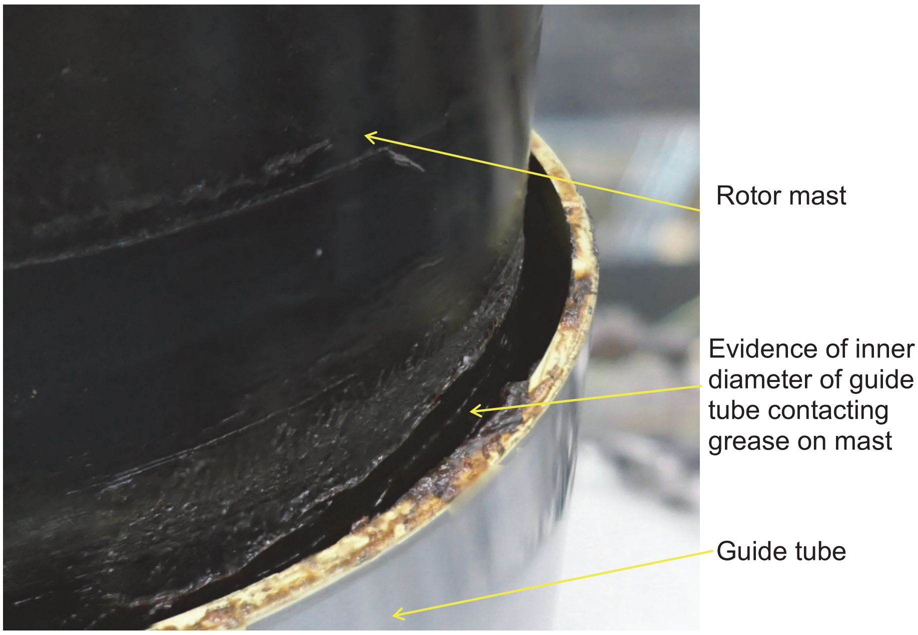

Figure 9

Flattening of grease between rotor mast and guide tube

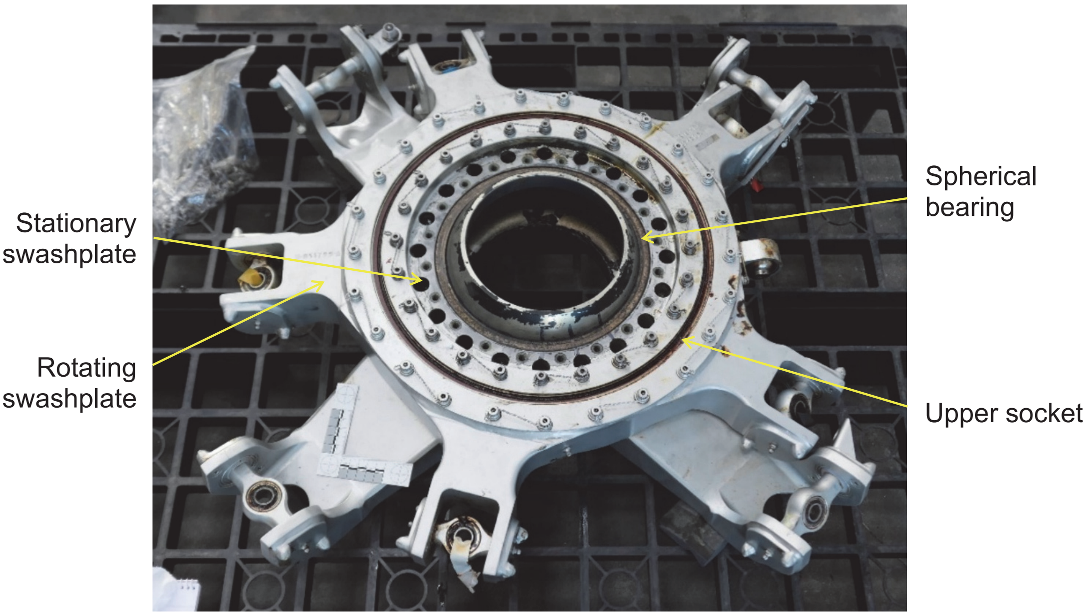

Figure 10

G-ATBJ swashplate after removal from the helicopter
(retainer, shim and spacer already removed in this image)

Examination of the sockets identified that both the upper and lower sockets had become skewed such that there was a gap between the lower socket and its retaining flange of up to 0.150 in. The upper socket had also skewed with a variation of up to 0.023 in. The sockets were re-seated thus allowing the spherical bearing to be released.

The grease between the sockets and the spherical bearings was in very poor condition, with crystalline deposits within it (Figures 11 and 12). Elemental analysis of the deposits found them to contain aluminium, chlorine, sodium, copper, tin and oxygen. This indicates that the aluminium spherical bearing had corroded, and deposits had been retained within the grease. A section of the grease was cleaned from the bearing to reveal areas of corrosion pitting to a depth of 0.018 in (Figure 13). A build-up of plaque-like material was adhered to the bearing. Analysis of this material found it to be bronze material that had released from the socket, combined with the grease and adhered to the bearing surface.

Figure 11

G-ATBJ spherical bearing once removed from swashplate

Figure 12

G-ATBJ upper spherical bearing socket showing corrosion product adjacent to bearing surface

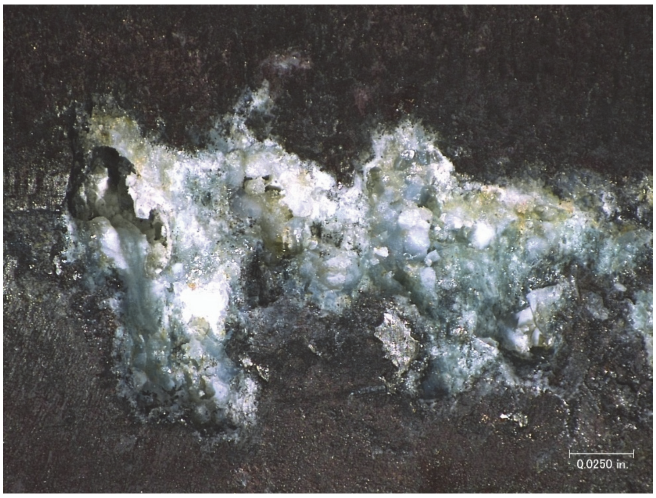

Figure 13

G-ATBJ example of spherical bearing corrosion pit

Once the spherical bearing was cleaned, a ring showing signs of severe corrosion was identified around the location where the lower socket had been. Closer inspection identified that a number of deep corrosion pits were located along the intersection between spherical bearing and where the top of the lower socket bearing face made contact (Figure 14).

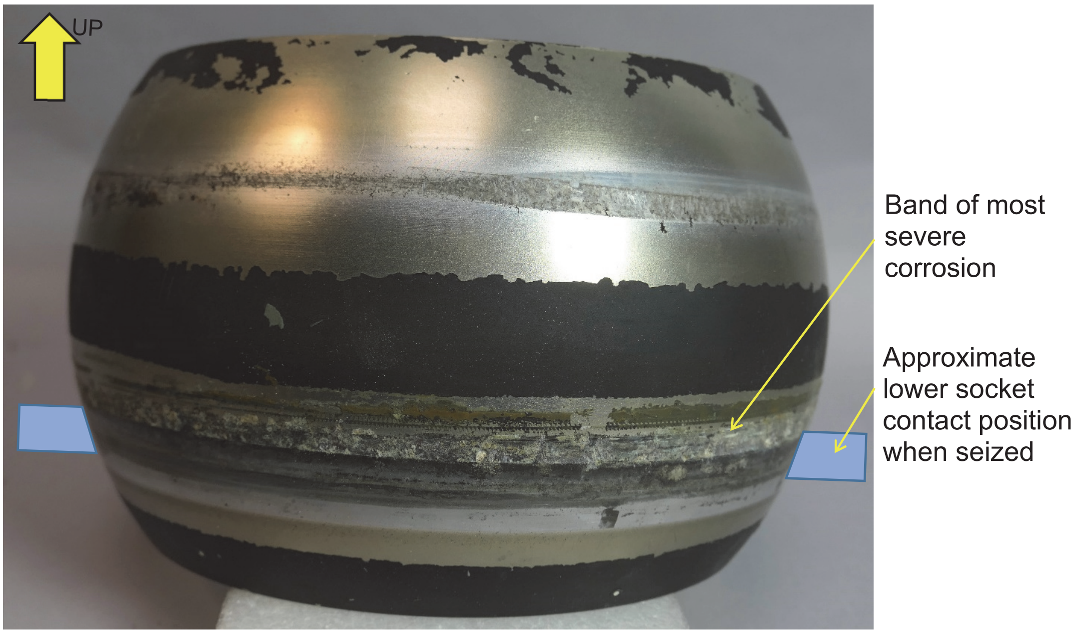

Figure 14

Spherical bearing showing area of heavy corrosion above the location of the lower socket

Swashplate Service history

The swashplate fitted to G-ATBJ was last overhauled in January 2014. It was fitted to the helicopter in June 2016, 44 months before the accident, during which it had accumulated 2,493.5 operating hours. In-service assessment of the vertical play is required every 500 hours and was most recently completed 33.5 hours prior to the event. During the assessment, the vertical play was measured as 0.080 in, 0.010 in outside of limits and so the shim was adjusted to increase spherical bearing clamping. There were no reports of any issues with the swashplate subsequent to the 500-hr check.

S-61N maintenance

The level and type of maintenance to be completed on the S-61N is defined by the helicopter manufacturer and is detailed in the S-61N Equalized Inspection and Maintenance Program, SA 4047-13 (EIMP). This document defines what and when inspections, servicing, component replacements and checks need to be carried out during the lifecycle of the helicopter. In addition, the Aircraft Maintenance Manual (AMM) contains guidance related to long-term parking that is of relevance, including recommended use of protective covers over the rotor head and swashplate that would minimize the effects of a salt atmosphere. The AMM also identifies the conditional inspections to be performed after exposure to saltwater or salt spray.

Operators often develop their own Approved Maintenance Plans (AMP) which incorporate the manufacturer's requirements but are better aligned to the type of operation being undertaken by the helicopter.

The EIMP defines several inspection types, the most frequent being a Pre-flight Inspection. There are also Safety Inspections, Progressive Period Inspections, Special Frequency Inspections, Unscheduled Maintenance Check and Major Inspections. A Safety Inspection is defined as an inspection that:

> *'shall be done once each fifteen (15) flight hours. If the helicopter is not flown daily or is stored for any extended period, the Safety Inspection must be done within the 24-hour period immediately preceding the next scheduled flight.'*

As G-ATBJ had not been operated for over 30 days while it was in transit, a Safety Inspection should have been carried out on the aircraft prior to flight. The operator's AMP (S-61N AMP MP/01016/1381) subsumes the intent of the Safety Inspections defined in the EIMP into its 'Daily' maintenance requirements. These Daily inspections contain mandatory items that must be carried out within a period not exceeding 10 flying hours or 24 elapsed hours prior to flight.

For the swashplate assembly, the EIMP required an Inspection and Check to be carried out as part of the Safety Inspection, a remark was also made to '*Check for binding in the ball-ring socket per Maintenance Manual*'. In reviewing the AMP, it was identified that this check was not annotated within the original maintenance requirements and therefore was not carried out as part of the Daily inspections.

Section 80 65-12-7 of the S-61N Maintenance Manual, SA 4045, refers to swashplate maintenance. Paragraph 3 D, titled '*Check for Binding in Ball-Ring Socket*' defines the check referred to in the EIMP. This check requires a binding check to be carried out by motorising the servos systems and, by exercising the collective and cyclic with an observer on the service platform, assessing that the motion and travel of the swashplate is smooth and continuous. This check was not completed during the pre-flight preparations on 29 or 30 January 2018.

Safety action by the helicopter manufacturer and the helicopter operator

On 22 July 2019, the helicopter manufacturer issued a Safety Advisory to highlight to operators the necessity of performing the prescribed Safety Inspections after long-term storage of the aircraft, specifically the inspection/check of the swashplate.

The helicopter operator has incorporated the assessment of the ball ring socket for freedom of movement in the Daily inspections. In addition, it has made the decision that, in the future, helicopters that have been transported by sea will then be road transported from their port of entry to the maintenance facility. The operator has also undertaken to investigate increased environmental protection for its helicopters during sea voyages.

Other information

With the spherical bearing within the swashplate seized, the torque load applied to the swashplate from the servos would cause the guide tube and supporting structure to flex until the servos stalled. This flex would allow some relative movement of the swashplate about its centre in relation to the rotor head and would subsequently allow the rotor blades to move in the correct sense to a cyclic input. A video taken of the manipulation of a seized swashplate from another S-61 was provided to the AAIB by the helicopter manufacturer. This confirmed that some guide tube movement is likely when a cyclic load is applied (Figure 15). This would translate into blade movement as the guide tube is flexed. From the information provided it was not possible to correlate the amount of blade pitch change in relation to the cyclic input.

The manufacturer conducted an analysis of the control system geometry to determine whether a full back stick input could be applied without any apparent movement of the swashplate. The calculations were based on a simple model of guide tube flexing and hydraulic actuator sloppy link movement, with stalled servos, and was able to account for most, but not all, of the aft cyclic input range being available to the pilot. The level of flex in the control runs was not known. As discussed, this would yield some blade movement in the right sense by virtue of the guide tube flexing but with a significantly restricted range.

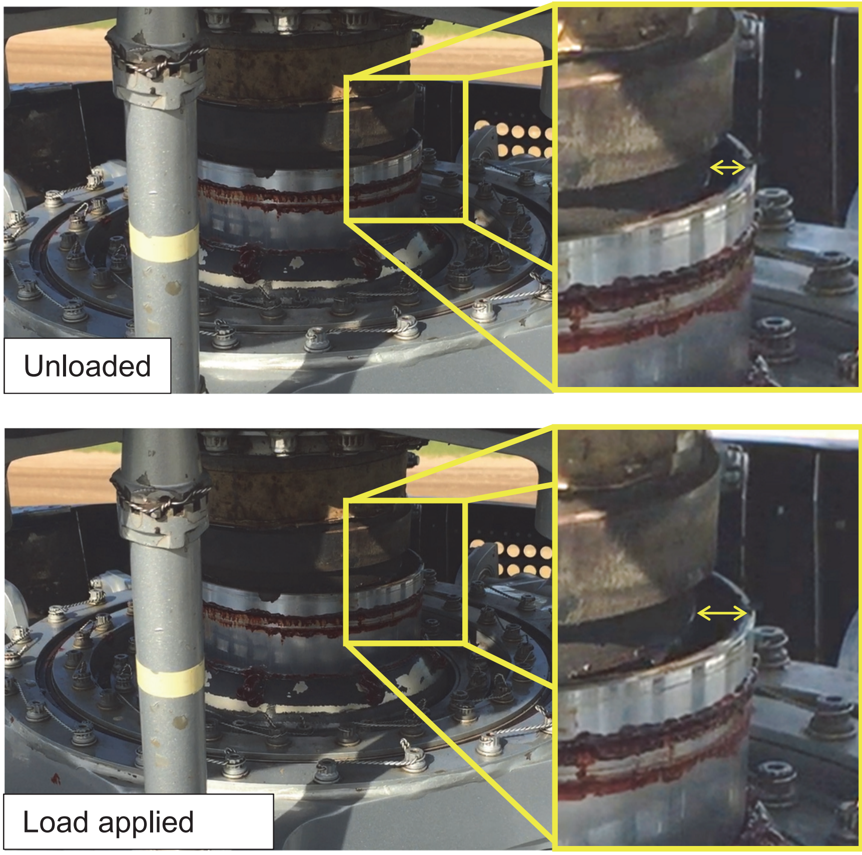

Figure 15

Stills from video of another S-61 showing levels of guide tube deflection when cyclic was applied to a seized swashplate

Analysis

The uncommanded pitch nose-down on lift off from Marchwood following the first flight after transportation by ship from the Falkland Islands was most likely as a result of a restriction of the swashplate which had seized. The seizure had not been detected during the reinstatement of helicopter in preparation for flight or in the pre-flight control checks.

Swashplate seizure

It is possible that there was some corrosion present within the spherical bearing sockets prior to the shipment of the helicopter back to the UK. However, with regular operation, there was no opportunity for any corrosion to dwell and allow the ball-ring to seize. During the shipping of the helicopter from the Falkland Islands, where the rotor head was unprotected, water ingress between the sockets is likely to have occurred, either from inclement weather or due to spray from the sea. Any water that was captured in the socket area would have welled above the lower socket. The dissimilar materials of the spherical bearing and the socket would promote galvanic corrosion if exposed to salt water. This would promote rapid corrosion propagation and adherence between the socket and bearing surfaces.

Following a period of inactivity, the helicopter should have been subject to a Safety Inspection as detailed in the S-61N Equalized Inspection and Maintenance Program, SA 4047-13 (EIMP). As part of the Safety Inspection of the swashplate assembly, the EIMP requires a '*Check for Binding in Ball-Ring Socket*'. It is likely that this check, had it been carried out, would have identified the seized swashplate before the accident flight.

Upon application of cyclic control inputs during the pre-flight checks the swashplate will have initially tilted. With the socket and bearing locked together the force will have lifted the lower socket out of position, in doing so it will have wedged the spherical bearing in position, preventing any further movement.

Any cyclic load applied subsequently would have resulted in guide tube deflection with an associated small change in blade pitch.

Flight control servo system checks

At the time of the accident, G-ATBJ carried two external batteries which were to be used as an external power supply for remote starting and ground motoring. With limited battery charge available it was perceived that ground operations under battery power should be minimised so that there would have been enough charge available for the engine start at Bournemouth.

After engine 2 had been started, the crew completed a limited check of the flight controls and observed the main rotor blades moving in the correct sense. This would have confirmed to the handling pilot that he had freedom of movement and continuity in the controls. Given this and the fact that the cyclic was able to move to the rear stop, it is unlikely the crew would have noticed the seized swashplate prior to takeoff. However, had an external observer monitored the main rotors and the swashplate during this check, the seizure may have been identified.

Conclusion

The cyclic control restriction was found to be as a result of seizure of the spherical bearing with the swashplate. The seizure was determined to be as a result of corrosion build-up within the bearing sockets. Prolonged inactivity during the transportation of the helicopter from the Falkland Islands allowed corrosion to develop sufficiently to cause the bearing to seize. Following the helicopter's arrival in the UK, Safety Inspection checks detailed in the S-61N Equalized Inspection and Maintenance Program, SA 4047-13 were not carried out; it is likely that the seized swashplate would have been identified if they had.

Despite the seizure, the investigation determined that full fore/aft travel of the cyclic control could still be achieved which indicates that this is not a reliable indication that the swashplate is free to move. During pre-flight checks by maintenance engineers and the flight crew, the flight control servo system checks were not completed to the full extremes of travel. With a seized swashplate, the rotor blades changed pitch due to flexing of the guide tube and the blade movement was incorrectly identified as a positive confirmation of control authority. There was no confirmation by external observation of the main rotor and swashplate operation during the limited range pre-flight checks.

The perceived limitations of the hydraulic system when pressuring the hydraulics from the battery powered DC motor (motorising) compounded by the restrictions of using an external battery for starting were identified as contributory factors because control movements were not made to the full extremes of the cyclic envelop during the pre-flight checks.

Safety actions

The helicopter operator

On 20 June 2018, the operator issued Flying Staff Instruction (FSI) 2018-35 to remind all crews to conduct the flight control servo system check, which includes a full and free check, as required in Appendix 2 of the Operations Manual Part B S61 Section 02. This FSI contained the detailed check as an Appendix.

The operator has continued to monitor that its pilots perform the check, to the extremities, through routine simulator checks and, through its flight data monitoring programme, during operational flying.

The operator has incorporated the assessment of the ball ring socket for freedom of movement in the Daily inspections. In addition, it has made the decision that, in the future, helicopters that have been transported by sea will be road transported from their port of entry to the maintenance facility.

The operator has also undertaken to investigate increased environmental protection for its helicopters during sea voyages.

The helicopter manufacturer

On 22 July 2019, the helicopter manufacturer issued a Safety Advisory to highlight to operators the necessity of performing the prescribed Safety Inspections after long-term storage of the aircraft, specifically regarding the inspection/check of the swashplate.

Published: 30 January 2020.

Bulletin correction

On page 20 of the report, it was incorrectly stated that the swashplate vertical play was measured as **0.008 in, 0.001 in** outside of limits.

The text should read:

> During the assessment, the vertical play was measured as **0.080 in, 0.010 in** outside of limits and so the shim was adjusted to increase spherical bearing clamping.

The online version of this report was corrected on 12 March 2020.

ACCIDENT

Aircraft Type and Registration:	Skyranger Swift 912S(1), G-SKSW
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2007 (Serial no: BMAA/HB/553)
Date & Time (UTC):	15 September 2019 at 1040 hrs
Location:	High Cross airstrip, Hertfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to nose landing gear, engine cowling, engine, propeller, cockpit windscreen, left and right wings
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	10,300 hours (of which 160 were on type) Last 90 days - 14 hours Last 28 days - 8 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft's nose landing gear failed during a normal landing roll, causing the aircraft to pitch over and come to rest inverted. It is probable that the landing gear fork was damaged during a recent, but unidentified, landing or taxiing event that weakened the fork to the extent that it subsequently failed during the accident flight. The nosewheel fairing would have made it difficult for a pilot to fully inspect the area where the failure occurred during the pre-flight inspection.

History of the flight

The pilot returned to High Cross airstrip from Clacton airfield after a 30-minute flight in fine weather conditions. An uneventful approach to Runway 22 was flown, followed by a normal touchdown on the main landing gear. As the nose was lowered during the landing roll, the nose landing gear fork failed, causing the nose leg to dig into the surface of the grass runway. This caused the aircraft to decelerate suddenly and to pitch forward, coming to rest inverted (Figure 1). The pilot and passenger, who were wearing four-point harnesses, were uninjured and able to unfasten their harnesses and vacate the aircraft without assistance.

Figure 1

G-SKSW following the nose landing gear failure

Accident site

The aircraft came to rest approximately 170 m along Runway 22. The runway's grass surface was firm, following a prolonged period of dry weather. Witness marks made by the aircraft on the runway were consistent with a progressive collapse of the nose landing gear fork during the landing roll. There was no evidence of the nose landing gear having struck an object and there were no significant holes or depressions in the runway surface.

A small quantity of fuel had leaked from the aircraft's left wing fuel tank whilst the aircraft was inverted.

Aircraft information

The Skyranger Swift is a high-wing, two seat microlight aircraft with a conventional fixed landing gear. The nose and mainwheels are enclosed in fairings that limit the degree of examination of the landing gear during normal pre-flight checks. G-SKSW was built in 2007 and had accumulated 422 hours at the last maintenance check, which occurred on 21 August 2019. The aircraft had suffered a landing accident in 2012 that bent the nose landing gear leg, which was replaced by a new component as part of the repair.

The aircraft owners were not aware of any recent taxiing or landing events that may have damaged the nose landing gear.

Aircraft examination

The aircraft sustained damage to the nose landing gear, propeller, engine cowling and engine. The cockpit windscreen was broken and the upper surfaces of both wings were damaged.

The left leg of the nose landing gear fork had failed at its welded joint with the nose landing gear down tube (Figure 2). The right leg of the fork remained attached to the down tube and had folded rearwards, with the nosewheel remaining attached to it. The nosewheel tyre was in good condition and no pre-accident defects were evident when it was examined.

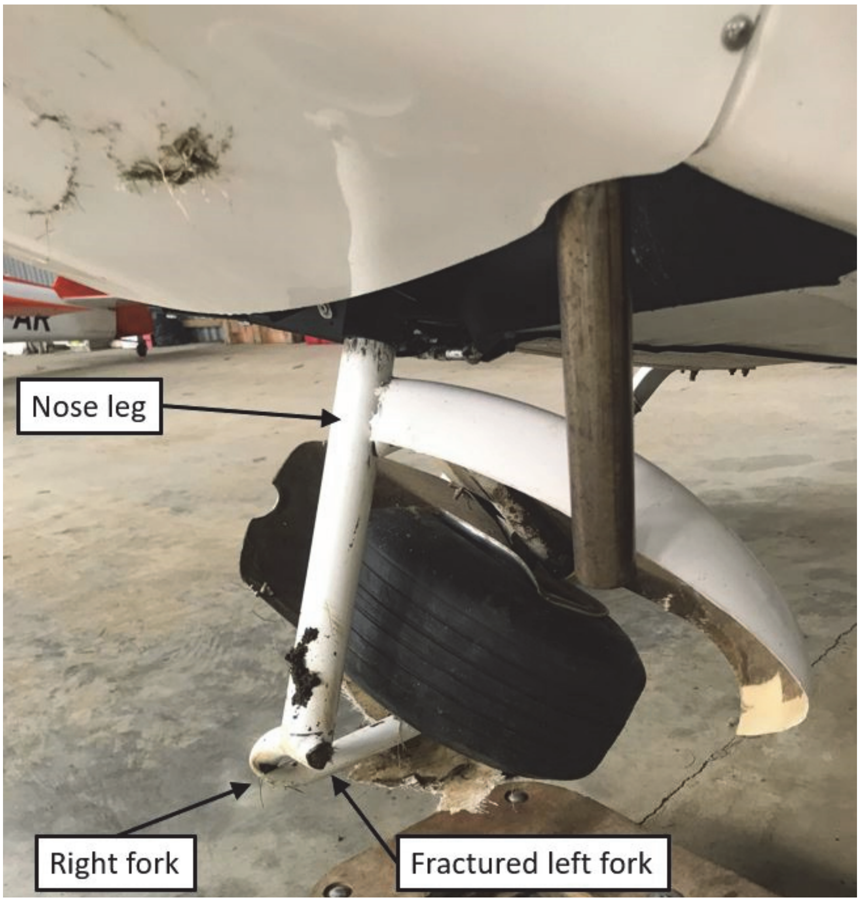

Figure 2

Fractured nose landing gear left fork

The fractured section of the nose landing gear fork was subjected to a metallurgical examination, which revealed that the left fork tube had bent rearwards during the failure, at the point where the fork tube was attached to the down tube by a welded joint. The rear section of the welded joint between the fork and the down tube had failed in ductile overload close to the edge of, but within, the weld bead (Figure 3). The front section of the left fork tube had failed in ductile overload outside the welded area.

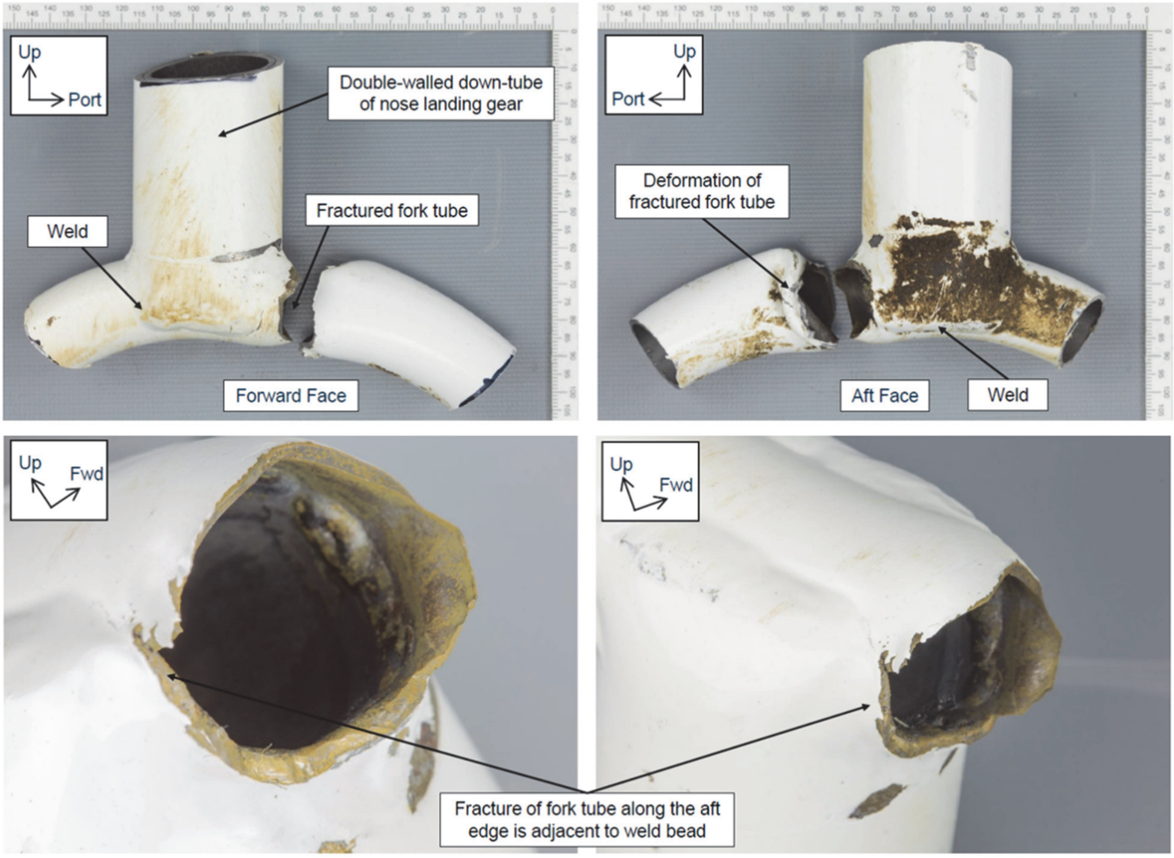

Figure 3

Fractured section of the nose landing gear fork tube (image courtesy of QinetiQ)

Some light corrosion was evident across the fracture surface although there were no heavily corroded areas as might be expected with a pre-existing crack in the fork. There was also no evidence of progressive crack growth in the fracture surface.

The welded joints were examined by taking microsections and no defects such as porosity, inclusions or micro-cracking were evident within the weld beads. No significant heat-affected zones were observed in the tube material adjacent to the welded areas. Although the degree of weld penetration was variable in the welds examined, it was not thought to have significantly affected the strength of the welded joints in the fork assembly.

No significant discrepancies were identified in the material composition and tensile strength of the fork tube material between the manufacturer's specifications and those values noted during the metallurgical examination.

Analysis

The metallurgical examination of the nose landing gear left fork determined that the fork had failed in overload, due to being subjected to loads in excess of its design strength. It also found that there were no material defects or progressive cracking present that may have contributed to the failure.

The initial stage of the landing during the accident flight was uneventful, with a normal touchdown on the main landing gear. The nose landing gear collapsed during the landing roll without having been subject to an excessive impact. It is, therefore, considered likely that the nose landing gear left fork had been previously damaged, during a recent but undetermined landing or taxiing event, that caused a crack to form which eventually led to the failure of the fork during the landing roll.

Conclusion

The investigation established that the most likely cause of the failure of the nose landing gear leg was a crack emanating from damage that occurred prior to the accident flight. The fixed nosewheel fairing would have constrained the pilot's inspection of the damaged area during the pre-flight inspection.

Published: 30 January 2020.

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.

SERIOUS INCIDENT

Aircraft Type and Registration:	Airbus A319-131, G-EUOG
No & Type of Engines:	2 International Aero Engine V2522-A5 turbofan engines
Year of Manufacture:	2001 (Serial no: 1594)
Date & Time (UTC):	2 October 2019 at 0736 hrs
Location:	London Heathrow Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 96
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	17,341 hours (of which 5,887 were on type) Last 90 days - 101 hours Last 28 days - 18 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

G-EUOG taxied out to Runway 27L at London Heathrow Airport for a flight to Leeds Bradford Airport. The planned departure intersection was N2W (TORA[1] 3,380 m). As the aircraft taxied out, the Pilot Monitoring (PM) asked for intersection N4E (TORA 2,702 m) which was granted by ATC. After starting the second engine and completing the checklist, the aircraft departed from N4E using takeoff performance data calculated for N2W.

History of the flight

The crew completed pre-flight preparations for a flight from London Heathrow Airport to Leeds Bradford Airport. Both crew members were conscious that it was a very short flight and in preparation for this they discussed the destination as well as the departure during the pre-flight preparations.

The aircraft taxied out using a single engine for a departure from Runway 27L at Heathrow. The figures for the takeoff performance had been calculated from N2W. During the taxi out, the PM mistakenly requested N4E for departure which gave a TORA 678 m shorter than from N2W. Both intersections are shown in Figure 1. This was not intentional from the PM. The new intersection was rapidly approved by ATC leaving the crew little time

Footnote

[1] TORA: Takeoff Run Available.

to complete their pre-departure duties. The crew started the second engine and were cleared to line up for departure. Aircraft performance from the new intersection was not discussed or entered into the Flight Management Guidance Computer (FMGC).

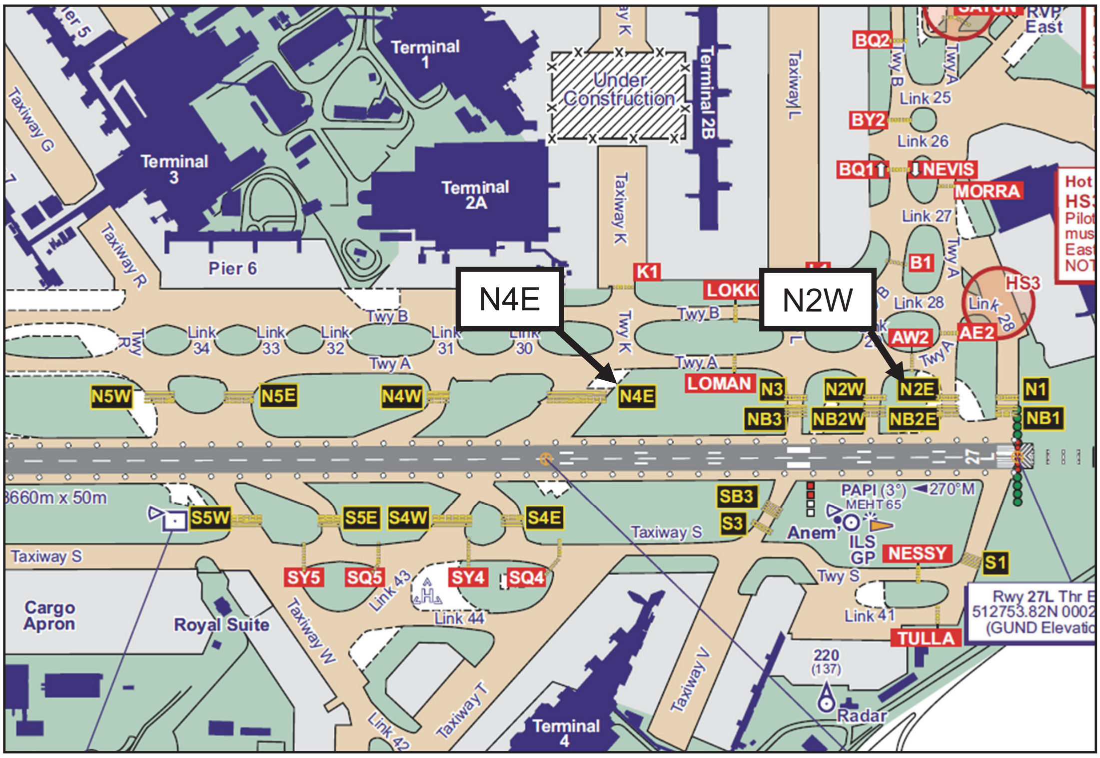

Figure 1

Holding points for Heathrow Runway 27L

As the aircraft lined up on the runway, the Pilot Flying (PF) realised that the figures for N4E had not been entered into the FMGC and asked the PM if he was happy to continue with the departure. The PM did not realise that the question related to takeoff performance but instead assumed it was about completion of the rapid engine start and departure process. Since he was content that both were complete, he replied positively. From his experience, the PF felt that the performance was adequate and, given that the PM also seemed happy, he elected to continue. The takeoff was unremarkable. The calculated takeoff performance included a thrust reduction and the PF did not select full thrust during the takeoff.

With such a short sector, the event was not discussed in flight but the post-flight debrief revealed a different understanding between the two pilots. The PM had not realised that he had asked for a different intersection from the one used in the performance calculation. The crew reported the incident to the operator as soon as they were able.

Both crew felt that the rushed departure contributed to them commencing the take off with incorrect performance figures in the FMGC. They commented that either declining the rapid line-up clearance or informing ATC they were not ready could have prevented this incident from occurring. Heathrow is also their home base and both crew members had departed from N4E on previous flights, so the use of the intersection was not unusual.

Analysis

As a result of a mistaken request for a different intersection the crew departed with aircraft performance figures calculated for a runway length 678 m longer than was actually available. Rushing to complete the pre-takeoff procedures, familiarity with the airport, and the lack of a shared mental model between the crew contributed to what could have been a significant event. Fortunately, the aircraft was light, with a limited payload and fuel for only a short flight, so the takeoff was unremarkable and the takeoff performance was not compromised.

AAIB comment

Takeoff performance data errors come in many types, including data entry errors, selection errors, mistaken takeoff point errors and change of runway or intersection errors. Despite extensive training and standard operating procedures, performance errors continue to occur on many different aircraft types throughout the world. Whether at a familiar home base or at a challenging, limiting runway, takeoff performance calculations require time free from interruptions and distractions, concentration and co-ordination, as well as adherence to standard operating procedures, to reduce the possibility of errors being made.

The CAA and AAIB continue to work with operators, manufacturers, and EASA in seeking measures that may further mitigate the risks of takeoff performance data errors. These include raising awareness of the nature of the risks to crews and operators, trying to quantify the risks using flight data monitoring programmes to look for errors, and exploring the possible development of a technological barrier to warn crews when errors have been made.

ACCIDENT

Aircraft Type and Registration:	Boeing 787-9 Dreamliner, G-CKWB
No & Type of Engines:	2 Rolls-Royce Trent 1000-J3 Ten turbofan engines
Year of Manufacture:	2018 (Serial no: 38788)
Date & Time (UTC):	12 August 2019 at 0915 hrs
Location:	London Gatwick Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 10 Passengers - 342
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to tail cone
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	18,084 hours (of which 4,492 were on type) Last 90 days - 186 hours Last 28 days - 56 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

G-CKWB was parked on Stand 38 at London Gatwick Airport. The aircraft was loaded, with the doors closed ready to depart for its flight to the USA. Permission was granted by the ground controller for the aircraft to push back and start engines at 0910 hrs. The aircraft was pushed back using the incorrect line and as a result the aircraft tail cone struck the blast screen.

History of the flight

The aircraft was parked on Stand 38 at Gatwick ready to push back. Stand 38 is in a corner of the ramp with blast screens on two sides (Figure 1).

Due to the confined nature of the stand, special procedures are used so that sufficient clearance from the blast screens is maintained both during the pushback and subsequent taxi out. The apron has a line on the ramp to indicate to the pushback tug driver where the aircraft should be pushed to and where the nose wheel should be before the aircraft is disconnected from the tug. The pushback requires the aircraft to be positioned by the driver at an angle to the taxiway, and markings are also provided for the guidance of the flight crew when taxiing for departure. There is insufficient room for an aircraft to be pushed back onto the centreline of the taxiway at right angles to the stand. The markings for the pushback are shown in Figure 2.

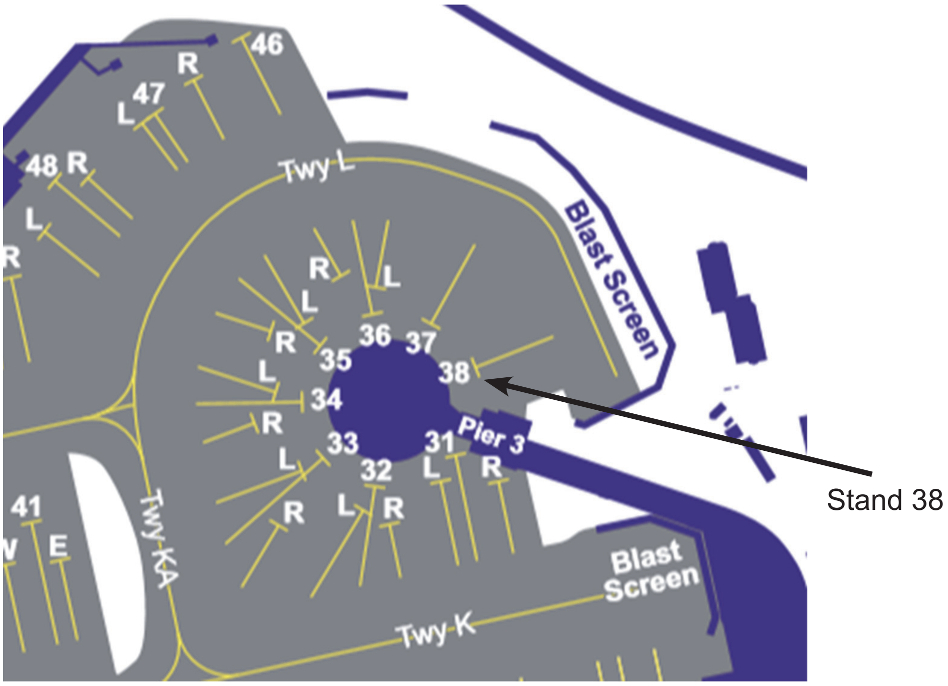

Figure 1
Position of Stand 38 at Gatwick

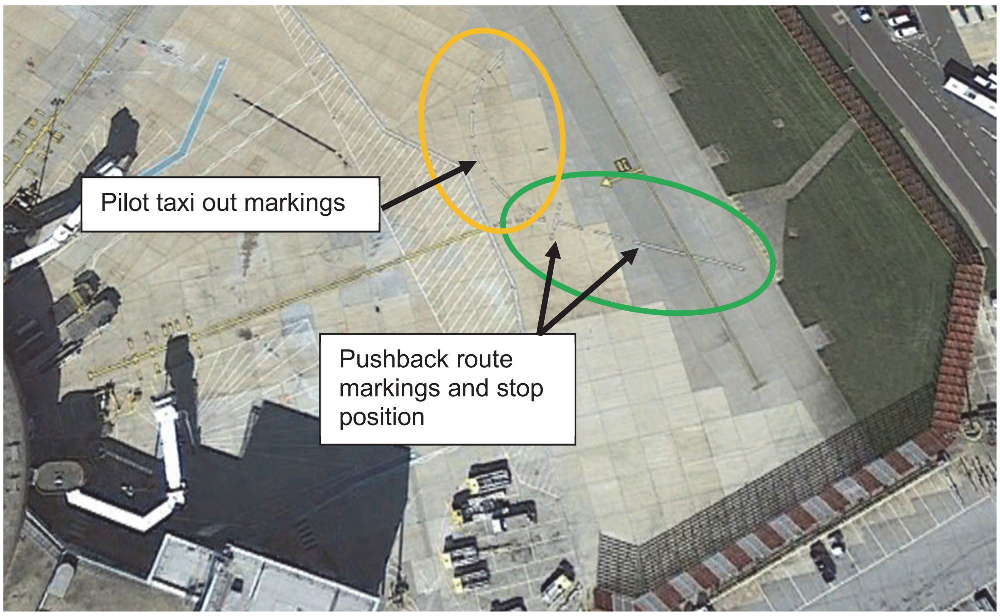

Figure 2
Apron markings Stand 38

At 0910 hrs, the crew received permission to push back from Stand 38. The tug driver began the pushback, and CCTV showed the aircraft pushing straight back along the yellow line for the initial part of the pushback before beginning to deviate from the route markings off the back of the stand. The headset operator signalled to the driver to slow down, with the intention of directing him to pull the aircraft forward into the correct position but, before this could be done, the aircraft tail cone struck the blast screen. The final position of the aircraft is shown at Figure 3.

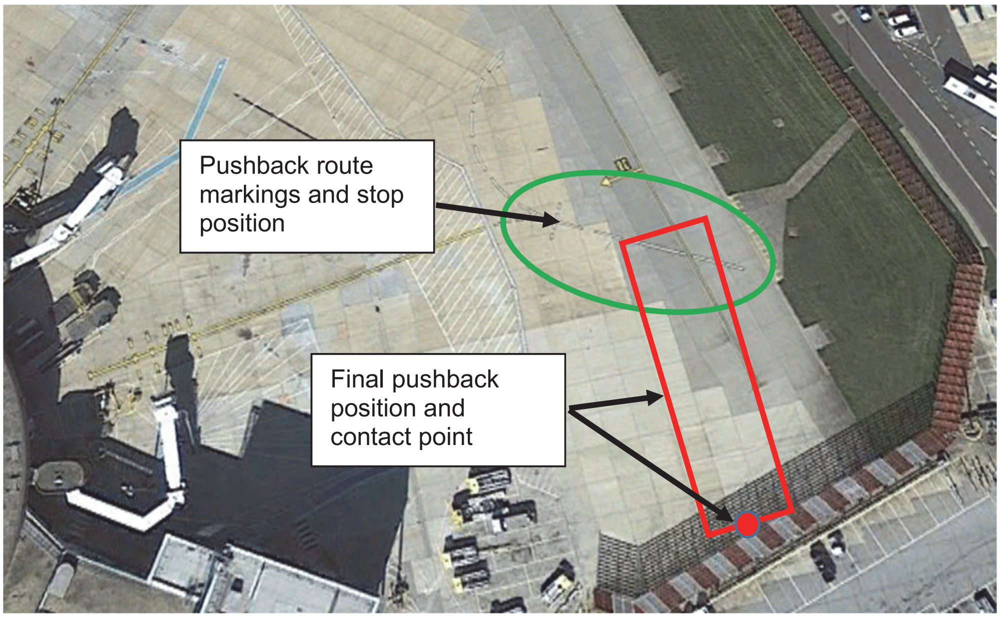

Figure 3
Final pushback position

Neither the headset operator nor the tug driver was aware of the contact, but they were alerted by another ground handler who was in a vehicle within the equipment parking area at the stand and had observed the contact and damage to the aircraft. The flight crew were also unaware of the contact but noted that the Auxiliary Power Unit (APU) had shut down automatically. The headset operator informed the flight crew of the damage who then advised ATC. After the damage was assessed, the aircraft was positioned under its own power onto Stand 37, where the engines were shut down and the passengers were disembarked.

The APU exhaust fairing was subsequently found to be damaged.

Ground handling personnel

Both the headset operator and the tug driver had significant experience operating on the ramp at Gatwick and had pushed aircraft back from Stand 38 previously. Both had begun their shift at 0400 hrs, and were around half way through their rostered shift, and had finished work the previous day at 1230 hrs.

Neither the driver nor headset operator was able to see the tail of the aircraft during the pushback.

The tug driver was retrained and returned to duty. The tug driver also spent a two-week period with the safety team, which included a focus on aircraft safety processes. The Safety

Manager also spent time with the driver to ensure he was in the correct mindset prior to returning to work.

Analysis

Stand 38 at Gatwick requires a non-standard pushback due to the limited space. The stand has pushback route markings and a stop line to assist the tug driver and headset operator position the aircraft correctly.

G-CKWB was not pushed from the stand onto the required line or stopped at the correct point. This meant that the aircraft came into contact with the blast screen and the APU exhaust fairing was damaged. As a result, the aircraft was withdrawn from service for repairs.

Pushing back any aircraft can present a challenge to the ground crew especially when there is limited space, they are unable to see all parts of the aircraft, and the noise on the ramp may prevent verbal communications. Stopping the pushback immediately when any of the team has concerns about the aircraft position or direction of travel is a vital part of ensuring the safety of the aircraft and ground personnel.

Safety action

The aircraft operator took the following safety action:

- Use of Stand 38 by the operator was suspended temporarily.
- The aircraft operator decided to prepare a risk assessment on the use of additional ground staff to watch the wingtips and tail of aircraft during the pushback. The airport operator agreed to consider this assessment once it was complete.
- Notices were issued by the aircraft operator to all pushback crews to remind them of the procedures and importance for stopping a pushback should the aircraft deviate from the centreline.
- Additional training was given to headset operators to increase their understanding and awareness of pushback hazards.

The airport operator took the following safety action:

- A ‘STOP’ mark was painted on the ramp beside the nosewheel stop line on Stand 38 to make it clear that the aircraft should not be pushed back further than this line. This mark matches others at Gatwick where the pushback is limited by the confined space.

INCIDENT

Aircraft Type and Registration:	Cessna 152, G-BMXA
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1977 (Serial no: 152-80125)
Date & Time (UTC):	3 October 2019 at 1445 hrs
Location:	Bridge of Earn, Perthshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Private Pilot's Licence
Commander's Age:	25 years
Commander's Flying Experience:	388 hours (of which 59 were on type) Last 90 days - 78 hours Last 28 days - 31 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

While en route to Edinburgh during a training flight, thick white smoke began to enter the cabin through the heating vents. The instructor followed the aircraft checklist drills and made a successful forced landing near Bridge of Earn. Both occupants were uninjured, and the aircraft suffered no damage but an engine oil leak was found that had led to the smoke entering the cabin.

History of the flight

The aircraft departed Perth on a training flight and the plan was to route to Edinburgh and then return to Perth. Approximately 15 minutes after takeoff, thick white smoke began to enter the cabin through the heating vents. The instructor took control from the student and began the checklist drills for an engine fire. He retarded the fuel mixture lever to IDLE CUT OFF and accelerated to V_{NE}. However, he quickly realised that there were no signs of flames, only smoke. He therefore re-advanced the fuel mixture to fully RICH to keep the engine running. He made a MAYDAY call to Perth Radio, appraised them of the situation and informed them of his intention to make a precautionary forced landing.

The instructor then told the student to liaise with ATC. The student entered the emergency code, 7700, on the transponder and kept ATC updated on the aircraft's position. The instructor selected a field for landing and positioned the aircraft for the forced landing. At approximately 400 ft agl, when sure of reaching the chosen field and of its suitability, the instructor selected FULL FLAP and shut down the engine. The aircraft landed in a field of recently planted crops, and the crew vacated and moved upwind taking the fire extinguisher with them. Neither crewmember was injured, and the aircraft suffered no damage.

After vacating the aircraft, the crew could see that there was oil streaking down the left side of the aircraft and dripping to the ground from beneath the engine cowling. A subsequent examination of the engine revealed a crack in the engine crankcase.

Analysis

The crack in the engine crankcase caused a significant oil leak and this was the source of the smoke entering the cockpit. The instructor recognised there were no flames and decided to keep the engine running until he was certain of achieving a landing in his chosen field. Given the scale of the leak it is unlikely the engine would have kept running sufficiently long for the aircraft to reach an airfield. The field landing was an appropriate choice and was well executed.

ACCIDENT

Aircraft Type and Registration:	DH82A Tiger Moth, G-ANLD
No & Type of Engines:	1 De Havilland Gipsy Major 1C piston engine
Year of Manufacture:	1943 (Serial no: 85990)
Date & Time (UTC):	22 May 2019 at 1015 hrs
Location:	Goodwood Aerodrome, West Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - 1
Nature of Damage:	Substantial damage to wings, landing gear, propeller, engine, and nose
Commander's Licence:	Private Pilot's Licence
Commander's Age:	79 years
Commander's Flying Experience:	643 hours (of which 485 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft veered to the right during the takeoff roll. The pilot left full throttle applied and attempted to climb away from obstructions. The aircraft did not gain sufficient airspeed, stalled at low altitude and struck an airfield hut and some ground equipment.

History of the flight

The aircraft was on a local flight from Goodwood Aerodrome. The weather was good with a light southerly wind, and Runway 28 was in use. Runway 24 would have been closer to the wind but was out of use.

The pilot completed his takeoff checks and everything appeared normal, so he applied power for takeoff. Video evidence showed that, as the tail lifted from the grass, the aircraft veered to the right. The pilot reported that he applied full left rudder but was initially unable to arrest the yaw, leaving the aircraft heading toward a wooden hut approximately 150 m from the runway edge. He considered that if he closed the throttle, the aircraft might not stop before the hut, but he thought he had enough speed to lift off, climb and turn left to avoid the obstruction. The video showed the aircraft continue along the ground towards the hut in a tail-low attitude before lifting off briefly. It then stalled, struck the ground and collided with the hut and some ground equipment.

Both those on board were flung forward in their harnesses and sustained minor leg and facial injuries. The pilot switched off the engine ignition and turned off the fuel supply. Both occupants were assisted from the aircraft by ground personnel.

Tiger Moth takeoff characteristics

Tiger Moth aircraft do not accelerate as quickly as normal during takeoffs with a tail-low attitude. However, the positive angle of the wing to the oncoming air can cause the aircraft to lift off before it reaches proper flying speed. In these circumstances, the tail-low, high-drag attitude of the aircraft prevents it from accelerating or climbing, and it either continues to 'fly' level in ground effect[1] or stalls if the pilot tries to climb.

Analysis

The aircraft took off with a crosswind from the left. Due to the high keel area and somewhat limited control authority the aircraft is quite restricted in terms of crosswind capability. The pilot recalled deflecting the ailerons into wind for the crosswind takeoff. The tendency of this aircraft type is to yaw right with full power applied because of propeller slipstream effects. In this case, the yaw began before the aircraft was airborne indicating that it was still at relatively low speed and perhaps explaining why the rudder did not control the yaw initially.

A few seconds after the right yaw commenced the aircraft direction stabilised but with the aircraft tracking away from the runway towards a hut on the airfield perimeter. The aircraft has no wheel brakes and the pilot was concerned that should he close the throttle the deceleration would have been insufficient to avoid striking the hut. He therefore maintained full power to continue the takeoff, although it is likely that the tail-low attitude and bumpy surface impeded the aircraft's acceleration. The aircraft left the ground briefly before stalling, descending and striking the hut and adjacent ground equipment.

Conclusion

The aircraft veered right from its takeoff roll and exited the runway. The pilot maintained full throttle to try and continue the takeoff to avoid a hut on the airfield perimeter. Although the aircraft became airborne briefly, it stalled and collided with the hut.

Footnote

1 Ground effect: increased wing lift when flying in close proximity to the ground.

ACCIDENT

Aircraft Type and Registration:	Extra 330SC, OO-SDJ
No & Type of Engines:	1 Lycoming AEIO 580 B1A piston engine
Year of Manufacture:	2009 (Serial no: N/K)
Date & Time (UTC):	23 July 2019 at 1125 hrs
Location:	Wickenby Aerodrome, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Fabric detached from rear fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	906 hours (of which 250 were on type) Last 90 days - 25 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During an aerobatic flight the pilot felt an unusual vibration through the left rudder pedal. He aborted the flight and, after landing, found that the fabric covering the rear fuselage had torn disrupting the airflow around the rudder. The cause for the fabric failure could not be identified.

History of the flight

The pilot was performing an aerobatic flight overhead of Wickenby Aerodrome, Lincolnshire. Approximately ten minutes into the flight, whilst performing a vertical climb manoeuvre, he felt a significant vibration in the left rudder pedal. He immediately aborted the manoeuvre and bought the aircraft into level flight. He reduced the speed and monitored the level of vibration, which did not significantly diminish. He therefore decided to land the aircraft. After landing the pilot found that the fabric that covered the rear fuselage had ripped and that the loose fabric had been flapping in the airflow around the left side of the fuselage, inducing the rudder vibration (Figure 1).

The pilot had completed normal pre-flight inspections and did not identify any damage to the fabric prior to the flight.

Figure 1

Rear fuselage of OO-SDJ showing extent

The Ceconite 102 fabric was removed from the aircraft and sent to the AAIB for further examination. This identified that the failure was likely to have initiated at the front of the fabric panel adjacent to the right lower stringer which runs along the tubular steel spaceframe rear fuselage. Initially a lateral and axial tear is likely to have occurred, which would have progressed rearward along the stringer (Figure 2), until it met the skin surrounding the tail cone. The cause for the initial material failure could not be positively identified.

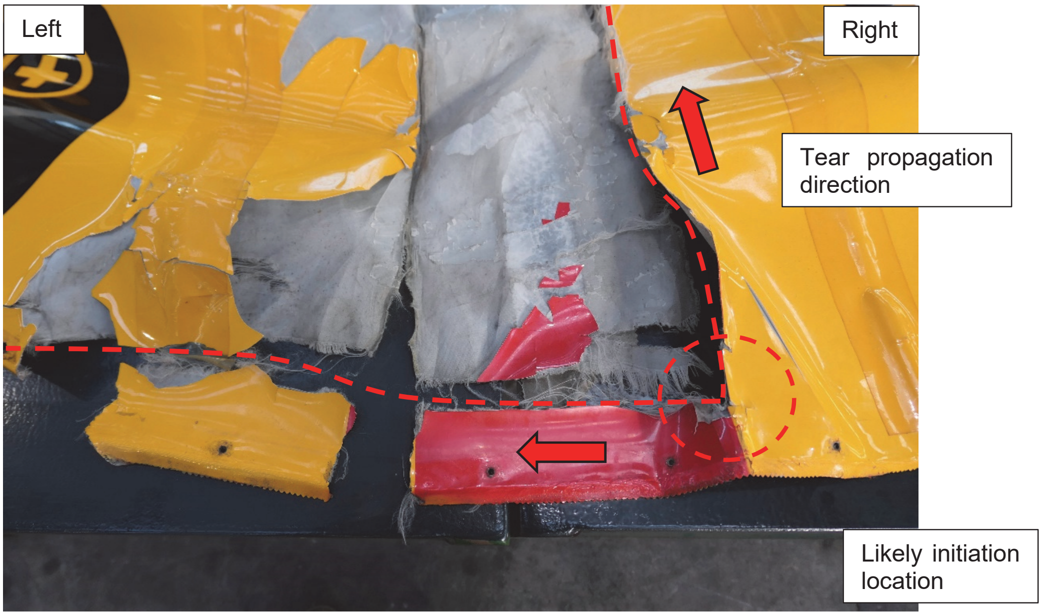

Figure 2

OO-SDJ removed fabric.
Note: fabric laid flat with forward edge toward the bottom of the image

AAIB comment

In this instance the loose fabric caused sufficient aerodynamic disruption to be felt by the pilot through the rudder pedals. With the loose fabric exposed to the airflow it is likely that further tearing would have occurred, leading to possible entanglement with the control surfaces. The prompt action by the pilot in aborting the flight showed positive and timely decision making in light of an abnormal aircraft characteristic.

ACCIDENT

Aircraft Type and Registration:	DJI Phantom 4 Pro, (UAS Registration n/a)
No & Type of Engines:	4 electric motors
Year of Manufacture:	2018 (Serial no: OAXDDAF0A20120)
Date & Time (UTC):	15 September 2019 at 1845 hrs
Location:	Mangersta Stacks, Isle of Lewis
Type of Flight:	Aerial Work
Persons on Board:	Crew - N/A Passengers - N/A
Injuries:	Crew - N/A Passengers - N/A
Nature of Damage:	Lost at sea
Commander's Licence:	Other
Commander's Age:	38 years
Commander's Flying Experience:	67 hours (of which 67 were on type) Last 90 days - 31 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The UAS was flown at Mangersta Sea Stacks[1], Isle of Lewis in order to capture cinematic shots for a television series. The electronic flight log showed that the UAS was travelling at 6.5 mph at the last recorded data point. Whilst the UAS was being flown near to the Sea Stack, it either drifted or was flown too close to the feature before it struck the Sea Stack and then fell into the sea below it.

The UAS pilot stated that the accident happened very quickly. He and the observer did not know exactly what had happened, but the last recorded images showed the sea stack coming into view before the image recording ended, with the UAS flying sideways towards it. The flight log did not show any errors and there was no suggestion of a technical failure. The obstacle avoidance system did not detect the stack, give warning of an imminent impact or automatically avoid the stack. Prior to impact, the UAS had been holding its position adequately in the air in wind speeds of up to 8 m/s (15.5 kt). The UAS was not recovered so the cause could not be determined.

Footnote

[1] A sea stack is a geological landform consisting of a steep and often vertical column of rock in the sea near a coast, formed by wave erosion.

AAIB Record-Only Investigations

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

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

The accuracy of the information provided cannot be assured.

Record-only UAS investigations reviewed January 2020

26-Sep-19 **DJI Matrice 210** Hillsborough Football Ground, Sheffield, Yorkshire

Control of the UAS was lost after "aircraft disconnected" and "navigation issue" warnings were displayed. The UAS disappeared from the pilot's view and was not located.

01-Oct-19 **DJI Matrice 210** Shearwater Platform, North Sea

During the flight the pilot received error messages and control of the UAS was lost. The UAS subsequently descended into the sea.

18-Nov-19 **DJI Phantom 4 Pro** Sunderland, Tyne and Wear

Following takeoff and at a low height, the UAS stopped responding to fore and aft commands but was able to be controlled in height. The operator therefore descended the UAS but could not prevent it crashing into a wall 90 ft away.

03-Dec-19 **DJI Phantom 4 Pro+** Cruden Bay, Aberdeenshire

The UAS was being used to survey a church tower and was at a height of 40 m when it stopped responding to the pilot's control inputs or the 'Return Home' button. Eventually the battery level reduced to 0% and the UAS descended onto the roof causing damage to the landing gear and camera. The cause of the control signal loss was not established.

23-Dec-19 **DJI Mavic Enterprise** Birmingham

The UAS was airborne for about one minute and, on takeoff, had only established seven GPS satellites. This was not enough for GPS flight. The pilot could not control the UAS and the decision to cut power to the motors was made.

06-Jan-20 **Yuneec H520** Coney St, York

On take off a compass calibration error displayed. The compass was calibrated and the error displayed again but disappeared, so the UAS was launched. The UAS began moving on automated route but then moved off in the wrong direction, gaining speed and altitude. The UAS was not found.

07-Jan-20 **DJI Matrice** Training Ground (CFA) at Manchester City, Manchester

A parachute pin tag caught a blade during take off. The UAS reached 10 m altitude then descended, colliding with terrain and sustained substantial damage.

Miscellaneous

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

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

BULLETIN CORRECTION

Aircraft Type and Registration: Grob G109B, G-KHEH

Date & Time (UTC): 10 June 2018 at 0959 hrs

Location: Near Raglan, Monmouthshire

Information source: AAIB Field Investigation

AAIB Bulletin No 7/2019, page 32, line 15 refers

The information in the paragraph detailing the Standardised European Rules of the Air rule 5005(f) provided by the CAA has been revised and additional text has been inserted following the original boxed quote. The section now reads:

> *'Except when necessary for take-off and landing, or except by permission from the competent authority, a VFR flight may not be flown:*
>
> *(2) […] at a height less than 150m (500ft) above the ground or water, or 150m (500ft) above the highest obstacle within a radius of 150m (500ft) of the aircraft.'*

The relevant element of CAA ORS-4 No.1174 states that:

> *The Civil Aviation Authority permits, under SERA.3105, SERA.5005(f) and SERA.5015(b), an aircraft to fly below the heights specified in SERA.5005(f) and SERA.5015(b) if it is flying in accordance with normal aviation practice and:*
>
> *(b) practising approaches to forced landings other than at an aerodrome if it is not flown closer than 150 metres (500 feet) to any person, vessel, vehicle or structure.*

The online version of the report was amended on 13 February 2020.

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

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

Published June 2014.

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

Published September 2014.

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

Published July 2015.

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

Published August 2015.

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

Published October 2015.

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

Published March 2016.

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

Published September 2016.

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

Published March 2017.

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

Published March 2018.

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

Published November 2018.

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

http://www.aaib.gov.uk

GLOSSARY OF ABBREVIATIONS

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

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