AAIB
Air Accidents Investigation Branch

AAIB Bulletin 5/2024

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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.

Serious Incident

Aircraft Type and Registration:	Beech 400A, N709EL	
No & Type of Engines:	2 Pratt & Whitney Canada JT15D turbofan engines	
Year of Manufacture:	1992 (Serial no: RK-52)	
Date & Time (UTC):	7 October 2022 at 1100 hrs	
Location:	Newquay Airport, Cornwall	
Type of Flight:	Private	
Persons on Board:	Crew – 2	Passengers – 1
Injuries:	Crew – None	Passengers – None
Nature of Damage:	Damage to mainwheel tyres	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	40 years	
Commander's Flying Experience:	5,263 hours (of which 2,692 were on type) Last 90 days – 150 hours (of which 30 on type) Last 28 days – 47 hours (of which 4 on type)	
Information Source:	AAIB Field Investigation	

Synopsis

Immediately after touchdown the flight crew noticed the deceleration was greater than normal. Reverse thrust and speed brakes were applied, and as the aircraft slowed below about 50 kt the aircraft started to drift towards the right side of the runway. A combination of weathercocking into the wind and applying left pedal brought the aircraft back to the runway centreline where it came to rest angled about 45° to the left of the centreline, with the mainwheel tyres deflated and the brakes seized.

The rapid deceleration on touchdown was caused by either the tyres having already deflated due to the fuse plugs having melted, or the brakes being seized, or a combination of both. This was the result of the brakes having been heated during the takeoff run because the parking brake had been left on with partial pressure applied.

The lack of a light or caption to indicate that the parking brake is on, or an aural or visual warning that the parking brake is on when takeoff power is applied, may have contributed to the incident, as may have the lack of a 'release parking brake' item in the 'Before Takeoff' checklist. One Safety Recommendation is made to the aircraft manufacturer regarding the 'Before Takeoff' checklist.

History of the flight

During the takeoff roll from East Midlands Airport the commander reported that the acceleration seemed normal through 80 kt, but then there was a hesitation in acceleration at about 95 kt. He felt there might be extra drag on the nosewheel, but the aircraft rotated and climbed normally after liftoff.

The crew completed the after-takeoff checks and there were no indications of abnormalities. The commander thought the reduced acceleration at about 95 kt might have been caused by possible loss of nosewheel tyre pressure, because the tyre had been replaced prior to flight. Another possibility considered was a gust of wind during takeoff as the wind was 22 kt gusting 33 kt. He discussed these theories with the co-pilot.

Prior to the descent, the commander was scanning the flight deck and noticed that the parking brake handle on the lower left side of the instrument panel was not fully pushed in. He pushed it in, which required some force but no more than he sometimes experienced when disengaging the parking brake on the ground after it has been applied after a landing. He then realised that the reduced acceleration was probably caused by the parking brake remaining on, with partial brake pressure locked in the system, causing the brakes on the main wheels to remain applied during the takeoff. He considered the possibility that the brakes had then become heated during the takeoff roll due to the friction in the brake pack as the wheels attempted to rotate against the brakes. The heat generated may then have caused the thermal relief plugs in the wheel hub to melt and release main wheel tyre pressure.

He did not recall setting the parking brake at the holding point prior to takeoff, but he assumed he probably did. He could not recall if he subsequently pushed the parking brake handle partially in to release or not at all. He reported that a normal amount of break-away thrust was required to leave the holding point and the initial acceleration felt normal, so the brakes could only have been applied with partial brake pressure. The parking brake operates by locking in the pressure applied by the toe brakes, so applying a small amount of toe brake pressure will provide a small amount of parking brake pressure. The commander reported that there was a slight uphill gradient at the holding point and without brake pressure applied idle thrust alone would overcome the gradient and cause the aircraft to move forwards, so he thought it likely that he had only needed to apply a small amount of brake pressure to prevent the aircraft rolling forward.

The flight crew briefed for the possibility of loss of tyre pressure on landing. The landing gear was lowered early to allow for additional cooling of the brakes, although he realised that this would have no effect if the fuse plugs had already melted. The aircraft's Quick Reference Handbook (QRH) did not provide any guidance for this situation. At their destination of Newquay Airport the landing distance available was 8,000 ft which was within the calculated distance required of 3,300 ft, and the weather was suitable. They planned to touch down close to the runway threshold to maximise the runway available.

The ILS approach to Runway 30 at Newquay was normal, and the aircraft touched down close to the runway threshold. The wind at the time of the landing was from 240° at 21 kt. Immediately, the commander noticed the deceleration was greater than normal. Reverse thrust and speed brakes were applied, and as the aircraft slowed below about 50 kt the aircraft started to drift towards the right (downwind) side of the runway. A combination of weathercocking into the wind and applying left pedal brought the aircraft back to the runway centreline where it came to rest angled about 45° left of the centreline.

The flight crew shut down the engines and advised ATC they were evacuating on the runway. The crew and passenger then exited via the cabin door. The mainwheel tyres were found fully deflated and there was smoke emanating from them, but there was no fire. The airport fire service was on the scene shortly thereafter.

Recorded information

The aircraft was fitted with a Cockpit Voice Recorder (CVR) which was downloaded at the AAIB. The audio quality of the two flight crew channels was poor, rendering most of the speech unintelligible. Tests on the CVR did not reveal any faults so it indicated an issue with the aircraft's system. The operator re-installed the CVR and carried out the normal maintenance procedure checks which did not reveal any issues. However, the maintenance procedure does not require listening to a sample recording. The AAIB suggested this to the operator, but the aircraft was in the process of being sold so this was left to the new owners.

Aircraft information

The Beech 400A (later models were renamed the Hawker 400) is a light business jet with an MTOW of 7,303 kg (Figure 1). It has capacity for seven to nine passengers.

Figure 1

Incident aircraft Beech 400A after it came to rest off the runway centreline

The parking brake handle is located on the lower left side of the instrument panel (Figure 2). The parking brake is set by pulling the handle fully out and depressing the toe brakes. The hydraulic brake pressure applied by the toe brakes is then locked in the system when the toe brakes are released. Accordingly, the pressure applied when the parking brake is set is not a fixed value but varies depending on the instantaneous pressure applied at the toe brakes when the parking brake handle is pulled. Pilots can therefore set an intermediate (partial) pressure between zero and the maximum achievable brake pressure. The parking brake is released by pushing the handle in, which releases the brake pressure.

Figure 2

Parking brake handle location

The Pilot's Operating Manual[1] states that the parking brake is set by pulling out the handle and 'depressing the toe brakes two or three times'. It also states that: 'The parking brake should not be set if the brakes are very hot. This increases brake cool-down time due to decreased airflow. This may result in sufficient heat transfer from the brakes to cause the parking brake hydraulic pressure to rise excessively, or to melt the thermal relief plugs in the wheel.' The aircraft manufacturer clarified that the above description is applicable when the engines are not running, and the hydraulics are depowered. When the engines are running and the hydraulics are powered, pulling the parking brake handle out with toe brakes depressed will be sufficient. There is no guidance in the Pilot's Operating Manual on how hard the toe brakes should be pressed or what the brake pressure level should be. There is no indication of applied brake pressure in the flight deck.

Footnote

[1] Beechjet 400A Pilot's Operating Manual P/N 128-590001-149A14. Revised 4 September 2002.

There is no light or caption in the flight deck to warn the flight crew that the parking brake is applied, and there is no aural or visual warning if the pilot applies takeoff power when the parking brake is applied. There is, however, a pitch trim aural warning system which sounds when takeoff power is applied and the pitch trim is not set in the takeoff trim zone.

Aircraft examination

Both mainwheel tyres were intact but had partially separated from their wheel rims (Figure 3). The fuse plugs on both mainwheels were found to have melted, and both brake units had seized.

Figure 3

Left and right mainwheel tyres after the incident landing

The operator's maintenance organisation examined the parking brake system and did not find any faults. It then carried out tests to determine at what parking brake handle position the brake pressure was released. When the handle was pushed fully in, there was 7 mm of metal shaft exposed, and when it was pulled fully out there was 77 mm of shaft exposed (Figure 4). When the handle was slowly pushed inwards from the fully out position the parking brake remained on until it reached a position where 28 mm of shaft was exposed, at which point pressure started to release (Figure 5). The total travel of the handle from 'out' to 'in' was 70 mm, but the travel from brakes ON to OFF was only 21 mm. The first 49 mm of inwards travel did not change the brake pressure.

Figure 4

Parking brake handle on N709EL: left image, fully in (OFF); centre image, 28 mm out (ON); right image, fully out (ON)

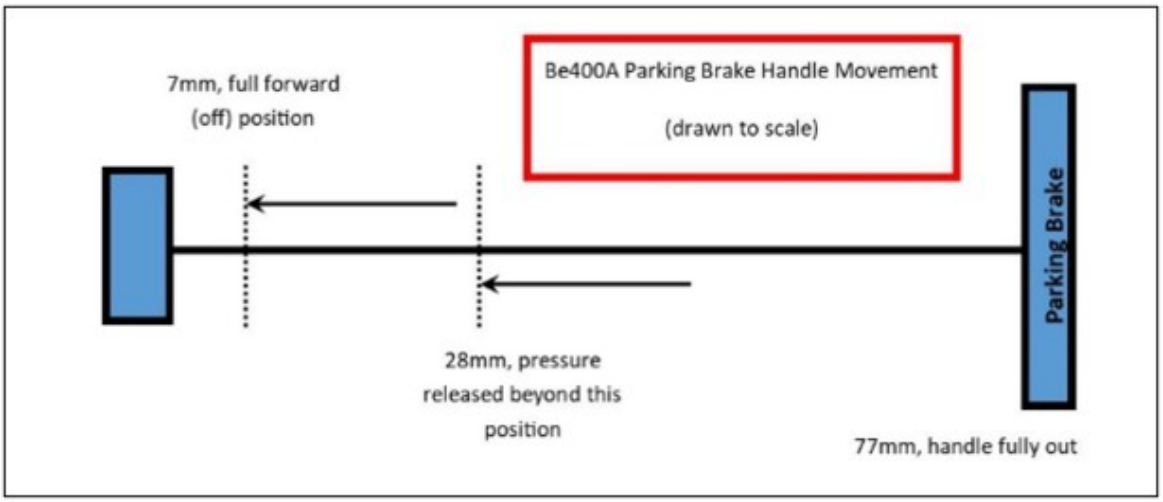

Figure 5

Measurements of parking brake handle position

Aircraft manufacturer information

The aircraft manufacturer stated that the parking brake rigging instructions do not specify a mid-position of the handle at which the parking brake valve should actuate. The parking brake handle only has two lock positions: 'in' and 'out'. If the parking brake is ON when the handle is fully out, and OFF when the handle is fully in, the system is rigged correctly.

The aircraft manufacturer was not aware of any incidents similar to this one on the Beech 400.

Checklist

The aircraft checklist in the Approved Airplane Flight Manual[2] states 'Parking Brake…SET' at the beginning of the 'Starting Engines' checklist, and then there is no further reference to the parking brake in any subsequent checklist until the 'Shutdown' checklist. The 'Taxi' checklist includes 'Wheel Brakes check' which is a check carried out by pressing the toe brakes. The 'Before Takeoff' checklist, which would normally be carried out before entering the runway, does not include any reference to brakes. The 'Takeoff' checklist, which is normally done by memory once lined up on the runway, states:

'1. Thrust…….APPROXIMATELY 90% N_1

2. Engine Instruments……CHECK

3. Wheel Brakes……..RELEASE'

The commander was using a checklist published by an international training organisation that was based on the Approved Airplane Flight Manual checklist. The 'Before Takeoff' checklist was the same in that it did not contain any reference to brakes. The 'Takeoff' checklist was not included in this checklist as it was intended to be carried out by memory.

Commander's comments

The commander stated that he could not recall setting the parking brake at the holding point but that it is possible he did. There was a delay to the departure clearance which involved some negotiation as the clearance was not as filed; this resulted in an extended period at the holding point. There was a slight uphill gradient at the holding point and it is likely that he only needed to apply a small amount of brake pressure to prevent the aircraft from rolling forwards under idle power. He reported that historic fleet problems with releasing the parking brake, after it has been applied to hot brakes, had conditioned him to only apply sufficient brake pressure required for the situation when manoeuvring on the ground and applying the parking brake. He stated that even when the brakes were not hot, he had experiences in the past where considerable force was required to release the parking brake at the holding point. By applying only sufficient brake pressure helped him to avoid this issue. He had never considered that the aircraft could be taxied onto the runway and accelerate seemingly normally with the parking brake applied. The suggestion of applying higher than necessary brake pressure had never been highlighted during his training nor had the thought crossed his mind prior to the incident. He stated that full parking brake pressure was not defined, unlike on some types, and there was no minimum or threshold of brake pressure which must be applied before the parking brake can be selected ON. And since there was no parking brake ON caption, there was no indication of when full parking brake pressure was achieved. He considered that the only objective measure of parking brake pressure was whether it was sufficient or not for the conditions.

Footnote

[2] Beechcraft Beechjet 400A FAA Approved Airplane Flight Manual (RK-24 thru RK-92). P/N 128-590001-109 (last amended 3 November 2006).

He also stated that it did not help that there was no item for 'Parking brake…..Release' in the 'Before Takeoff' checklist, and he considered a possible contributing factor was his lack of recency on type which may have reduced his ability to perceive reduced acceleration.

Operator comments

The operator was asked if they had considered adding a 'release parking brake' item to their 'Before Takeoff' checklist. They stated that they had considered this but after reviewing checklists of other aircraft types they decided it was unnecessary. They stated that checklists for other similar types and light business jets do not have a 'release parking brake' item in the 'Before Takeoff' checklist and that it is down to airmanship to remember to select it off if it is used, because the parking brake will not always be used. They stated that an event like this had never previously happened in their operation.

It is possible that there have been unreported cases of aircraft lining up and commencing takeoff with the parking brake applied, which has been noticed and corrected at the last minute, but not been reported.

Certification requirements

The Beech 400A was certified to US Federal Aviation Regulations 14 CFR Part 25 Airworthiness Standards: transport category airplanes effective 1 February 1965 with some amendments, with the most recent amendment dated 18 June 1990. 14 CFR Part 25 section 25.735 on 'Brakes' stated:

> *'d) The airplane must have a parking control that, when set by the pilot, will without further attention, prevent the airplane from rolling on a paved, level runway with takeoff power on the critical engine.'*

There was no requirement for the parking brake to hold the aircraft when takeoff power was applied to all engines, and there was no requirement for a parking brake light or for a warning system when takeoff power is applied while the parking brake is set.

On 24 May 2002, section 25.735 was amended (Amendment 25-107) to include the following requirement[3] for new aircraft certified after that date:

> *'There must be an indication in the cockpit when the parking brake is not fully released.'*

There is still no requirement for the parking brake to hold the aircraft with all engines at takeoff power, and there is no requirement for a warning system when takeoff power is applied while the parking brake is set. However, many large jet airliners have such a warning system installed.

Footnote

[3] Amendment No 25-107 on 26 December 2002 is also the most recent amendment – the section on the parking brake is the same in EASA CS 25.735.

Previous incidents of takeoffs with the parking brake on

The AAIB published a report in October 2003[4] about a Cessna Citation 560 Ultra business jet (registration VP-CSN) that had departed with the parking brake partially applied, which then suffered a similar rapid deceleration and tyre deflation during landing to that of N709EL. Various distractions had led to the parking brake being left on, and there was no light or caption to indicate the parking brake was on. There was also no aural or visual warning that the parking brake was on when takeoff power was applied, and there was no 'parking brake off' check in the pre-takeoff checklist.

The AAIB published a report in March 2011[5] about a Cessna Citation CJ+ business jet (registration N646VP) that carried out a rejected takeoff and overran the end of the runway. It was suspected that the parking brake was at least partially on during the takeoff run. The report states that the aircraft manufacturer was considering fitting a 'parking brake applied' warning on future models of the Citation.

The US National Transportation Safety Board (NTSB) published a report on a fatal accident to a Cessna Citation 560 (registration N560AR) that occurred on 2 September 2021. The report[6] states that during takeoff the aircraft hit a pole at the end of the runway; the aircraft then struck the ground and a building destroying the aircraft and fatally injuring all occupants. The parking brake was found in the ON position, and the flight data showed that the aircraft did not lift off when the pilot pulled the yoke aft at the rotation speed. Analysis revealed that the action of the parking brake caused a nosedown pitching moment that countered the attempts of the pilot to rotate the aircraft nose-up. The report refers to other previous events involving Cessna 550 and 560 aircraft which tried to take off with the parking brake applied and which resulted in runway overruns.

The NTSB made three safety recommendations[7] to the FAA to require:

> (1) in-service Cessna 560XL aircraft to be modified with a parking brake indication as per Amendment 25-107 of 25.735 (recommendation A-22-8);
>
> (2) require newly manufactured Cessna 560XL and derivative models to have a parking brake indication as per Amendment 25-107 of 25.735 (recommendation A-22-9); and
>
> (3) require the aircraft manufacturer to add a 'release parking brake' item to the pre-takeoff checklist of the Cessna 560XL (recommendation A-22-10).

Footnote

4 AAIB Bulletin 10/2003. Incident to Cessna Citation 560 Ultra, VP-CSN, on 23 April 2003 at Edinburgh Airport. https://assets.publishing.service.gov.uk/media/54230496ed915d1371000cbb/dft_avsafety_pdf_024592.pdf [accessed 20 October 2023].

5 AAIB Bulletin 3/2011. Accident to Cessna Citation CJ+, N646VP, on 7 June 2010 at Leeds Bradford Airport. https://assets.publishing.service.gov.uk/media/5422f5b6e5274a131400055f/Cessna_Citation_CJ1___N646VP_03-11.pdf [accessed 20 October 2023].

6 National Transportation Safety Board (NTSB) Report ERA21FA346 on Cessna 560 registration N560AR https://data.ntsb.gov/carol-repgen/api/Aviation/ReportMain/GenerateNewestReport/103791/pdf [accessed 20 October 2023].

7 National Transportation Safety Board (NTSB) AIR-22-06 report, published 4 May 2022. Require Safeguards to Prevent Cessna 560XL Takeoff with Parking Brake Engaged, https://www.ntsb.gov/investigations/AccidentReports/Reports/AIR2206.pdf [accessed 20 October 2023].

The FAA responded that they conducted a risk assessment on the absence of a parking brake indication on the in-service Cessna 560XL fleet and determined that the concern did not constitute an unsafe condition requiring airworthiness directive action.

The FAA stated that, with regards to recommendation A-22-9, the aircraft manufacturer has agreed to voluntarily update future derivative Cessna 560XL airplane models to include an indication for the parking brake.

The FAA stated that, with regards to recommendation A-22-10, the aircraft manufacturer has proposed to voluntarily update all airplane flight manuals and pilot checklists for the Cessna 560XL with text about releasing the parking brake prior to takeoff.

Analysis

The pilots experienced a rapid deceleration immediately after touching down at Newquay Airport which could have been caused by either the tyres having already deflated due to the fuse plugs having melted, or the brakes being seized, or a combination of both. During the cruise the commander had found the parking brake handle was not fully pushed in and had noticed a reduced acceleration late during the takeoff, which meant it was highly likely that there was partial parking brake pressure applied during the takeoff which would have heated the brakes. This heat alone could have melted the fuse plugs, but the flight manual states that hot brakes can increase the parking brake pressure by heating the hydraulic fluid, which increases the brake heat and can then cause the fuse plugs to melt.

From past experience the commander would only apply sufficient toe brake pressure when setting the parking brake. He did this to prevent the brakes from seizing which was a known issue when the brakes were hot, but he had also experienced difficulty releasing the brakes when they were not hot and higher pressure had been applied. On this occasion a slight uphill gradient at the holding point helped to partially counter forward movement due to residual idle thrust, so it is likely that the commander only applied sufficient (partial) toe brake pressure when setting the parking brake at the holding point prior to takeoff, whilst the crew addressed issues with their clearance. It is possible the commander set the parking brake subconsciously which, combined with the distraction of negotiating the clearance with ATC, resulted in him not releasing the parking brake before taxiing onto the runway. If the commander had applied higher toe brake pressure when setting the parking brake, then he would have probably noticed a higher breakaway thrust being required and he would have probably noticed a more significant reduction in acceleration at the start of the takeoff roll. However, it may also be possible to take off with full brake pressure applied as there is no certification requirement for the parking brake to hold the aircraft with all engines at takeoff power.

The aircraft type was not fitted with any light or caption to indicate when the parking brake is applied, and it did not have an aural of visual warning to alert the pilot that the parking brake is on when full power is applied. Either of these features could have helped prevent a takeoff with the parking brake applied.

The parking brake handle is located just to the left of the commander's left leg and so it is unlikely that the co-pilot, in the right seat, will detect if it has been left in the ON position. The travel from ON to OFF was only 21 mm, on this aircraft, so there was only a small visual difference between a handle that has only been partially pushed in and one that is fully in. There was also no 'release parking brake' item on the 'Before Takeoff' checklist, which could have served as a reminder to help prevent taking off with the parking brake applied.

There have been previous accidents involving pilots forgetting to release the parking brake and then not noticing the reduction in acceleration during the takeoff run. These have occurred on other aircraft types that also did not have a visual caption to indicate the parking brake was applied and did not have a 'release parking brake' item in the 'Before Takeoff' checklist.

The solution most likely to help prevent recurrence would be for the aircraft fleet to be modified with at least a parking brake indication as per Amendment 25-107 of 14 CFR Part 25 Section 25.735. However, the FAA has already determined that the situation does not constitute an unsafe condition requiring airworthiness directive action for the Cessna 560XL fleet, so it is unlikely to have a different view for the Beech 400A fleet.

The Beech 400A is no longer manufactured so there is no scope for requiring a modification for future-built aircraft.

Adding an item to the checklist to remind flight crews to release the parking brake prior to takeoff is a less effective solution than a modification; however, checklists are used because they help flight crew to remember important actions. A checklist prompt to release the parking brake could help to prevent a future accident; therefore, the AAIB makes the following Safety Recommendation:

Safety Recommendation 2024-007

It is recommended that Textron Aviation Inc. amend the checklists for the Beech 400 series of aircraft to include a 'release parking brake' item in the 'Before Takeoff' checklist.

Conclusion

The rapid deceleration and mainwheel tyre deflation after touchdown was caused by either the tyres having already deflated due to the fuse plugs having melted, or the brakes being seized, or a combination of both. This was the result of the brakes having been heated during the takeoff run because the parking brake had been left on. It is likely that the commander applied the parking brake while holding short of the runway, with only sufficient (partial) brake pressure applied, and then, after addressing a departure clearance issue, either did not push the handle in or did not push it fully in prior to taxiing onto the runway.

The lack of a light or caption to indicate that the parking brake is ON, or an aural or visual warning that the parking brake is ON when takeoff power is applied, may have contributed to the incident, as may have the lack of a 'release parking brake' item in the 'Before Takeoff' checklist.

Published: 4 April 2024.

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:	ATR 72-212 A, G-CMMT
No & Type of Engines:	2 Pratt & Whitney Canada PW127M turboprop engines
Year of Manufacture:	2013 (Serial no: 1109)
Date & Time (UTC):	30 December 2023 at 0930 hrs
Location:	Belfast City Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew – 4 Passengers – 53
Injuries:	Crew – None Passengers – None
Nature of Damage:	Nose landing gear and left main landing gear subject to loads exceeding the design limits
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	5,300 hours (of which 4,700 were on type) Last 90 days – 150 hours Last 28 days – 45 hours
Information Source:	Aircraft Accident Report Form submitted by the commander and further enquiries by the AAIB

Synopsis

The left main landing gear and nose landing gear contacted the runway heavily during a second approach to Belfast City Airport in gusty wind conditions. The commander elected to go-around and diverted to Belfast Aldergrove Airport, where the aircraft landed uneventfully. The left main landing gear and the nose landing gear required replacement because of excessive loads and visible damage.

The AAIB considers that the event arose from a normal operating hazard that is listed in the UK Aeronautical Information Publication[1].

History of the flight

The aircraft was operating a scheduled flight from Edinburgh Airport to Belfast City Airport. The weather was reported to be gusty and the flight crew were familiar with the challenges of operating at Belfast City Airport with winds over 15 kt blowing from a south-easterly direction (100°-160°). The commander flew the approaches to Runway 22. The approaches met the stable criteria at 1,000 ft aal. The first approach was discontinued due to destabilising wind effects approaching Decision Height. Conditions for the second attempt were more

Footnote

[1] UK Aeronautical Information Publication available at eAIS Package United Kingdom (nats.co.uk) [accessed 12 February 2024].

benign and the approach was reportedly uneventful until the aircraft was flared for landing. During the flare, wind effects destabilised G-CMMT resulting in it touching down firmly on the left main landing gear and then bounced before touching down heavily a second time, nose landing gear first. The commander initiated a go-around and the aircraft subsequently diverted to Belfast Aldergrove Airport for an uneventful landing.

Airfield information

Belfast City Airport's listing in the UK Aeronautical Information Publication (AIP) contains the following warning to pilots.

> *'EGAC AD2.20 Local Aerodrome Regulations, Paragraph 4 Warnings…*
>
> *b. Pilots should anticipate windshear on approach to Runway 22 and departure from Runway 04 when the surface wind direction is between 100° and 160° + 15 KTS. Due to strong wind conditions, turbulence may be expected on approach or climb out to/from either runway…'*

Recorded data

The AAIB reviewed the flight data and CVR.

Both approaches into Belfast City Airport were stabilised at 1,000 ft and crew cooperation appeared to be working well. For the second approach, the last wind report from ATC was 140/22, which was inside the 28 kt recommended maximum crosswind value for the reported runway conditions. The automatic altitude callouts progressed as expected down to 20 ft, but shortly after, it became apparent that the touchdown was not as expected and the commander initiated a go-around.

Below 500 ft QNH on the approach the recorded CAS had been generally fluctuating in the range +10/-9 kt of the pilots' target V_{APP} of 120 kt. As the aircraft descended through approximately 70 ft QNH the speed briefly became more unstable, averaging approximately 134 kt over an eight second period as the aircraft approached the flare. In the final two seconds before the first touchdown the recorded CAS values were 124 and 130 kt.

Aircraft damage

The operator reported that the nosewheel tyres were damaged and when the wheels were removed, the left nosewheel axle was slightly bent.

The flight data showed an acceleration of approximately 2.2 g in the normal axis when the aircraft contacted the runway before the go-around. The aircraft manufacturer assessed that the left main landing gear and the nose landing gear had both experienced loads beyond their allowable limits and required replacement before the aircraft could be returned into service.

Conclusion

The landing gear sustained damage during a heavy touch down after the aircraft became destabilised, due to wind effects experienced during the flare, immediately before touchdown.

Accident

Aircraft Type and Registration:	AW139, 5N-BOX
No & Type of Engines:	2 Pratt & Whitney Canada PT6C-67C turboshaft engines
Year of Manufacture:	2012 (Serial no: 31386)
Date & Time (UTC):	13 November 2023 at 0958 hrs
Location:	Norwich Airport
Type of Flight:	Commercial Air Transport (Non-Revenue)
Persons on Board:	Crew – 2 Passengers – None
Injuries:	Crew – None Passengers – N/A
Nature of Damage:	Damage to main rotor blade tips
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	2,600 hours (of which 2,100 were on type) Last 90 days – 200 hours Last 28 days – 80 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The helicopter was ground taxiing to the parking area on return from an air test flight. As the commander manoeuvred the helicopter to align with other helicopters on adjacent parking spots the main rotor blades struck a lamp post on the airport perimeter. All five main rotor blades were damaged. The helicopter was shut down and no personnel were injured. The handling agent took safety action to require the use of marshallers for crew unfamiliar with or visiting the airport and to replace the stand markings in early 2024.

History of the flight

The helicopter, an AW139, had concluded a post maintenance test flight and was returning to its parking position at Norwich Airport (Figure 1). Neither of the pilots were based at Norwich so their familiarity with the airport was limited.

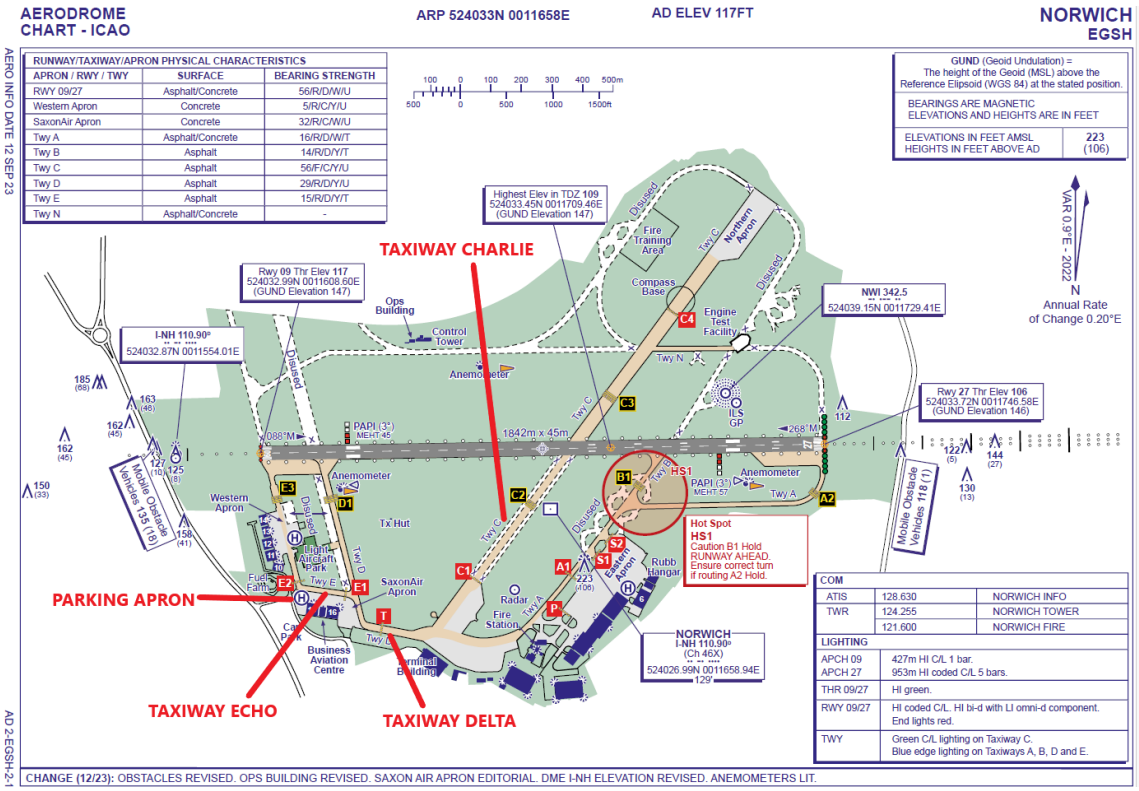

Figure 1

Norwich Airport chart

The helicopter made an approach to Runway 27 and vacated at the intersection with Taxiway Charlie (Figure 1). The helicopter was manoeuvred south down Taxiway Charlie and then turned right to continue via Taxiways Delta and Echo to the parking apron (Figure 1).

The only unoccupied parking stand on the apron was Stand 12 which is the closest stand to the airfield perimeter (Figure 2). Stand 11 is disused. As the helicopter ground taxied toward Stand 12 the commander was PF. He stated that he followed the yellow line off Taxiway Echo into the parking stand and then followed the outer yellow circular line (Figure 3) to the right to allow him to turn left and park facing to the east, in the same direction as the helicopter on the adjacent Stand 13.

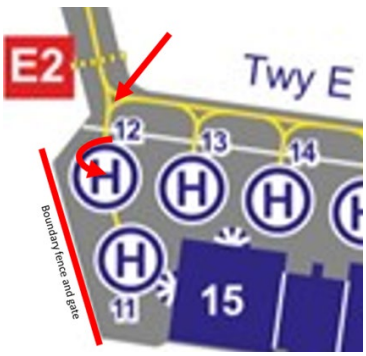

Figure 2

Parking stand positions

The commander believed that following the outer line would give the helicopter clearance from obstacles. However, as the helicopter turned left toward the centre of Stand 12 the main rotor blades struck a lamp post that was located on the street just outside the airfield perimeter. The path followed by the helicopter is illustrated in a sketch provided by the commander (Figure 3).

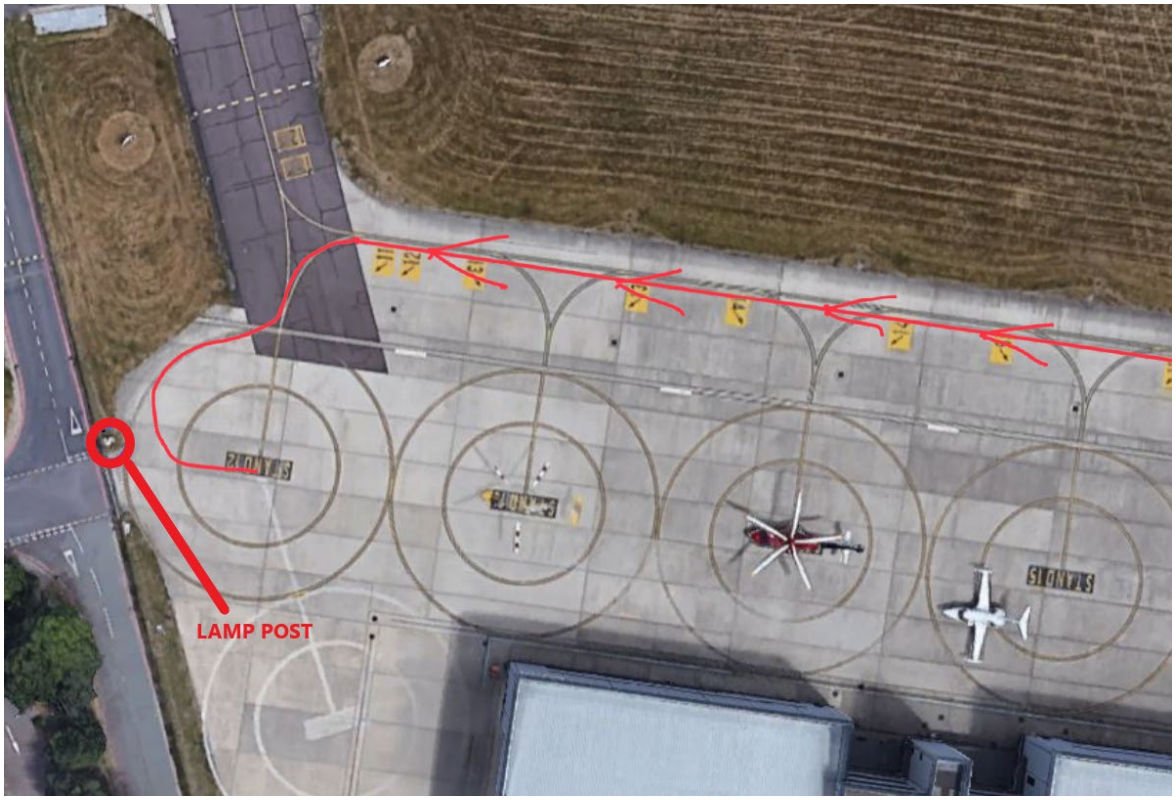

Figure 3

Sketch of taxi path provided by commander

After the blade strike, the commander turned further left to move the helicopter away from the obstacle. The helicopter was then shut down on Stand 12. All five main rotor blades were damaged and there was impact damage on the lamp stanchion. Some small pieces of debris were scattered all around the vicinity of Stand 12. No personnel were injured.

Meteorology

The weather report for Norwich published at 0950 hrs indicated a wind from 180° at 12 kt with the direction varying between 140° and 230°.

Parking Stand Markings

The standards for helicopter parking stand markings are contained in Annex 14 to the Chicago Convention. An extract showing standard marking layouts is at Figure 4.

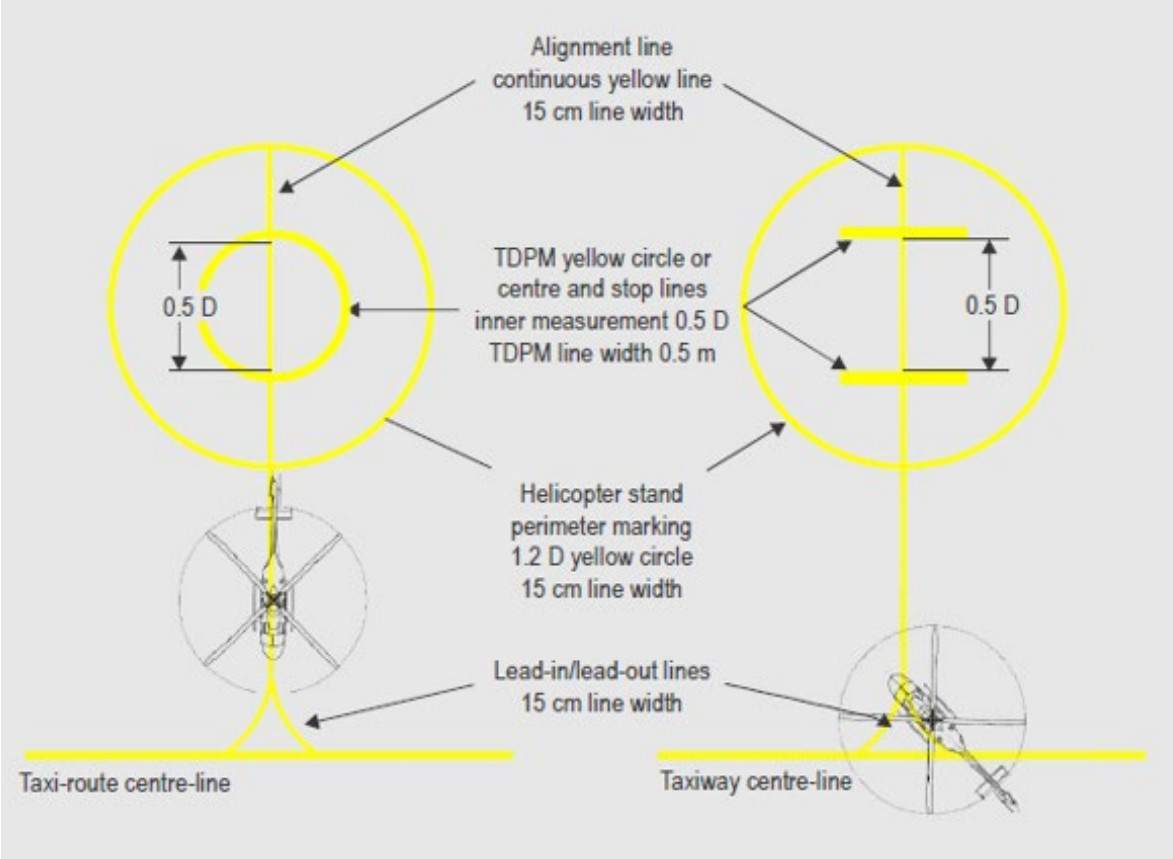

Figure 4
Annex 14 stand markings

The markings at Norwich conform with the left design, using a circular Touch Down Position Marking (TDPM). The D in the diagram is a variable dimension for the size of the markings, where D is the diameter of the rotor and delineates the largest helicopter which could use the stand. The Norwich stands were sized for AW139 helicopters.

A photograph supplied by the handling agent (Figure 5) shows that the surface markings at Norwich were somewhat faded. The red arrow indicates the helicopter direction of travel round the outer circle of the stand.

Figure 5

Norwich stand markings. The commander stated that he was familiar with the markings for a stand as described in Annex 14

Analysis

The helicopter was returning to the parking stand at Norwich following an uneventful post maintenance test flight. After clearing the runway, the commander was ground taxiing the helicopter to park on Stand 12 at Norwich. Along Taxiway E, the commander correctly followed the yellow centreline marking. As the helicopter approached Stand 12 the commander initially followed the lead-in line from the taxiway centreline toward Stand 12. However, as he entered the stand he turned right and followed the yellow perimeter line of the stand, believing that would give him clearance from obstacles. The commander's intention in making the right turn along the perimeter line was to create sufficient room for a left turn to park on the TDPM with the helicopter facing east. The helicopter on the adjacent Stand 13 was parked facing east and the commander was distracted by this to do the same. The prevailing wind was from the south so following the lead-in line directly to the TDPM would have left the helicopter on an into-wind heading for shutdown.

Room for the manoeuvre was constrained so the commander was endeavouring to give himself maximum room for the turn. The lamp post that the main rotor struck was outside the airport perimeter, painted grey and would not have been obvious to the commander, particularly given his focus on positioning the helicopter for the left turn to east.

Despite his knowledge of helicopter parking stand markings, the commander mistook the yellow stand perimeter line for a continuation of the taxiway lead-in line which is also painted yellow. At that juncture he believed that following the perimeter line would give the helicopter clearance from obstacles in the same way as the taxiway centreline is designed to. This would likely have reduced his attention to possible obstacles to the right of the helicopter since he believed they would not be a factor. The poor definition of the ground markings may have contributed to the commander's misinterpretation of the correct taxi path.

As the perimeter line is not intended to give clearance from obstacles and with reduced crew attention to the right the helicopter main rotor blade tips struck the lamp post, damaging all five.

Conclusion

The helicopter main rotor blades struck a lamp post while ground taxiing to park on Stand 12 at Norwich Airport. All five main rotor blades were damaged and small pieces of debris were spread over a considerable area. No personnel were injured. Two safety actions were taken.

Safety action

To reduce the likelihood of a re-occurrence of a similar event with crews that are not Norwich based, the handling agent for the parking apron took the following safety action:

A local procedure was established so that crews not based at Norwich would be directed to their parking positions by an aircraft marshaller.

The stands would be resized for different helicopters in the early part of 2024 and the stand markings would be erased and replaced with new painted surface markings.

Serious Incident

Aircraft Type and Registration:	Boeing 737-4K5, G-JMCZ	
No & Type of Engines:	2 CFM56-3C1 turbofan engines	
Year of Manufacture:	1989 (Serial no: 24126)	
Date & Time (UTC):	18 October 2023 at 0017 hrs	
Location:	Belfast International Airport	
Type of Flight:	Commercial Air Transport (Cargo)	
Persons on Board:	Crew – 2	Passengers – None
Injuries:	Crew – None	Passengers – N/A
Nature of Damage:	Melted R61 contactor	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	40 years	
Commander's Flying Experience:	4,951 hours (of which 2,173 were on type) Last 90 days – 55 hours Last 28 days – 19 hours	
Information Source:	Aircraft Accident Report Form submitted by the commander and further enquiries by the AAIB	

Synopsis

After landing the crew started the APU and transferred the aircraft systems to be powered by the APU generator. When the APU generator was transferred to the right bus, the R61 contactor for the forward galley failed, emitting a noise, a flash and fumes. The crew discharged a fire extinguisher towards the source. The associated circuit breaker (CB) had opened, isolating the R61 contactor.

Assessment of the contactor did not determine the cause of its failure, but it is likely that either loose connectors on the input terminals, or loss of hermitic sealing of the unit caused the event. As the associated CB opened after the failure, it is considered that protection systems operated normally on the aircraft. The use of the fire extinguisher by the crew was an appropriate response based on the information available to them at the time, although the failure was contained without this intervention.

History of the flight

The crew reported for duty at Belfast International Airport at 2030 hrs and operated one sector to East Midlands Airport. The return sector to Belfast was the end of the rostered duty and the airborne flight was uneventful. The commander who was PF, flew a VOR approach to Runway 07 after which the aircraft vacated the runway at A1. ATC instructed the crew to hold at position L1 to allow another aircraft to taxi out of their planned parking position (Figure 1).

The crew performed the after landing checks and started the APU as normal, in preparation for engine shut down. The aircraft was stationary at the L1 position when the APU became available to provide electrical power.

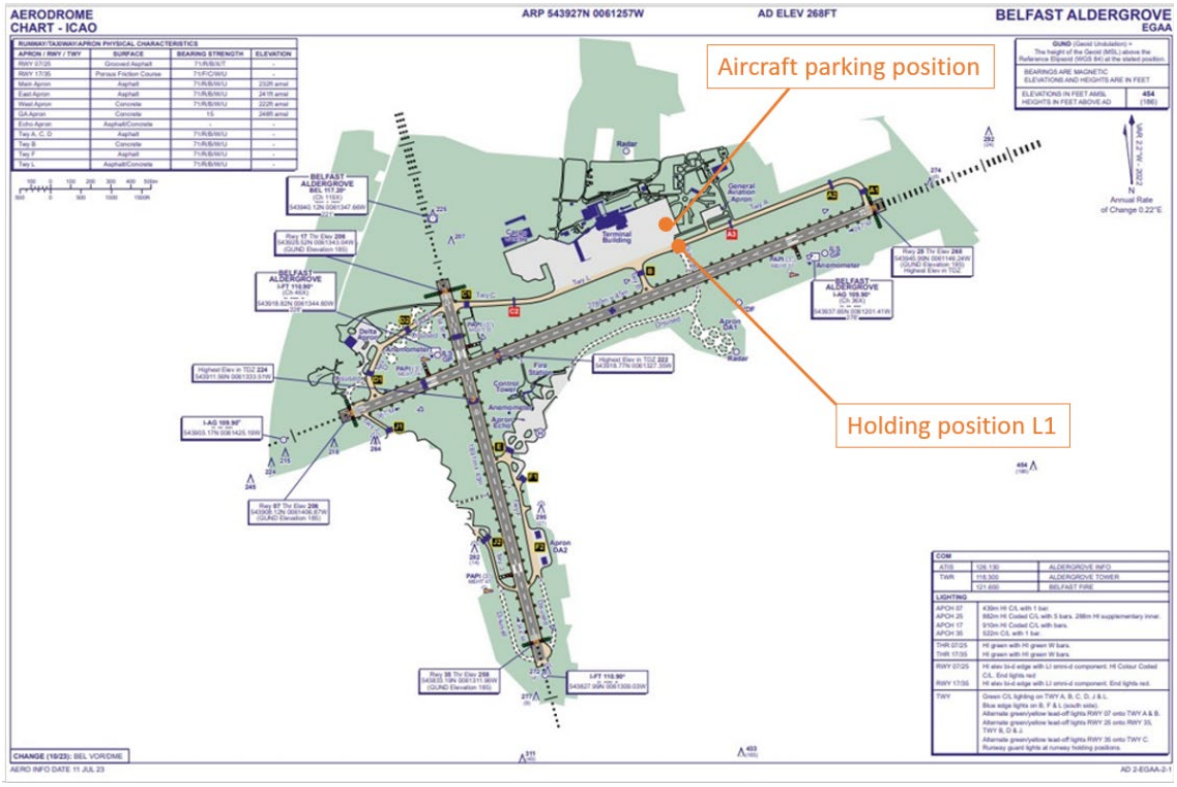

Figure 1

Belfast International Aerodrome Chart

The PM transferred the left bus to the APU generator and when the right side was selected ON there was a loud *'clunk and a flash'*. The crew turned around and saw the CB panel behind the co-pilots seat was glowing orange. They reported a strong smell of burning. The co-pilot recalled that after a closer look, he could see what looked like flames coming from behind the CB panel. The commander transferred the electrical power back to the engines while the co-pilot left his seat, removed the fire extinguisher from its stowage position and discharged it behind the CB panel. The commander spoke to ATC and requested the fire service attended the aircraft.

After the extinguisher was discharged, the co-pilot returned to his seat and the crew agreed there was no longer any evidence of fire or burning. They elected to continue to their parking position which was close by. The fire crew attended the aircraft after it was parked on stand and found no evidence of fire.

Aircraft information

G-JMCZ is a Boeing 737-400 series aircraft converted, under Supplemental Type Certificate, to become a freighter.

When converting the aircraft, the electrical systems remained essentially the same, with the wiring remaining in situ for the devices that had been removed, such as the galleys.

Primary electrical power is supplied by two engine driven generators which provide 115 V AC. In normal operation each generator supplies its own bus system but can supply essential loads of the opposite side bus system if one generator was inoperative. The APU operates a generator which can supply power to either or both AC generator busses on the ground or one AC generator bus in flight. The electrical system is designed such that it is not possible to provide power to a device from multiple sources, known as 'paralleling', and when a source of power is being connected to a generator bus, the system automatically disconnects the existing source.

To provide power to the aircraft systems when on the ground the APU can be started and its generator transferred to power the two generator busses. This unloads the engine generators and allows the aircraft to remain electrically powered when the engines are shut down.

Contactors are used to switch the 115 V AC power and are activated by 28 V DC coils within them. To suppress arcing within the contactor unit the armature housing is hermetically sealed.

Circuit breakers are used to protect and isolate systems when an over current is experienced. When an over current is detected a circuit breaker will open, isolating the affected circuit. If a circuit or system is not required or has malfunctioned and is not in the minimum equipment list, its circuit breaker can be 'pulled and tagged' to manually isolate the system. Tagging the circuit breaker prevents the circuit breaker from being closed and gives a visual indication that a circuit breaker has been intentionally pulled.

Aircraft examination

After the incident, the aircraft was shut down and batteries disconnected. The fire was identified as having been behind the P6-2 circuit breaker panel, behind the co-pilot's seat. The panel was lowered and the R61 contactor (Figure 2), was found to be melted. This contactor which, when the galley switches were set to ON, switched power to the forward galley from the left 115 V AC bus. Molten material and debris from the contactor had fallen from it and came to rest in the bottom of the compartment. Paint on the underside of the compartment floor had blistered.

The FWD GALLEY circuit breaker had 'tripped'.

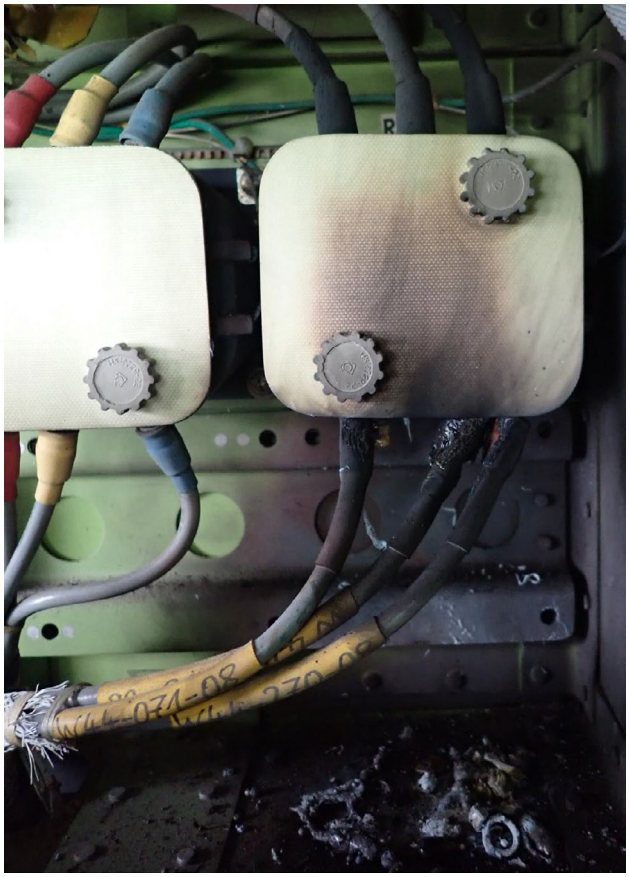

Figure 2

R61 forward galley contactor

When the contactor was removed it was evident that the contactor housing had been breached and the three input terminals had been destroyed during the fire. (Figure 3).

Figure 3

R61 Contactor, Part Number 9124-8073, after removal showing melted housing and loss of input terminals

Apart from some evidence of over current in the APU bus tie contactor associated with the contactor failure, troubleshooting of the electrical systems found no other issues.

Analysis

Due to the nature of the damage to the contactor, the cause of the failure could not be determined. It is possible that either the hermetically sealed contactor housing failed, allowing ambient conditions to enter the body resulting in the possibility of arcing within the unit, or the input terminal connectors had become loose, allowing external arcing and heat generation.

When the short circuit occurred, arcing generated heat and intense light, resulting in the melting of the contactor housing. This short circuit also reduced the circuit resistance and increased the current. The increased current was detected by the circuit breaker causing the circuit breaker to trip.

To avoid circuit breakers tripping due to momentary current spikes they are rated to trip when a sustained over current is sensed. When the circuit breaker trips, the system is isolated, as in this case, and stops the flow of current to the location of the short circuit.

Troubleshooting after the event found no issues with the aircraft that could have caused the short circuit and as such it is considered that the issue was isolated to the contactor. When the generators are transferred from one source to another momentary power spikes can occur, which may agitate the electrical systems. When the left bus was transferred to the APU power the R61 contactor was live. When APU power was transferred to the right bus, with the APU already connected to the left bus, a power spike may have agitated the R61 contactor allowing an arc to establish.

In the event, the crew were confronted by a noise followed by light and fumes from behind the CB panel. The dark cockpit will have exacerbated the intensity of the light generated during the failure. Although the safety systems isolated the failing contactor, the residual heat, fumes and glow of the hot components will have persisted so it is considered that the use of the fire extinguisher by the crew was appropriate in the circumstances.

Conclusion

The R61, forward galley, contactor failed, likely as a result of a loose connector or loss of sealing of the contactor housing. The failure resulted in arcing of the 115 V AC system, emitting light and fumes. The crew acted quickly to extinguish the perceived fire with a handheld fire extinguisher. At this time the associated circuit breaker tripped isolating the R61 contactor. The protection systems operated normally on the aircraft. The use of the fire extinguisher by the crew was an appropriate response based on the information available to them at the time.

Accident

Aircraft Type and Registration:	Piper PA-18-150, G-CLYI	
No & Type of Engines:	1 Lycoming O-320-A2B piston engine	
Year of Manufacture:	1981 (Serial no: 18-8109006)	
Date & Time (UTC):	13 May 2023 at 1415 hrs	
Location:	Sleap Aerodrome, Shropshire	
Type of Flight:	Private	
Persons on Board:	Crew – 1	Passengers – None
Injuries:	Crew – None	Passengers – N/A
Nature of Damage:	Damage to propeller, rudder strut and windscreen	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	22 years	
Commander's Flying Experience:	610 hours (of which 32 were on type) Last 90 days – 35 hours Last 28 days – 10 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot.	

Synopsis

The aircraft pitched over onto its back while making a short field landing at the end of a short takeoff and landing event. This was probably as a result of braking while landing with a tailwind. The aerodrome has identified actions to improve the safety management of flying events.

History of the flight

At the end of a short takeoff and landing (STOL) event, the aircraft made an approach to a grass strip at the left edge of Runway 18. G-CLYI, a tail wheel aircraft, was equipped with large bush wheels and a large propeller to enhance its STOL performance. The pilot stated that after touch down on the main wheels he applied gentle braking. However, as the aircraft slowed to below 10 kt with the tail remaining off the ground, the wind shifted to a light tailwind, and the tail lifted further into the air. In response, he attempted to give "a blip of throttle" to raise the nose, but without effect. As the tail lifted further into the air, the pilot reduced the throttle to idle and turned off the magnetos, at which point the propeller struck the ground. The aircraft tipped further onto its nose and then onto its back. The pilot turned off the electrics and fuel and exited the aircraft uninjured. The propeller, windscreen, struts and rudder were damaged.

STOL event

The event had been advertised only to members and other pilots, and not to the public. The pilot of G-CLYI stated that, as airfield accountable manager, he had previously been on the ground during the competition, supervising the adjudicators. He then took G-CLYI for a short flight towards the end of the event to conduct a STOL. The wind at the time was reported as light and variable.

Video evidence

A video (from which Figure 1 is a still image) showed two people adjacent to a line of cones at the point the aircraft touched down and two further people where the aircraft tipped over onto its back. These people had been adjudicating the STOL event.

Figure 1

Video screenshot of G-CLYI after landing

Aerodrome information

Sleap Aerodrome has licensed Runways 05/23 and 18/36. Runway 18/36 is 18 m wide, requiring a runway strip to the side of 30 m from the centreline to be maintained clear in accordance with CAP 168. A line of cones was placed 45 m from the runway centreline and delineated the aircraft parking area to the east from the runway and runway edge strip. The grass strip used for the STOL event was not a licensed runway but was part of the runway edge strip to the left of Runway 18.

Analysis

It is likely the aircraft landed with a tailwind and that this, combined with the application of brakes while attempting to perform a landing in as short a distance as possible, caused the loss of control. Persons adjudicating the STOL event were positioned beyond the limit of the runway edge strip for Runway 18. However, the use of the grass strip eroded the effectiveness of the measures in place to assure suitable separation between persons and aircraft operating on it.

The pilot stated that, as accountable manager, from the point that he went flying he had not exercised proper control of people on the ground, as he had not delegated his responsibilities during that time. To reduce the chance of reoccurrence the accountable manager identified several areas for improvement including:

- To appoint a deputy regardless of the scale of the event.
- To include risk management as part of event planning within the Safety Management System (SMS).
- To nominate a separate safety officer for events, to help identify safety issues from a different viewpoint.
- To work closely with experienced event planners and flying display directors for future events at the airfield.

The following safety actions have been taken.

- The SMS has been updated to include risk management in event planning.
- The airfield manager has gained a Tier 1 Flying Display Director accreditation.

Conclusion

It is likely the aircraft pitched over because of a combination of a light tailwind and braking to achieve a short landing.

AAIB Record-Only Investigations

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

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

The accuracy of the information provided cannot be assured.

Record-only investigations reviewed: February - March 2024

21 Sep 2023 **UAS DJI M300 RTK** Whiteside, West Lothian

While being used by an energy company to inspect electrical power lines, the UA lost contact with its controller. The UA struck the power line conductor structure, and fell to the ground.

26 Dec 2023 **UAS MA Mini Chevron** Weston-super-Mare, Somerset

The 0.9 kg model aircraft was being flown from an established model flying club site adjacent to a private road at the end of a lane. The pilot lost control of the aircraft, which struck the ground about 200 m away in a field next to, and at the boundary with, the lane.

11 Jan 2024 **UAS DJI Mini SE** Forest Mill, Clackmannanshire

The UA was flying above a river at a height of approximately 18 m when the control signal was lost. The UA struck a tree and, although the remote pilot regained control and tried to fly it out from within the branches, it fell into the river.

31 Jan 2024 **UAS DJI M30T** Derby

A remote pilot was allocated a high priority search task. The UAS had 15 mins of battery life remaining, but the pilot believed he could complete the task within that time. Approximately 12 minutes after takeoff, the Return To Home (RTH) alarm activated. The pilot cancelled the RTH alarm in the belief that the task could still be completed. Shortly after, with insufficient battery power remaining, the UA started to land autonomously. Due to its proximity to obstacles the pilot attempted to fly the UA away from them, but it struck some small trees and fell to the ground.

21 Feb 2024 **UAS DJI M30T** Stoke South Junction, Staffordshire

After completing inspections on several sets of railway points the UAS was being recovered for landing when it struck railway overhead powerlines and fell approximately 30 ft onto the track. The remote pilot reported that a lesson he learned was “to fly either side of pylon cables...instead of trying to fly over/under them.”

28 Feb 2024 **UAS DJI Mavic Mini Pro 4** Streatham, London

During a hand launch, a propeller clipped the launcher's finger and the UA fell to the ground.

4 Mar 2024 **UAS DJI M30 T** East Garston, Berkshire

The remote pilot was bringing the UA back to the intended landing site. It went into a low battery level mode and did not respond to controller input. The UA clipped a hedge near the intended landing site.

Record-only investigations reviewed: February - March 2024 cont

04 Mar 2024 **UAS DJI Phantom 4 RTK** Southport, Merseyside

The UA was being used for surveying. The remote operator received a battery error message, and the UA did not respond to the return to home request. It flew away in the direction of the wind and was later recovered.

19 Mar 2024 **UAS DJI M30T** North Gosforth, Northumberland

The UA began to automatically return to home due to insufficient battery level. The Remote Pilot had overridden the return to home mode and during the landing the UA struck a tree.

21 Mar 2024 **UAS PW One** Rugby, Warwickshire

After takeoff from a field, the UA pitched up, stalled, and struck the ground nose first.

26 Mar 2024 **UAS DJI M30T** Near Oxted, Surrey

The UAS was being used for image recording. With the remote pilot behind the UA, it was initially flown in Normal mode and then in Fine mode as the recording started. Once recording was complete the pilot rotated the UA to fly home. The pilot intended to select Normal mode, but Sport mode was engaged. The UA reacted quicker than expected to the pilot inputs and flew into a bush.

Miscellaneous

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

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

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

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

Published October 2015.

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

Published March 2016.

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

Published September 2016.

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

Published March 2017.

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

Published March 2018.

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

Published November 2018.

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

Published March 2020.

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

Published May 2021.

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

Published September 2023.

2/2023 Sikorsky S-92A, G-MCGY
Derriford Hospital, Plymouth, Devon
on 4 March 2022.

Published November 2023.

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

http://www.aaib.gov.uk

GLOSSARY OF ABBREVIATIONS

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

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