Air Accidents Investigation Branch

AAIB Bulletin 2/2019

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(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:	Cessna 172S JT-A, PR-PTS
No & Type of Engines:	1 Technify Motors TAE 125-02-114 turbocharged diesel piston engine
Year of Manufacture:	2017 (Serial no: 172S12057)
Date & Time (UTC):	23 December 2017 at 2133 hrs (1733 local time)
Location:	Following takeoff from Providenciales Airport, Turks and Caicos Islands
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Brazilian Commercial Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	At least 1,398 hours (of which at least 342 were on type) Last 90 days - unknown Last 28 days - unknown
Information Source:	AAIB Field Investigation

Synopsis

Shortly after takeoff from Providenciales Airport, Turks and Caicos Islands, the aircraft engine lost power, most likely due to a failure of, or detachment, of an intercooler induction hose. The pilot attempted to reposition for a landing at the airport but lost control of the aircraft whilst attempting to turn. Both the pilot and passenger were fatally injured.

History of the flight

The aircraft was newly-built at the manufacturer's facility at Independence, Kansas, USA. As part of the purchase the aircraft had been fitted with a diesel engine in accordance with an FAA Supplementary Type Certificate (STC) before being handed over to the ferry company pilot on 20 December 2017. There had been some delays in the delivery due to technical issues with the aircraft which had required some replacement parts to be fitted before the aircraft was released.

The aircraft was to be ferried to Sao Paulo, Brazil in order to receive its mandatory technical survey by the Brazilian authorities for importation. The crew consisted of a ferry pilot and a passenger who was an employee of the purchaser. Due to the size and range of the aircraft, the ferry flight was planned through Florida and the Caribbean islands before crossing into Brazil. In all, the flight was planned with ten stops before reaching its destination. The stop in Providenciales was originally planned as an overnight stay but due to the late delivery of the aircraft, and the time of year, suitable hotel accommodation was not available on the island. As a result, the flight was re-planned to proceed from Providenciales on to Punta Cana, Dominican Republic, a flight of approximately 2.5 hours. The crew were then planning to stay for the night before re-joining their original ferry plan.

On 20 December 2017, the pilot and his passenger left Independence, Kansas, in the aircraft for a 2.9 hour flight to Meridian, Mississippi, where the occupants stayed for a night. The next day they completed the 4.5 hour leg to Fort Lauderdale, Florida. The crew left Fort Lauderdale on 23 December 2017. The routing from Fort Lauderdale to Providenciales is around 520 nm and would have taken approximately 5 hours. The aircraft landed at Providenciales at 2022 hrs (1622 local time) and the occupants disembarked into the fixed base operator (FBO) terminal. The aircraft was refuelled for its onwards flight to Punta Cana. The aircraft occupants were reported by witnesses to be relaxed without any concerns about the aircraft or the route.

The weather in Providenciales was excellent with an easterly wind of 10 kt, visibility in excess of 10 km and a temperature of 28°C. It was daylight. At 2123 hrs (1723 local time) the pilot of PR-PTS requested taxi instructions from the tower at Providenciales for his flight to Punta Cana. Six minutes later he was cleared to enter and backtrack Runway 10. Another aircraft called on finals, and at 2131 hrs the pilot was asked by the tower if he could depart from his present position. The pilot answered that he could and at 2132 hrs PR-PTS was cleared for takeoff. The aircraft then made a 180° turn on the runway and began its takeoff roll.

As soon as the aircraft became airborne from the runway, the tower controller and assistant noticed smoke coming from the aircraft. Very shortly after takeoff the pilot requested an immediate return which was granted by the controller, who asked the pilot to report on finals. The controller and assistant then saw the aircraft start a turn to the left. They observed an increasing angle of bank in the turn before the nose dropped and the aircraft was lost to sight behind some buildings. Other aircraft on the frequency reported to the controller that the aircraft had crashed and the emergency procedure was initiated. Around a minute later the controllers could clearly see a large cloud of black smoke although they were unable to see the accident site.

The aircraft had struck the ground to the north of the airport and outside the perimeter fence (Figure 6). The accident site was a corner piece of undeveloped land bordered by roads and next to a petrol station. Police and fire services arrived at the scene quickly but a fierce fire had taken hold. The aircraft occupants were fatally injured. Post-mortem investigations showed that it is highly likely both occupants died instantly due to the initial impact.

Pilot

The pilot held a Brazilian Commercial Pilot's Licence. His logbook was kept electronically and could not be accessed after the accident. Evidence from the Brazilian authorities and from paper copies of aircraft technical logs indicated he had at least 1,398 hours total flying experience, although witnesses reported that the total was much higher at around

3,000 hours. The vast majority of this experience was in single-engine light aircraft. It could not be determined how much flying the pilot had completed in the previous 28 and 90 days. Having collected the aircraft from the manufacturer, the pilot had completed nearly 12 hours in the accident aircraft en route to Providenciales. It was reported that the pilot had ferried aircraft from the USA to Brazil on previous occasions but it has not been possible to verify this.

Accident site and on-site wreckage examination

The aircraft had struck the ground in a steep nose-down attitude, and had come to rest at the impact point (Figure 1) approximately 270 m north of the runway extended centreline. The impact heading was 010°M, 90° to the left of the departure runway heading. Both wing fuel tanks were ruptured on impact and a severe post-impact fire had developed, consuming the majority of the aircraft's cabin and inboard wing structure.

Figure 1
Accident site

All major components of the aircraft were located at the accident site. Continuity of the flying controls was established between the cockpit controls and the flying control surfaces. The flaps were fully up and the elevator trim tab was in a neutral position. The pre-impact position of the fuel selector valve could not be determined due to disruption of the cockpit during the accident.

There was insufficient fuel remaining in the fuel system from which to take a fuel sample, although traces of fuel with the appearance and odour of JET A were present in the engine's fuel rail. A fuel sample drawn from the fuel bowser that was used to refuel PR-PTS prior to the accident flight was tested and found to conform to the specifications of JET A fuel.

The post-crash fire had consumed most of the engine's air induction and coolant hoses. The intercooler was recovered with both hose clamps and a remnant of the silicone hose in position at the intercooler inlet. The intercooler outlet hose clamps had released from the intercooler during the impact and subsequent fire, but were later identified within the aircraft wreckage. The induction manifold inlet had both hose clamps still in position although the hose itself had burned away. The turbocharger compressor outlet coupler was secured to the turbocharger by its metal V-band clamp, however the single hose clamp that attaches the compressor outlet hose to the turbocharger was not located in the aircraft wreckage or at the accident site.

The engine's FADEC[1] unit, which was also burned, was recovered from the wreckage for analysis. The engine was removed from the aircraft for detailed examination at the engine manufacturer's facility in Germany.

Aircraft information

The Cessna 172S is a single-engine, four seat light aircraft with a high-wing and a fixed tricycle landing gear. The Cessna 172S JT-A is a conversion of the 172S, in which the Lycoming IO-360-L2A piston engine is replaced with a Technify Motors turbocharged diesel TAE 125-02-114 engine. The aircraft manufacturer discontinued production of the 172S JT-A in May 2018. For PR-PTS, this engine conversion was embodied as an STC modification, prior to delivery of the newly-built aircraft to the customer. During installation of the engine a modification was carried out to the cylinder head[2] and the fuel rail pressure regulation valve was replaced[3]. The modification to the cylinder head required the exhaust manifold and turbocharger to be removed from the engine, to provide access to the cylinder head. The necessary maintenance steps for removal of the exhaust manifold and turbocharger were specified in Chapters 72-40.03 and 72-04.01 of the engine Repair Manual, RM-02-02.

RM-02-02 contains the following turbocharger removal instructions:

> *'De-installation*
>
> 1. *Remove the clamp of the turbocharger air* [inlet] *hose and remove the air* [inlet] *hose from the compressor case. Seal the opening with an appropriate plug to protect it from contamination or dirt.*

Footnote

1 Full-Authority Digital Engine Control.
2 Repair Instruction RI-05-0014-01, carried out on 18 October 2017.
3 Service Bulletin TMG 125-1022 P1, carried out on 27 October 2017.

> 2. *Remove the Wiggins clamp of the turbocharger pipe and remove the air pipe from the compressor case. Seal the opening with an appropriate plug to protect it from contamination or dirt.*
>
> 3. *Remove the hoses from the wastegate control valve to the turbocharger. This requires the Cobra clamps to be removed.'*

The 'Wiggins clamp' referred to in step 2 above relates to a previous standard of TAE 125 engine, in which the induction air hose was connected to the turbocharger compressor outlet by a single clamp. This design was superseded when a turbocharger outlet adapter was introduced, which is attached to the turbocharger compressor outlet with a steel V-band clamp. The turbocharger compressor outlet air hose is secured to the outlet adapter with a single hose clamp. This later configuration of the TAE 125 engine was installed in PR-PTS.

The technician who performed RI-05-0014-01 stated that he loosened both hose clamps that attach the induction hose to the inlet of the intercooler, to permit removal of the turbocharger. The same technician reinstalled the turbocharger and air hose after completing the cylinder head modification. The aircraft's airworthiness certificate was issued on 18 December 2017 and at the time the accident occurred the aircraft had accumulated 32.4 hours and the engine 24.6 hours in operation.

The TAE-125-02-114 engine is equipped with a dual-channel FADEC to control the engine operation in response to pilot demands. The FADEC unit also records engine parameters during engine operation.

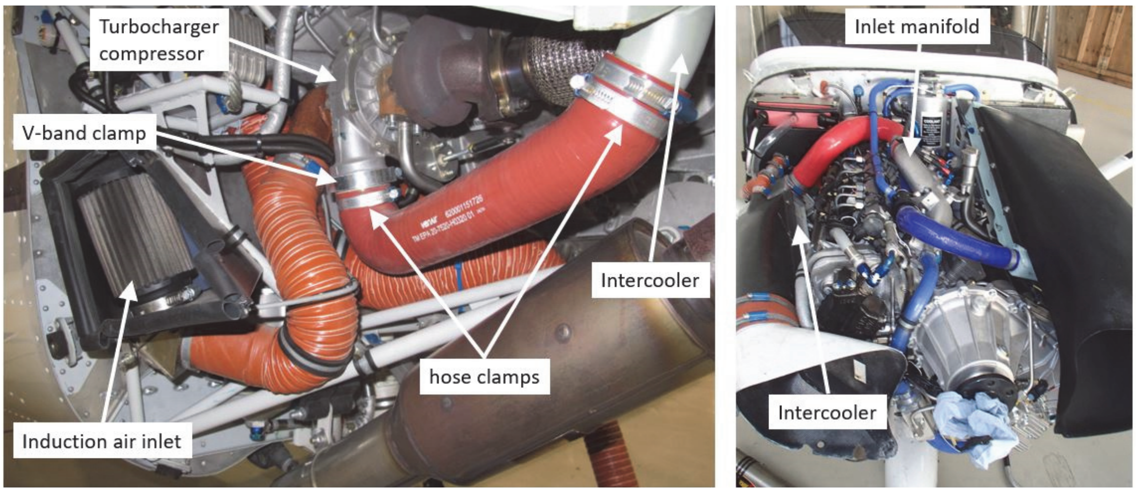

Figure 2

TAE-125-02-114 air induction system

Engine air induction system

Engine induction air is drawn though an inlet and filter on the right lower cowling, before being ducted to the turbocharger compressor inlet (Figure 2). Pressurised induction air passes from the turbocharger compressor outlet via a silicone hose to an intercooler where the induction air is cooled prior to being routed via a second silicone hose to the engine inlet manifold. Two manifold air pressure sensors, one for each FADEC channel, measure the induction air pressure at the inlet manifold.

The turbocharger compressor outlet has an adapter attached to it, secured by a metal V-band clamp. The silicone hose connecting the turbocharger compressor outlet to the intercooler is attached with a single hose clamp at the coupler end as there is insufficient space for two hose clamps. This hose has two hose clamps at the intercooler end. The silicone hose that connects the intercooler outlet to the inlet manifold has two hose clamps at either end of the hose.

Recorded information

There were no radar recordings. The radio transmissions were recorded and are described in the 'History of the flight' section of this report.

Recorded data was recovered from both control lanes of the fire-damaged FADEC by removing and downloading the memory chips. The data comprised event logs and continuous recordings.

The recordings included more than 41 hours of data covering 16 flights, starting in October 2017 and ending with the accident flight. They contained a comprehensive parameter set for each control lane, with an update rate of once per second. Altitude and position were not recorded.

Altitude was derived from the recorded barometric air pressure parameter and corrected to match the pressure altitudes the aircraft transponder was reporting during previous flights. The pressure recordings did not vary smoothly, but changed in increments of either two or three hPa, equating to 55 ft or 82 ft respectively near sea level.

There were two flights recorded on the day of the accident, the first with a duration of nearly five hours, the second was the accident flight with a very short duration, stopping shortly before impact. The data shows the test switch was used before each of these flights. There was also a brief period of running the engine at maximum rpm on the ground prior to the first flight of the day.

Accident flight

The pertinent parameters for the accident flight are shown in Figure 3.

The FADEC started logging data at a recorded time of 2118:31 hrs. The engine speed on the ground was generally held stable at 1,500 rpm. A test was carried out at 2130:49 hrs. Three minutes later the engine started developing full power and then the aircraft started to climb. Shortly after this the manifold air pressure (MAP) fell to approximately ambient pressure conditions and the engine waste gate was commanded to close to increase this pressure. The data stopped shortly after this. The displayed power had reduced to 49.8%.

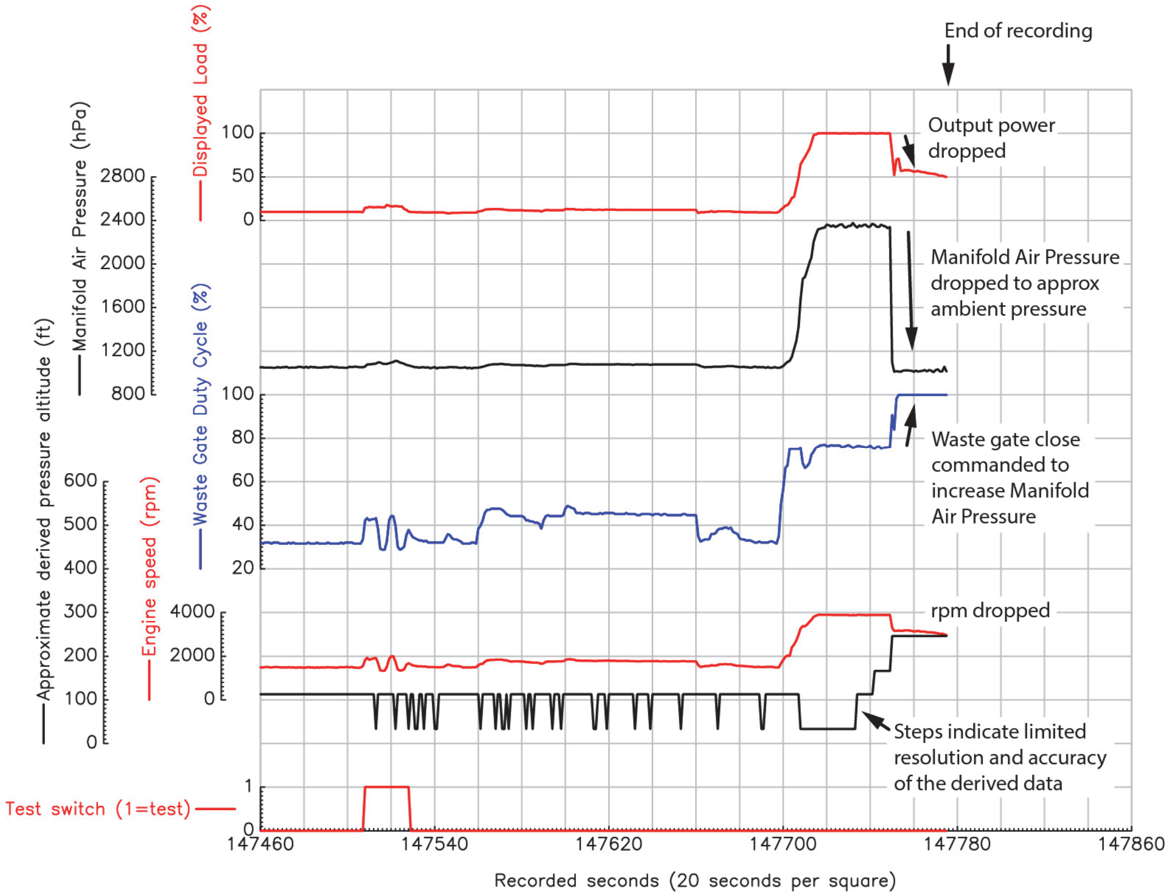

Figure 3

Extract from FADEC data – accident flight

The event log did not include any warnings associated with the time of the failure. A comparison of this initial takeoff with previous successful ones using the same aircraft did not find any anomalies up to moment when the MAP dropped.

Previous flight

During the first flight of the day (Figure 4), climbing through approximately 1,000 ft agl, there was a period where the MAP started to fluctuate with a peak-to-peak value of approximately 200 hPa (200 mbar). This stopped when the engine rpm was reduced after levelling off. The fluctuations returned to a lesser degree when climbing once more, reducing in amplitude as the climb progressed. The waste gate control values also fluctuated when the MAP was fluctuating.

As the MAP and waste gate parameters were only recorded once per second, it could not be determined whether the waste gate control fluctuations were driving the MAP fluctuations or reacting to them. The limited sample rate also means that the frequency of the fluctuations and an accurate amplitude for the fluctuations could not be determined.

The engine manufacturer stated that tests allowed up to 75 mbar of fluctuation but they are normally much less than this, 30 mbar at most.

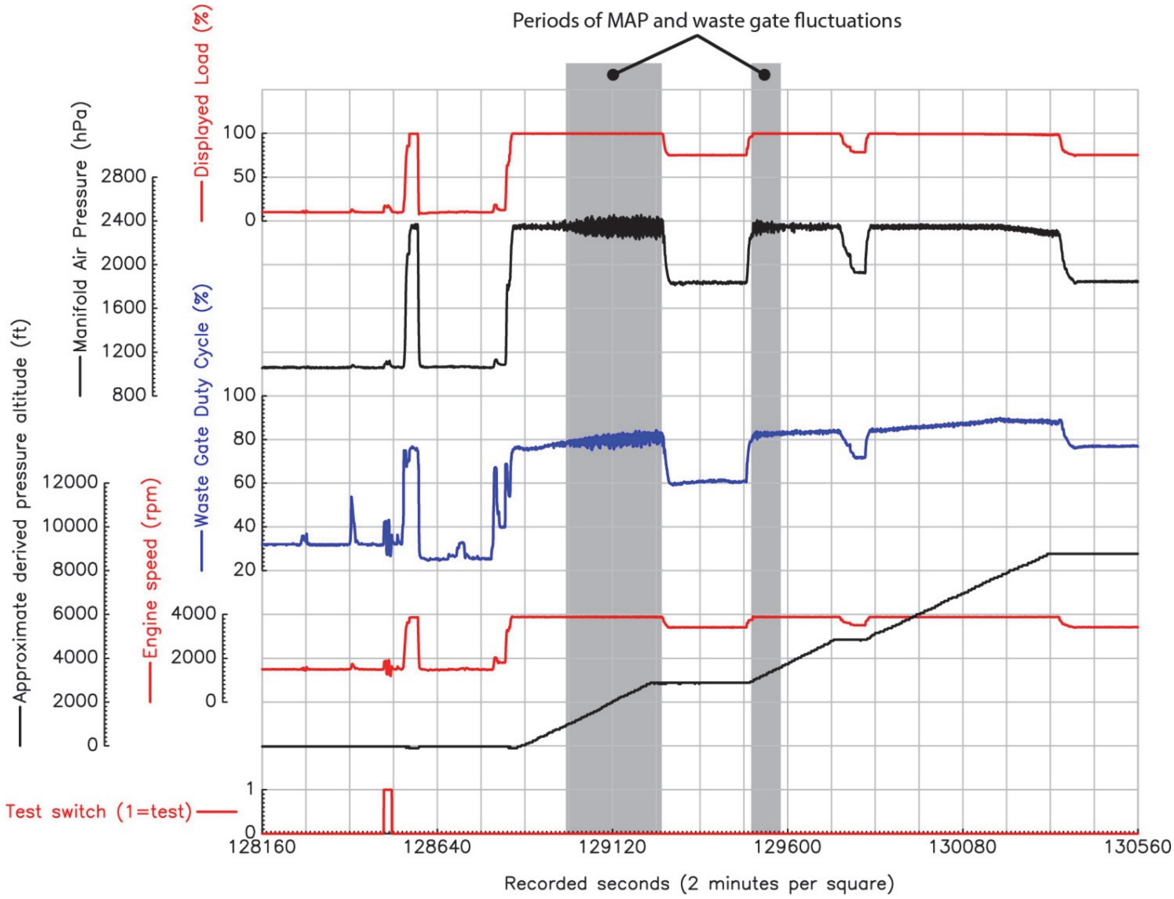

Figure 4

Extract from FADEC data – previous flight

The MAP fluctuations were also first observed with similar amplitudes, in excess of the manufacturer bench test limits, during a pre-delivery test flight conducted by the aircraft manufacturer on 16 December 2017. Similar MAP fluctuations were present on all subsequent flights. The data shows the MAP fluctuations on 16 December 2017 were present to a greater extent than that shown in Figure 4 but had not drawn the attention of the test pilot. The recorded displayed load parameters indicates that full power was available during the periods of MAP fluctuation.

The engine maintenance manual requires that the FADEC is downloaded and the data examined for anomalies every 100 hours of engine operation, or at the annual inspection, whichever occurs first. The engine manufacturer also routinely examines the FADEC data for anomalies when the engine is first run on a test bench, when it is first ground-run after installation in the aircraft, and after the initial test flight. In this instance, the engine manufacturer reported that downloaded FADEC data from PR-PTS had shown no abnormalities from the point of manufacture up to and including the initial test flight and the engine had not yet reached 100 hours of operation at the time of the accident.

Engine manufacturer

In the light of the data recovered from the FADEC in PR-PTS, the engine manufacturer reviewed past data from other engines, looking for previous cases of high MAP fluctuations. Although minor manifold pressure fluctuations are an inherent property of piston engines, the manufacturer could find no instances of fluctuations approaching those in PR-PTS (approximately 200 hPa (200 mbar)). There was therefore no basis, from service history, for determining the likely cause of this fluctuation in PR-PTS.

Engine examination

The engine was disassembled at the engine manufacturer's factory in Germany with oversight from the AAIB and the BFU. There was no evidence of a pre-accident mechanical failure within the engine and all damage to the engine was consistent with the ground impact during the accident.

The turbocharger turbine wheel blades had tip damage caused by contact with the turbine shroud, demonstrating that the turbocharger was turning at high speed at impact. The turbocharger shaft, which connects the compressor to the turbine, was fractured and a metallurgical examination of the fracture surface showed that the fracture was a ductile overload, caused by bending of the shaft during ground impact. The turbocharger waste gate operated normally when actuated by hand.

Ground-running tests of a TAE-125 engine

A series of ground-running engine tests were performed on a Piper PA-28 that was powered by a TAE 125 engine, similar to that fitted to PR-PTS. The tests were conducted to determine whether detachment of the hose which connects the turbocharger compressor outlet to the intercooler would result in a similar reduction in engine power to that observed in the FADEC data from the accident flight.

Three configurations of the securing of the turbocharger compressor hose were tested (Figure 5). The first test involved the turbocharger hose clamp being correctly positioned and loosened to the point where it was free to rotate about the hose, but still tight enough not to slide over the bulge in the hose due to the turbocharger outlet barb feature. When the engine was run at full power, the hose remained attached and the engine ran normally.

The second test involved removal of the hose clamp. The engine started and ran normally at idle power, but when the power lever was advanced the hose immediately detached from the turbocharger, before full power was reached. When the hose detached, the manifold pressure reduced to ambient pressure and the load reduced to approximately 55%. The exhaust gases were a dark, smoky colour due to an excessive level of unburnt fuel. The engine manufacturer confirmed that an abrupt reduction in manifold pressure would result in a lower air mass flow, leading to a sootier combustion which is visible in the black exhaust gases.

A third test was performed with the hose clamp incorrectly positioned over the bulge in the hose where it passed over the turbocharger barb. With the hose clamp loose enough to be rotated by hand, the hose detached when the engine ran before full power was reached, with similar results to the second test. A fourth test was performed with the hose clamp positioned as for the third test, but with the clamp tightened to the 5 N cm torque level, as required by the Aircraft Maintenance Manual (AMM). The hose clamp and hose remained attached during the subsequent engine run and the engine developed full power with a normal exhaust gas appearance. The clamp torque level was then reduced to 2.5 N cm, only 50% of the AMM-required level. Despite this reduction in clamp torque, the clamp and hose remained attached during an engine run to full power, including slam-throttle tests where the engine was rapidly accelerated from idle to full power.

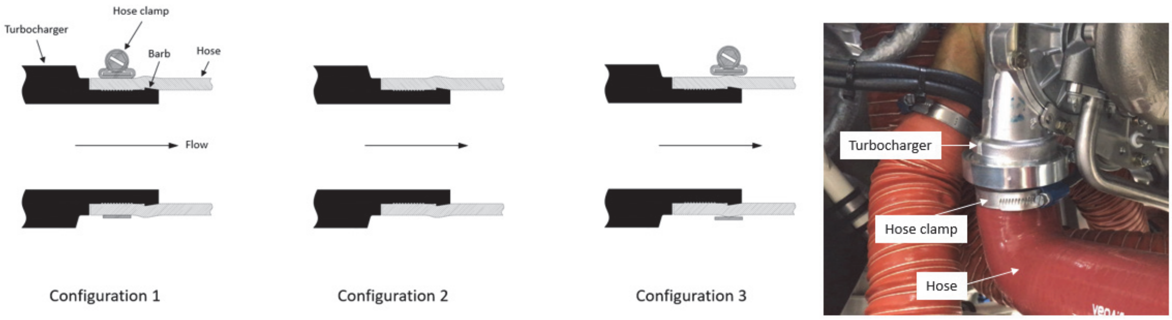

Figure 5

Turbocharger compressor outlet hose clamp

Weight and balance

Th aircraft was refuelled to full tanks in Providenciales. Using the weight of the pilot and passenger, as well as estimates for their baggage it was estimated that the aircraft was close to the maximum takeoff mass of 2,550 lbs. The aircraft balance was within limits.

Aircraft performance

Following the engine examination and ground-running tests, the aircraft manufacturer conducted a test flight with a Cessna 172S JT-A, to simulate the power loss which occurred in PR-PTS. The test aircraft was flown at a similar mass to PR-PTS and at a density altitude greater than that achieved during the accident flight. With a power setting the same as that seen on the PR-PTS FADEC-recorded data, the aircraft was able to complete a level turn at up to 15° angle of bank.

Airfield information

Providenciales is the main international airport serving the Turks and Caicos Islands. The airport is at 15 ft amsl and has a single runway orientated 10/28. The runway is 2,807 m long. At both ends of the runway there are areas of water. In the case of Runway 10, this is a shallow lagoon containing areas of mangroves. Figure 6 shows the general area of the airport and the areas of water at each end of the runway.

Figure 6
General area around the airport © Google Earth

Analysis

The cause of the power reduction

The FADEC recorded data showed that, shortly after takeoff on the accident flight, the manifold air pressure (MAP) fell to approximately ambient pressure. Testing later conducted by the engine manufacturer confirmed that this reduction in MAP would result in a substantial reduction in engine power, as seen during the accident flight. Tests also confirmed that the reduction in MAP recorded on the FADEC was consistent with a major leak in the air induction system, between the turbocharger compressor outlet and the engine intake manifold. This loss in manifold pressure resulted in a significant loss of engine power. The engine manufacturer confirmed that an abrupt reduction in manifold pressure would result in a lower air mass flow, leading to a sootier combustion which was consistent with the smoky appearance of the engine's exhaust gases observed by the witnesses in the control tower.

Through examination of the aircraft wreckage it was possible to eliminate the induction hose joints at both the inlet and exhaust of the intercooler and the inlet of the induction manifold as possible causes of the induction leak. It was also possible, after their inspection, to eliminate the intercooler and induction manifold. This leaves two remaining possibilities:

1. The induction hose connection to the turbocharger compressor outlet may have failed. Since the single hose clamp at this position was not recovered in the aircraft wreckage, it is possible that it detached during

the takeoff sequence although the absence of this component prevented further investigation into this scenario. Tests conducted by the engine manufacturer showed that, with the hose clamp either absent, or loose and misaligned over the turbocharger outlet barb, the induction hose did not remain attached to the turbocharger when the engine was run at full power. Therefore, as the aircraft had flown a number of flights successfully after the removal and reinstallation of the turbocharger and induction hose, for the modification RI-05-0014-01, it can be concluded that the hose clamp was present and was tight enough to retain the induction hose for at least the successfully completed flights.

2. As only a few fragments of the intercooler induction hoses remained following the post-impact fire, it was not possible to establish their condition prior to the accident. It is possible that one of the induction hoses may have failed, leading to the observed reduction in manifold pressure.

The cause of the recorded fluctuations in manifold pressure could not be determined. It is possible that the pressure fluctuations may have caused a component in the induction system to fail prematurely, leading to the significant loss in manifold pressure during the accident flight takeoff, but there was no remaining physical evidence available to support, or exclude, this.

Turnback decision

There are several reasons why a pilot may attempt to turn back towards the airport in the event of a complete or partial engine failure after takeoff. The primary reason would be that there are no areas in which to attempt a forced landing ahead. Other reasons may include a desire to 'save the aircraft,' a fear of landing in water, if that is what is ahead, and seeking the reassurance of a strip of runway. In many cases, the attempt ends in the aircraft entering a stall or spin with catastrophic results.

Decision making following engine failures requires a rapid appraisal of the conditions, followed by a prompt decision about the actions to be taken. When the situation is one of a partial or substantial power loss, but not a complete power loss, the decision making may be compounded by the need to rapidly assess the power available against that required to fly level or climb. Research by the Australian Transportation Safety Board (ATSB) concluded that partial power loss can be more challenging than full power loss, due to the choices confronting the pilot and general lack of training for such an event[4]. Training tends to concentrate on the complete loss of engine power.

When power is lost after takeoff (whether completely or partially), the priority must be to maintain control of the aircraft. This may require significant positive action by the pilot to avoid stalling, especially in a turn.

Footnote

[4] ATSB Transport Safety Report – Managing partial power loss after takeoff in single-engine aircraft (Canberra, 2011).

Conclusion

This aircraft suffered a power loss just after takeoff, which was confirmed by the recorded engine data. This power loss was consistent with a significant leak in the engine air induction system, which could have been caused by either the detachment of an induction hose or the failure of one of the induction hoses. The pilot's request to return shows that he was attempting to position the aircraft for a landing at the airport, but he then lost control in the turn. The aircraft bank increased, it is likely the lower wing stalled and the aircraft then descended rapidly into the ground. The pilot and passenger were almost certainly killed in the impact with the ground, not in the subsequent fire.

The loss of power was significant, but not complete, and the power available was sufficient to allow the aircraft to be flown level and to complete gentle turns. ATSB research shows that a partial and insidious loss of power may be more challenging for effective decision making than a full loss of power. In this instance, it is likely that a controlled forced landing into the shallow water ahead would have resulted in the probable loss of the aircraft but it is unlikely that it would have had fatal consequences.

ACCIDENT

Aircraft Type and Registration:	Rutan Long-Ez (Modified), G-BPWP
No & Type of Engines:	1 Continental Motors Corp O-240-E piston engine
Year of Manufacture:	1989 (Serial no: PFA 074A-11132)
Date & Time (UTC):	7 July 2018 at 1131 hrs
Location:	Dunkeswell Airfield, Devon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Minor)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	80 years
Commander's Flying Experience:	641 hours (of which 465 were on type) Last 90 days - 5 hours Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot was operating his aircraft with a mixture of automotive gasoline (Mogas) and aviation gasoline (Avgas) 100LL in the left fuel tank and Avgas 100LL in the right fuel tank. While on base leg to land on Runway 04 at Dunkeswell Airfield the engine, which was being supplied with fuel from the left fuel tank, suddenly stopped. The pilot established a glide to land in a field in the undershoot, but at a late stage in the approach he spotted a fence running across his chosen landing site. Whilst manoeuvring to avoid the fence the aircraft touched down firmly, seriously injuring the pilot; the passenger sustained minor injuries.

The likely cause of the engine stopping was either carburettor icing or a vapour lock in the aircraft fuel supply to the engine.

History of the flight

The pilot and his passenger planned to fly from Biggin Hill Airport, where the aircraft was kept in a hangar, to Dunkeswell Airfield. The aircraft departed at 1013 hrs, with the right fuel tank selected and about 20 gal of fuel on board. The flight progressed through southern England without event, during which time the pilot selected the left fuel tank when the right tank indicated about 6 gal. The fuel selector remained in this position for the rest of the flight.

As the aircraft approached Dunkeswell, the pilot requested joining instructions. At about this time the passenger advised the pilot that the fuel tanks indicated 4 and 6 gal (left and right tanks respectively) and asked the pilot if he should change tanks. As the engine was "running fine" the pilot replied "no". The Radio Controller informed the pilot that he should join right-hand downwind for Runway 04. Having joined downwind at about 1,000 ft aal, the pilot selected carburettor heat to HOT; he could not recall if he turned the fuel booster pump ON at this time. He then turned the carburettor heat to COLD at the end of the downwind leg.

The pilot became aware of two aircraft lining up on Runway 04 and decided to extend the downwind leg. Once the two aircraft had cleared the runway, he turned on to base leg and attempted to re-establish his normal circuit profile at a speed of 65 to 70 kt. The pilot believes that he turned the carburettor heat to HOT while on base leg.

Just before the pilot turned onto final approach, the engine stopped without warning. The pilot transmitted a PAN followed shortly thereafter by a MAYDAY. He attempted to restart the engine once, to no avail, and prepared to land in a field in the undershoot. He does not recall changing fuel tanks or checking that the fuel booster pump was ON. At about 20 ft agl he became aware of a fence ahead of the aircraft and turned left to avoid it. The aircraft subsequently landed firmly with left bank applied.

Once the aircraft had come to rest the pilot asked his passenger if she was "OK", opened the canopy and told her not to move but to await assistance. The airfield's emergency response vehicles were quickly on the scene and, with some of the eye witnesses, administered first aid to the occupants. The local RFFS, ambulance and air ambulance arrived soon thereafter and removed both occupants from the aircraft and transported them to hospital; the passenger, who had minor injuries, went by road and the pilot, who suffered serious injuries, went by air.

Weather information

The accident flight took place after a period of high ambient temperatures. The METARs for London Biggin Hill Airport indicated that the temperature, between 0500 hrs and 2100 hrs, during the seven days prior to the accident varied between 12°C and 29°C (Table 1). On the morning of the accident the recorded temperature varied between 21°C and 26°C.

Date	Minimum temperature (°C)	Maximum temperature (°C)
7 July	21	26
6 July	18	29
5 July	17	26
4 July	12	24
3 July	14	23
2 July	16	25
1 July	19	26

Table 1

Day time temperatures at Biggin Hill Airport

An aftercast produced by the Met Office stated that at the time of the accident, Dunkeswell Airfield was affected by an area of high pressure that gave a slack mainly north-north-westerly air flow. There was no weather and FEW clouds at 2,000 ft amsl. The temperature was 25°C, the dew point temperature was 14°C and the relative humidity was 56%. The QNH was 1024 hPa.

Accident site

G-BPWP came to rest in a field slightly to the left of the extended centreline, and approximately 550 m from the threshold of Runway 04, at Dunkeswell Airfield. The ground marks and damage to the aircraft indicated that the aircraft initially landed heavily on the left mainwheel and nosewheel. The left landing leg structural cross beam member failed at the centre of the fuselage, the nose landing leg detached, and the forward section of the fuselage was badly damaged when it struck the ground. The left fin and canard also contacted the ground with sufficient force to break the main spar in the left wing and damage the canard. Following the initial impact, the aircraft continued to travel across the ground for a further 54 m before stopping on a heading of 340°(M). The aircraft was 11 m from the fence which the pilot tried to avoid. See Figure 1.

Figure 1
Accident site

Recorded information

Sources of recorded information

Recorded data was available from ground-based radars, an aircraft tracking system[1], the pilot's portable GPS unit and tablet computer that were recovered from the aircraft. Data from a flight navigation software application[2], installed on the portable tablet, provided a complete track log of the accident flight with the data ending after the aircraft had come to a stop. This data comprised GPS-derived position, track, altitude and groundspeed recorded at a rate of once per second. The recordings from the radar, tracking system and GPS unit ended shortly before the aircraft landed.

To compensate for an inaccuracy in the tablet computer's GPS-derived altitude, the aircraft's altitude was reduced by 56 ft in order that the recorded height of G-BPWP aligned with the terrain elevation at the point that the aircraft landed.

RTF communications at Dunkeswell Airfield were not recorded.

Interpretation of recoded data

The pilot followed a route to Dunkeswell Airfield that he had entered into the navigation application on his tablet computer. The final approach is illustrated in Figure 2, with the GPS data during the final seconds of the approach at Figure 3.

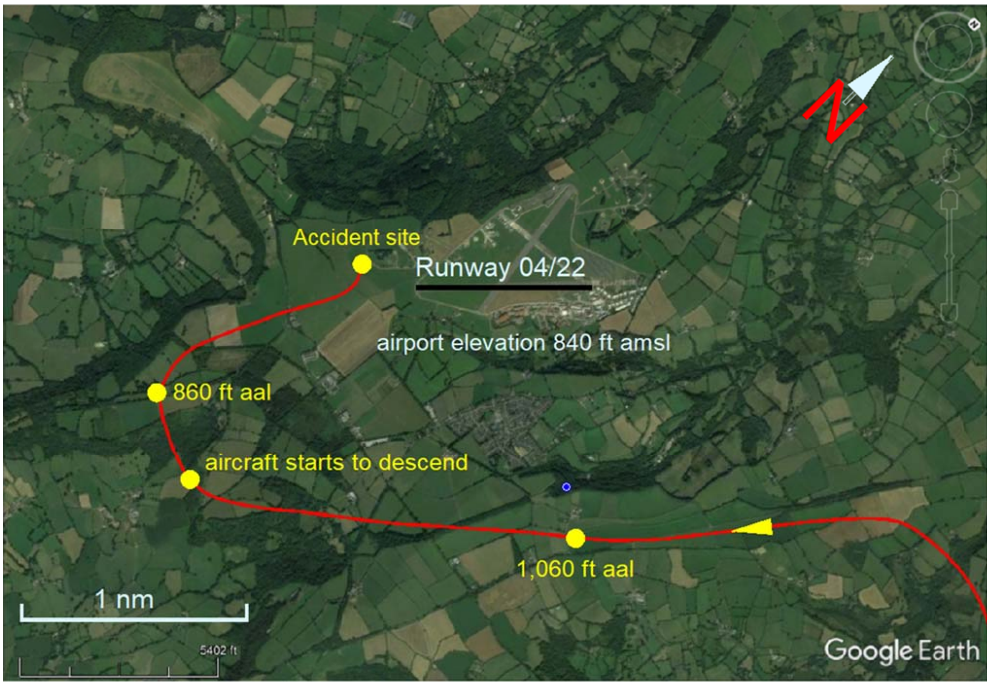

Figure 2

Ground track on approach to Runway 04

Footnote

1 www.flightradar24.com (as of July 2018).
2 SkyDemon flight navigation software application.

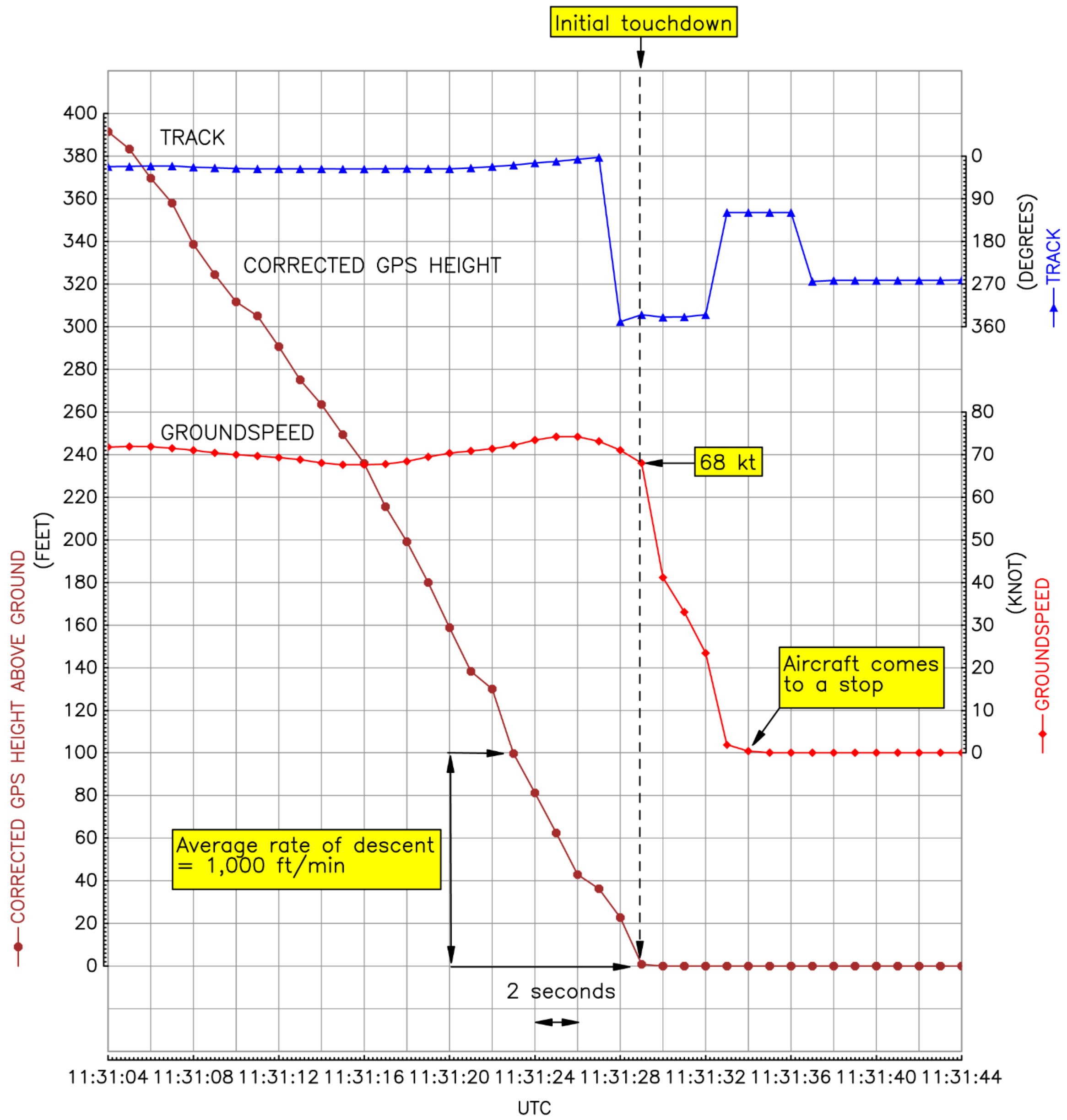

Figure 3

GPS data during final approach

As the aircraft descended on the final approach its average groundspeed was 70 kt. The recorded wind at Exeter airport, 10 nm to the south-west, was 3 kt and variable in direction. Based on this wind, the estimated true airspeed of G-BPWP would have been between 67 kt and 73 kt.

When the aircraft was about 800 m (0.4 nm) from the runway threshold it was at approximately 200 ft agl. The aircraft then started to alter track to the left, turning away from the extended runway centre line. Shortly after the aircraft touched down at a groundspeed of about 68 kt and at a calculated vertical descent rate of approximately 1,000 ft/min. The aircraft came to a stop five seconds later.

Aircraft information

The Rutan Long-Ez is a tandem two-seat, homebuilt aircraft with a canard wing configuration, a pusher engine and a tricycle landing gear consisting of a fixed main gear and a mechanically retractable nose leg. The aircraft is mainly constructed from glass fibre with a foam core. Only the pilot's position is equipped with flying and engine instruments. The pilot and passenger were both secured by a four-point harness.

The main wings are swept and tapered and at each wingtip there is a winglet which also acts as a fin and on which is mounted a moveable flap (rudder) which provides yaw control. See Figure 4. Ailerons are mounted on the inboard trailing edge of each wing and a canard, located in front of the cockpit, is fitted with full span elevators. The aircraft is also equipped with an electrically operated speed brake mounted on the lower fuselage just forward of the engine. The elevator and ailerons are connected mechanically through a system of rods, cables and cranks to a side stick mounted on the right side of the cockpit. The rudders are connected by cables and pulleys to the rudder pedals.

Figure 4

Rutan Long-EZ

Fuel system

Fuel is stored in two 19 gal integral tanks, located in the wing strakes, which gives a claimed[3] duration of up to eight hours. The tanks are fitted with baffles and the fuel contents is established by noting the level of the fuel that can be visually observed through a section of the tank walls in the rear cockpit that have not been covered with a gel coat (Figure 5). The pilot cannot see the fuel contents directly from the front cockpit and therefore must either rely on the passenger or use a mirror[4] mounted on the side of the front cockpit.

Footnote

3 Owner's Manual.
4 There are two scales for each tank, with one the mirror image of the other.

Figure 5
Fuel contents gauge

The outlet pipes from the fuel tanks are fed to a three-way fuel selector valve (OFF, LEFT, RIGHT) mounted on the front cockpit floor. From the selector valve the fuel is fed through a gascolator mounted in the engine bay to an electrical fuel boost pump and an engine-driven mechanical fuel pump, which provides fuel under pressure to the single carburettor mounted on the bottom of the engine.

There is almost no head of pressure between the fuel tanks and the mechanical fuel pump and with a low quantity of fuel in the tanks the mechanical pump would need to suck fuel through the fuel system. The electrical fuel booster pump is fitted at the lowest point in the fuel system and when selected ON would help to ensure that there is a positive fuel pressure at the inlet side of the mechanical fuel pump. The aircraft Owner's Manual states that the intended function of this pump is to ensure a degree of redundancy for the mechanical pump during take-off and landing.

The switch for the fuel booster pump was mounted on the circuit breaker panel fitted on the right side of the front cockpit. The engine throttle, mixture and carburettor heat controls were mounted on the left side of the front cockpit.

The Owner's Manual provides the following warning concerning the use of fuel, which reflects the fuel types[5] available in the USA during the 1980s.

Footnote

5 It should be noted that fuel specifications in Europe and the USA differ. There is also a significant difference in Mogas produced in 1980 and 2018.

> *'Caution*
>
> *Under no circumstances should fuel of a lower octane rating than that specified by the manufacturer for your engine be used. Be sure the minimum octane is clearly labelled by each fuel cap. Color coding for 80/87 is red, 100LL is blue and 100/130 is green. Auto gas especially the high aromatic content no-lead should never be used.'*

The Light Aircraft Association (LAA) advised the investigation that the Rutan LongEz has not been approved to use Mogas of any specification. The advice from the LAA on the use of Mogas in light aircraft considers: possible chemical degradation of composite fuel tanks; degradation of rubber and elastomeric fuel system components; corrosion of metallic engine and fuel system parts; increased tendency for vapour lock and carburettor icing.

Engine

G-BPWP was fitted with a rear mounted four-cylinder, air cooled, Rolls-Royce Continental 0-240E[6] engine driving a two-bladed fixed-pitch pusher propeller. The initial engine specification permitted the engine to be operated on leaded automotive gasoline.

The Owner's Manual provides the following information regarding carburettor icing:

> *'The Continental engines are particularly susceptible to carburator ice. Icing can occur during cruise in moist air, particularly at low cruise power settings. When in moist conditions, check carburator heat often or cruise with heat on.'*

Carburettor heat

The carburettor is mounted on a flange located approximately 9 cm beneath the front part of the crankcase. Air enters the induction system through an intake located on the bottom of the fuselage and passes through an air filter and into an airbox before entering the carburettor. From the carburettor the air and fuel mixture passes through the induction manifold to the cylinders. Carburettor heating is provided by ducting unfiltered air from around the engine exhausts into the airbox and into the carburettor. The selection of the source of air is by a flap valve within the airbox which is operated by a lever mounted on the left side of the front cockpit.

As the carburettor is not mounted directly onto the crankcase, the amount of conducted heat available to melt ice forming within the venturi and on the butterfly valve may not be as high as on other makes of engine where the carburettor is bolted to a combined sump and intake manifold. Moreover, the amount of heat provided by the carburettor heating system will be dependent on the temperature of the exhausts which may be lower when the engine is operating at low power settings such as during a descent.

Footnote

[6] The 0-240E engine is an experimental version of the 0-240A engine and has a compression ratio of 8.5 to 1.

G-BPWP

G-BPWP was built in the 1980's and was first registered and flew in July 1989. The aircraft was registered to the current owner, the pilot, in March 1999 and was operated on a CAA Permit to Fly, administrated by the LAA. The last Permit Certificate of Validity was issued on 15 June 2018 and was valid until 30 June 2019. As part of the Permit to Fly Revalidation a flight test was undertaken on 14 June 2018 during which the following air speeds were recorded while testing the aircraft's slow speed characteristics:

> *'Natural buffet speed 64 kt*
> *Minimum airspeed achieved 57 kt'*

Aircraft examination

The aircraft was initially examined by the AAIB at the accident site, followed by a more detailed examination at their facilities at Farnborough.

General

The impact forces during the accident were mostly absorbed by the left wing and the nose section of the fuselage, which were extensively damaged. The nose landing gear leg, which was in the extended position, detached from the aircraft at the point of impact. The main landing gear structural cross member also failed. The cockpit area, seat harnesses and canopy remained intact. The speed brakes were found in the retracted position.

Engine

The engine and propeller were undamaged and all the main engine components were intact. The throttle was found at the fully forward, OPEN, position, the mixture was at RICH, the carburettor heat was at the COLD position and both magneto switches were ON. The engine turned freely by hand.

There was clean oil in the engine and the oil filter was clean. The spark plugs were in a good condition and the colour of the plugs and the piston heads indicated that the engine had been running normally. There was no evidence on the cylinder bores of the pistons having started to seize. All the engine valves and the drives for the magnetos and mechanical fuel pump operated when the engine was rotated by hand.

The operating arm and the diaphragm in the mechanical fuel pump were intact. The carburettor and the floats were intact and all the valves and linkages operated smoothly. Clean fuel was found in the gascolator, mechanical fuel pump and carburettor fuel bowl.

Fuel system

The main fuel cock was found at the LEFT tank position and the electrical fuel booster pump switch was found at the OFF position. Both fuel tanks were empty; however, when they were filled with water prior to the recovery of the aircraft, the water leaked out from both fuel tanks along the seams of the tank walls which had been damaged in the accident. Fuel of a light green colour was found in the fuel pipes and fuel components between both fuel tank outlet pipes and the carburettor. There was no evidence of debris in the fuel tanks, aircraft or engine fuel system. When electrically tested the pump operated normally.

Fuel onboard during the accident flight

The pilot reported that for economic reasons, since December 2017 his practice had been to operate the aircraft with Avgas 100LL in the right tank and a mixture of Avgas 100LL and 95 octane unleaded Mogas in the left tank. The fuel was kept in separate tanks in case he experienced an *"airlock[7]"* with Mogas.

The right fuel tank was last refuelled from the self-service Avgas 100LL pump at Biggin Hill on 13 June when the pilot uplifted 39 litres (8.6 gal) of fuel. It then flew 4 hours over 5 flights before the accident at Dunkeswell.

The left fuel tank was refuelled with Mogas, from two jerry cans, just prior to the accident flight. The jerry cans had been stored in the hangar for approximately 4 weeks prior to the accident flight.

The pilot reported that after passing Crewkerne, which was approximately 17 nm from the accident site, there were 4 and 6 gal of fuel in the left and right tanks respectively. Based on the available refuelling records, and the pilot's fuel planning figures, the AAIB calculated that there should have been sufficient fuel onboard the aircraft to complete the flight.

Fuel tests

Three small samples of fuel were recovered from the aircraft before it was moved from the accident site. The samples were taken from the fuel line between the right fuel tank and selector valve; the selector valve with the left fuel tank selected OPEN; and the drain on the carburettor fuel bowl.

The quantity of fuel was not sufficient to determine the composition and characteristics of the fuel; therefore, the samples were analysed by Gas Chromatography – Mass Spectrometry. All three samples appeared to be virtually identical and contained lead and no more than 1% by volume of ethanol. The laboratory concluded that the samples were a mixture of automotive gasoline (Mogas) and Avgas 100LL.

The laboratory advised that automotive gasoline (Mogas) generally has a higher vapour pressure than Avgas 100LL and therefore the use of automotive gasoline will increase the likelihood of vapour lock and carburettor icing.

While the engine had been operating on a partial mixture of unleaded Mogas containing ethanol, which had not been approved by the LAA when operating on an LAA Permit to Fly, and which the engine specification and aircraft Owner's Manual did not allow, the use of Mogas had not appeared to have caused any damage or deterioration to the engine or aircraft fuel system.

Footnote

7 See the section in this report on vapour lock.

Carburettor icing

Carburettor icing occurs in humid air when the temperature drop in the venturi is sufficient to cause the water vapour to freeze and ice to form on the surfaces of the carburettor throat. This can change the airflow sufficient to cause rough running, a loss of engine rpm or the engine to stop. Carburettor icing can occur at ambient air temperatures above 30°C and is more likely to occur at idle or during cruise power settings.

An aftercast from the Met Office reported that at the time of the accident the air temperature was 25°C and the dew point was 14°C. From the CAA graph on the probability of carburettor icing (Figure 6), at the time of the accident there would have been a moderate risk of carburettor icing during the cruise and a serious risk during the decent.

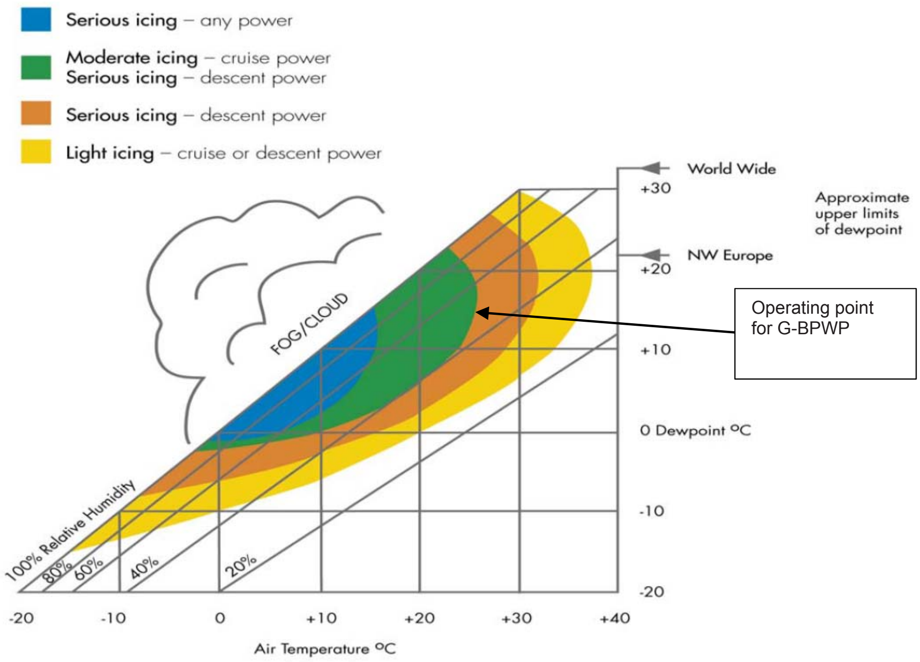

Figure 6

Probability of carburettor icing

Vapour lock

If fuel turns to vapour in the aircraft fuel system, large bubbles can form at high points within the fuel system or in a constriction in the fuel pipe which can prevent the passage of fuel to the engine. This phenomenon is known as 'vapour lock' and the effect can be a 'dead-cut' of the engine. Vapour lock is most likely to occur on aircraft fitted with engine-driven mechanical fuel pumps and where there is a low head of fuel pressure between the fuel tanks and the mechanical fuel pump.

In comparison with 100LL and UL91 Avgas, Mogas has a much higher vapour pressure and consequently fuel systems using Mogas are at an increased risk of vapour lock. An increase in the fuel temperature and drop in the fuel pressure within the fuel system, particularly in areas such as the diaphragm in the mechanical fuel pump, can release bubbles of gas sufficient to cause vapour lock. The LAA have advised that the risk of vapour lock occurring inside an engine-driven pump may increase greatly during a long throttled-back descent because the reduced flow rate through the pump allows the hot pump body time to heat the fuel inside to a higher temperature.

It should be noted that even when an aircraft has been cleared to use either Avgas or unleaded Mogas, the vapour pressure of a mixture of Avgas containing a small quantity of Mogas will be almost as high as that of pure Mogas.

The LAA has produced a Technical Leaflet (TL 2.26[8]) regarding the use of unleaded Mogas in piston engines. Due to the greater risk of 'vapour lock' the LAA have placed an operating limit on the use of Mogas of the fuel tank temperature not exceeding 20°C and the altitude not exceeding 6,000 ft.

Aircraft Owner's Manual

The first edition of the Long-Ez Owner's Manual[9], published in May 1980 states:

> *'Descent/Landing*
>
> *Circuit Breakers – In*
> *Fuel – Fullest tanks*
> *Mixture – Rich as required*
> *Carb Heat On [HOT] as required*
> *Boost Pump – On below 1000 ft AGL*
> *Gear – Down below 110 knots*
> *Landing Brake – On as required'*

In the section on '*Emergency Procedures'* it states:

> *'ENGINE FAILURE*
>
> *…In the event of inflight engine stoppage, check mixture – RICH, fuel – switch tanks, boost pump on, magnetos, BOTH, and attempt a restart.*
> *…*
>
> *ENGINE OUT APPROACH*
>
> *If an engine-out landing is unavoidable, check wind direction, choose your landing area and establish your glide at 70 to 75 knots…Remember that with the engine out and prop windmilling, your glide will be considerably steeper than the normal engine-idle glide that you are accustomed to…Shut off the fuel valve…Turn your electrical power and mags off before touchdown to minimise any potential fire hazard…'*

Footnote

8 LAA leaflet TL 2.26 can be found here: https://www.lightaircraftassociation.co.uk/engineering/TechnicalLeaflets/Operating%20An%20Aircraft/TL%202.26%20Procedure%20for%20using%20E5%20Unleaded%20Mogas.pdf {accessed Nov 2018]

9 This manual was provided by the designer for guidance only and has no formal approval or recognition.

CAA Safety Sense Leaflet

The CAA's Safety Sense Leaflet, 1e, '*Good Airmanship'*[10] *states:*

> *'23 EN-ROUTE*
>
> *…*
>
> *d) Don't overlook en-route checks such as **FREDA** – **f**uel, **r**adio, **e**ngine, **DI** and **a**ltimeter. 'Engine' should include a carb heat check.*
>
> *…*
>
> *29 CIRCUIT PROCEDURES*
>
> *h) In most piston-engined aircraft, apply full carb heat early enough to warm it up BEFORE reducing power.'*

It is good airmanship to do a FREDA check approximately every 20 minutes and prior to making an approach to land.

Analysis

Operational aspects

The Long-Ez Owner's Manual includes, in the Descent/Landing checklist, the following selections: fullest fuel tank, carburettor heat HOT and fuel booster pump ON. However, despite the passenger advising the pilot that he had 4 gal in the left and 6 gal in the right fuel tank, he elected to leave the left (lowest) fuel tank selected. Had the pilot selected the fullest tank (right) the engine would have been supplied by Avgas during the later stages of the flight which is less susceptible to carburettor icing and vapour lock. The pilot acknowledged that he should have kept the carburettor heat selected HOT throughout the approach and landing.

The engine failure procedure in the Owner's Manual states that in the event of an inflight engine stoppage, change fuel tanks and select the boost pump ON before attempting a restart. The pilot did not follow these actions; however, given that the aircraft was at a very low height when the engine stopped, it was not unreasonable to have just attempted to restart the engine as there would have been limited time thereafter to prepare for the forced landing. The priority is always to fly the aircraft followed by actioning checklists if time is available.

The aircraft's estimated airspeed during the final approach was about 70 kt, which was consistent with the recommended glide speed of 70 to 75 kt. The damage to the aircraft, ground marks and recorded data indicate that the pilot may not have arrested the aircraft's high rate of descent sufficiently to prevent it landing firmly.

Footnote

[10] Safety Sense Leaflet 1e can be found here: http://publicapps.caa.co.uk/docs/33/20130121SSL01.pdf (accessed Nov 2018)

Engine failure

The engineering examination established that all the fuel components were serviceable, and the fuel system was clear of debris. The presence of fuel throughout the fuel system and the pilot's report of his fuel status prior to the engine stopping indicates that there was sufficient fuel on the aircraft to complete the flight.

The engineering examination could identify no fault that would have caused the engine to stop.

Carburettor icing

The Owner's Manual advises that the engine is susceptible to carburettor icing and in moist conditions the carburettor heat should be selected ON (HOT) often, or left ON, during the cruise. The humidity at the time of the accident was approximately 50% and there would have been a moderate risk of carburettor icing at cruise power setting and a serious risk at descent power setting.

Prior to the engine stopping, the aircraft had been in the cruise and then descended to circuit height at a relatively low power setting. The pilot stated that during the flight he had adopted his usual technique of applying carburettor heat every 20 minutes and that during the downwind leg he initially selected HOT and then COLD. It is therefore possible that the frequency of application may have been insufficient. It is also possible that the temperature of the exhausts at the low engine power settings might have been insufficient to warm the air sufficiently to clear any build-up of ice.

Vapour lock

The Rutan Long-Ez had not been approved to operate with Mogas and with relatively high ambient air temperatures in the days leading up to the accident, it is likely that the temperature of the fuel in the aircraft tanks was above the Mogas operating limitation of 20°C set by the LAA.

The design of the fuel system on the Rutan Long-Ez is such that at low fuel tank quantities there is no positive head of pressure between the fuel tank and mechanical fuel pump. With the electrical booster pump selected OFF, there would have been a pressure drop within the fuel system, including the suction side of the mechanical fuel pump, as it drew fuel through the system. The low fuel flow at the low engine power might also have contributed to an increase in the fuel temperature as it passed through the fuel pipes and components in the engine bay. The presence of these factors may have increased the possibility of a vapour lock occurring during the later stages of the flight sufficient to cause the engine to stop.

The electrical fuel booster pump is positioned at the lowest point in the fuel system and given the relative position of the fuel tanks its inlet will always have a positive head of pressure. Operation of the booster pump during all stages of the flight would ensure that there is a positive fuel pressure at the inlet to the mechanical fuel pump that might help to prevent vapour lock from occurring.

While the Owner's Manual states that the electrical fuel booster pump should be used to provide redundancy during take off and landing there might be merit in running the electrical pump throughout the flight, particularly when the ambient air temperature is relatively warm. However, consideration would need to be given to the capability and safety of running the electrical pump for long periods. There could be a similar situation with other aircraft that use Mogas and where there is a low head of pressure between the fuel tank and mechanical fuel pump.

Conclusion

The aircraft's engine most likely stopped because of either carburettor icing or fuel vapour lock. The probability of these factors occurring would have increased as a result of using Mogas, which the aircraft was not authorised for, and not ensuring that the electrical fuel pump and carburettor heat were selected ON during the approach and landing. Following the engine failure the pilot would have been faced with a steeper than normal glide approach and most likely did not arrest the high rate of descent sufficiently before the aircraft touched down firmly.

Safety action

> The LAA have advised that they will use this accident to publicise the risk from vapour lock when operating piston engines on Mogas.

AAIB Correspondence Reports

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

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

The accuracy of the information provided cannot be assured.

ACCIDENT

Aircraft Type and Registration:	Britten Norman BN2B-26 Islander, VP-FBM
No & Type of Engines:	2 Lycoming O 540-E4C5
Year of Manufacture:	1989
Date & Time (UTC):	11 June 2018 at 1454 hrs
Location:	Beaver Island, Falkland Islands
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to right oleo fairing, flap, wing inboard upper and engine upper mounts
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	16,635 hours (of which 16,030 were on type) Last 90 days - 89 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft touched down short of the undershoot area causing significant damage to the right landing gear, wing and engine mounts. The accident was probably caused by a stall or unexpected descent due to turbulence or windshear under the prevailing conditions.

History of the flight

The aircraft was on a short flight of about 12 minutes between airfields on Weddell Island and Beaver Island. It was being operated by a single pilot who had considerable experience on both the aircraft type and in operating in the Falkland Islands. This was his first day back after a period of leave, having returned to the Falkland Islands the previous day from a stay overseas. The pilot reported that he was well rested after only a short flight back.

Weddell Island was experiencing a southerly wind at the time the pilot took off so he was expecting to land on Runway 13 at Beaver Island. Whilst downwind for Runway 13 he contacted his destination by radio to be informed that the wind strength and direction favoured instead an approach to Runway 27. The pilot then repositioned the aircraft for Runway 27, rolling out of the final turn on short final.

Video footage taken by the passengers on board recorded that about 8 seconds after rolling out onto final the stall warning horn sounded, quickly followed by an impact as the aircraft appeared to touch down hard. The pilot reported that he had felt the right wing drop just before the impact.

A later inspection revealed marks from the left wheel on a small bank about 14.5 m short of the start of the runway undershoot area and from the right wheel about 12.4 m short. There were further marks from both wheels indicating the aircraft had struck further banks before both wheels remained on the ground 3.5 m inside the undershoot area.

During the subsequent landing roll the aircraft veered initially to the right but the pilot managed to keep it under control. He taxied the aircraft clear of the runway before shutting down. On inspecting the aircraft it was apparent there was significant damage to the right landing gear, engine mounts and wing.

Airfield Description

The airstrip on Beaver Island comprises a main strip, Runway 13/31 (414 m x 20 m), and a secondary strip, Runway 09/27 (287 m x 18 m). The thresholds on each are marked with L-shaped white markers and the sides with further white markers at 60 m intervals. There are 30 m undershoots to each strip, marked by red and white markers. These areas are deemed safe for aircraft manoeuvres, allowing an increased takeoff run and a safety margin in case of an aircraft touching down slightly short of the strip. There can be local wind effects due to the surrounding topography and the airfield has a maximum crosswind limit for flight operations of 20 kt.

Weather

The pilot reported the wind at the time of the accident was from the south-west at approximately 20 kt, requiring the use of the secondary strip, with a crosswind of about 15 kt. Visibility was about 8 km in mist with a cloud base of about 400 ft.

Conclusions

The evidence indicates it is likely the aircraft stalled, or suffered an unexpected descent, on final approach whilst at low height, just short of the undershoot area. This was probably caused by a combination of the low approach speed, necessary to operate to the short strip, and turbulence or windshear caused by the topography of the local area under the prevailing wind conditions. The pilot commented that the stall warner often sounds just prior to touch down and the fact it sounded on this occasion did not necessarily indicate a full stall of the aircraft.

Despite the challenges offered by the airstrip, the pilot was experienced and capable of operating under the prevailing conditions. The pilot was confident that despite his recent travel back to the Falkland Islands fatigue was not a contributory factor. The pilot also commented that it is not unusual in this sort of operation to fly only a short final approach, but it is possible that the late repositioning due to the change of landing runway contributed to the handling of the flight, just prior to touchdown.

As a result of the accident, the operator conducted its own review. This determined that whilst the strips on Beaver Island complied with relevant requirements, as a further precaution some of the banks short of the undershoot areas would be levelled off.

ACCIDENT

Aircraft Type and Registration:	Boeing 737-8AS, EI-GDZ
No & Type of Engines:	2 CFM56-7B26E turbofan engines
Year of Manufacture:	2018 (Serial no: 44820)
Date & Time (UTC):	30 April 2018 at 1035 hrs
Location:	London Stansted Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 7 Passengers - 170
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to the left elevator
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	19,300 hours (of which 5,800 were on type) Last 90 days - 395 hours Last 28 days - 51 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was being pushed back prior to engine start and was to stop abeam Stand 50R. The groundcrew did not stop the aircraft at the allotted place, which caused the aircraft's elevator to contact the blast fence.

History of the flight

The aircraft was parked on Stand 43L at Stansted Airport, and because it was unable to make a Calculated Take Off Time (CTOT) of 0845 hrs a new CTOT of 1005 hrs was allocated. The crew requested to "PUSH AND HOLD" which was granted by the ground controller who added, "PUSH ACROSS TO THE EAST LINE, ABEAM STAND 50R. DO NOT START ENGINES". These instructions were repeated to the groundcrew. During the pushback, ATC informed the crew of a new CTOT, very close to the present time. The crew informed the groundcrew and advised them that they would start engines after the pushback. Approaching the end of the pushback, the flight crew felt the tug stop abruptly. The commander asked the groundcrew if everything was alright and the groundcrew responded that they had pushed the aircraft too close to the blast fence and were going to pull it forward. The Senior Cabin Crew member called the flight deck on the interphone and informed them that she and the cabin crew seated at the rear of the aircraft felt that the tail of the aircraft had struck something. The commander checked with the groundcrew, who thought it hadn't, but the commander contacted engineering who sent out an engineer. On inspection, damage was found to the trailing edge of the left elevator. The commander called the ground controller and informed them of the collision. The Fire Service attended and, following an inspection, determined that there was no immediate danger to the aircraft or passengers, which was also confirmed by the engineer. The aircraft was towed to Stand 50L and the passengers disembarked using the air stairs.

Parking area

The aircraft was parked on stand C43L with the headset operator on the right side of the aircraft, in communication with the flight deck and the tug driver in his driving position. The weather was described as poor visibility with strong winds and heavy rain causing standing water, reflecting the airport lights and making the ground markings difficult to see. The intended stands and taxi lines are shown at Figure 1.

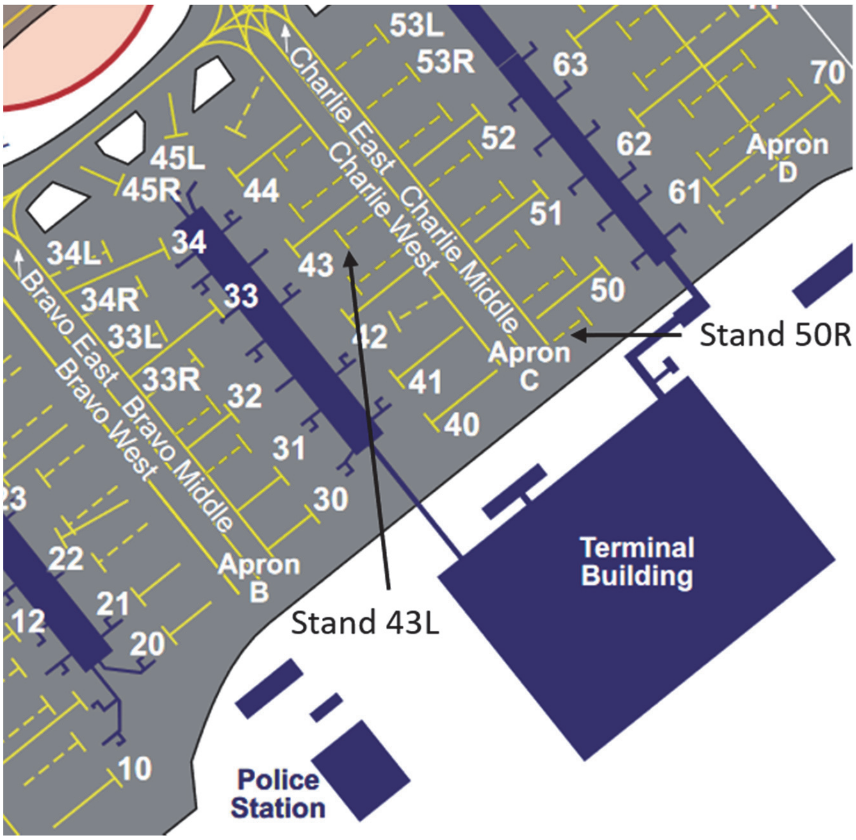

Figure 1

Parking stands and taxi lines with 50R being closest to the blast fence.

A person in a vehicle, which was not connected with the aircraft manoeuvring, witnessed the incident and pointed out the damage to the groundcrew. The company engineer, airfield operations vehicle and airport Rescue and Fire Fighting Service (RFFS) attended promptly and, once they declared the aircraft safe to be moved, it was positioned onto stand 50L and the passengers disembarked.

Recorded information

Closed-circuit Television (CCTV) of the event showed that the aircraft was pushed back but moved slightly from side to side as the tug driver attempted to locate and follow the taxi line. When the tail of the aircraft contacted the blast fence, the tug stopped and then reversed a short distance before becoming stationary. The images in Figures 2 to 6 were taken from the CCTV recording.

Figure 2
Initial pushback from the Stand 43L

Figure 3
The aircraft approaching the taxi line with the headset person on the right side of the aircraft

Figure 4
The aircraft established on the taxi line

Figure 5
The aircraft contacting the blast fence

Figure 6
The aircraft contacting the blast fence from a different camera angle

Pushback ground crew

The aircraft operator reported to the AAIB that the tug driver had highlighted the difficulty of identifying the taxiway line marking due to the surface water, which led to his loss of bearings. He also stated that he did not feel the impact of the collision from his position inside the tug, which was why he was not aware of what had happened. The headset operator was unsure of the term ‘abeam’ and thought that abeam was based on the position of the pilot’s window. This position, he thought, would allow enough clearance behind the aircraft from the blast fence and so he did not attempt to stop the pushback. He advised the tug driver that he thought the aircraft had struck the fence, and the tug driver pulled the aircraft forward. The headset operator was still in his training period and was being assessed by the tug driver but operating on his own alongside the aircraft.

Discussion

The clearance was to carry out a pushback of the aircraft to abeam Stand 50R and the headset operator believed this would be when the pilot’s window was in line with the stand. The pushback continued until the elevator struck the blast fence but the relative positions of the pilot’s window and the stand were not determined at this point.

The poor weather, light and poor clarity of the taxi line as seen by the tug driver meant that all his attention was focussed on his task. This and his restricted viewpoint from the nose of the aircraft prevented him from monitoring the actions of the headset operator and being aware of the proximity of the tail to the blast fence.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 787-9 Dreamliner, G-TUIM
No & Type of Engines:	2 General Electric Co GENX-1B70/P2G01 turbofan engines
Year of Manufacture:	2018 (Serial no: 62742)
Date & Time (UTC):	6 July 2018 at 1711 hrs
Location:	London Gatwick Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 11 Passengers - 353
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	11,576 hours (of which 2,708 were on type) Last 90 days - 165 hours Last 28 days - 74 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was on approach to Runway 26L at London Gatwick Airport and was being configured to land. After FLAPS 1 was selected, there was a progressive deterioration in normal flight controls, landing gear lowering and nosewheel steering capabilities. The crew performed a go-around and actioned the relevant checklists. The aircraft landed safely with FLAPS 20 set but with the nosewheel steering inoperative.

The cause of the system degradation was a failure of the Nose Landing Gear Isolation Valve (NLGIV). Following this event, the manufacturer changed its procedures in relation to the manufacturing and testing of the NLGIV.

History of the flight

The aircraft was on a flight from Tenerife South Airport (GCTS) to London Gatwick Airport (EGKK) and was being radar vectored on the base leg for an ILS approach to Runway 26L. The weather was good with CAVOK and a light wind. During the configuration for landing, and after FLAPS 1 was selected, there was a progressive deterioration in normal flight controls, landing gear lowering and nosewheel steering capabilities. Initially, the SLATS PRIMARY FAIL and FLAPS PRIMARY FAIL EICAS[1] messages were displayed after which there was

Footnote

[1] Engine Indication and Crew Alerting System (EICAS).

difficulty in lowering the nose landing gear and a fault was indicated with the nose wheel steering system. Given the deteriorating and complex situation, the crew discontinued the approach and used ATC to provide radar vectors and monitoring to allow them to action several checklists. The nose landing gear was lowered using the alternate system, but a fault was indicated with the nosewheel steering. The effects of landing without nosewheel steering were discussed, along with considerations associated with the need to land using FLAPS 20. Autobrake 4 was to be used initially, using rudder for directional control. Once the rollout was stabilized and the aircraft was approaching 80 KIAS, manual braking would be commenced to disconnect the autobrake and complete the rollout with a fairly high rate of deceleration. The commander's interest in stopping quickly was to allow spare runway distance to bring the aircraft back to the centreline using differential braking if required.

A NITS[2] brief was given to the cabin crew for a precautionary landing due to the flap and slat issue, which was then upgraded on the final approach to cover an emergency landing once the potential ramifications of the nosewheel steering problem had been considered. The Senior Cabin Crew Member (SCCM) initially briefed the other cabin crew using the interphone for a precautionary landing but, on instruction from the commander, he then briefed the passengers and cabin crew for an emergency landing and on the brace positions. He then looked out of the window and realised the aircraft was quite low. Having not heard any "CREW AT STATIONS" or "BRACE" commands from the flight deck, he initiated the "BRACE, BRACE, HEADS DOWN, HEADS DOWN" commands, which were heard by the other cabin crew and repeated by them. After the aircraft landed and came to a stop, the "CABIN CREW STANDBY, STANDBY" PA was made by the commander. Shortly afterwards, the commander made the "CABIN CREW NORMAL OPERATIONS, NORMAL OPERATIONS" PA and provided an explanatory PA to the passengers. The aircraft was towed to stand where the passengers were disembarked normally.

Recorded information

At 1652 hrs, during the descent and passing 5,500 ft, heading 054° M and approximately 3 nm north of the Mayfield VOR, FLAPS 1 was selected[3]. The EICAS caution SLATS PRIMARY FAIL was displayed and reported to ATC after which the crew actioned the Electronic Check List (ECL). The aircraft made a right turn under radar vectors, levelling at 4,000 ft, and continued in an extended orbit to the right. During the orbit, FLAPS 5 was selected and the EICAS displayed FLAPS PRIMARY FAIL. The ECL actions were carried out which required a FLAPS 20 landing. The aircraft completed the orbit and was vectored to the north-east, and, during a level left turn to intercept the localiser, FLAPS 20 was selected using the electrical alternate system. The aircraft was established on the localiser at approximately 18 nm, configured at FLAPS 20 and 154 KIAS. At approximately 9 DME the landing gear was selected down after which the EICAS message GEAR DISAGREE was displayed. The commander advised that the nose landing gear indication was a cross-hatched box, indicating the nose landing gear was in transit. Prior to capturing the Glideslope (GS), the approach was broken off and a left turn to the south was flown, continuing into another

Footnote

[2] Nature; Intentions; Timings; Special instructions (NITS).
[3] In the FLAPS 1 position, the leading edge slats extend to the mid position; the trailing edge flaps do not extend.

extended orbit during which the nose landing gear was successfully lowered using the alternate system. The aircraft was repositioned onto the ILS and a stable approach was made with the autopilot disengaged at 1,140 ft (threshold elevation196 ft). The aircraft landed, and no difficulty was reported with directional control on the runway where the aircraft was brought to a stop after a landing roll of 5,513 feet. The aircraft came to a stop at 1712 hrs and the engines were shut down at 1719 hrs.

Aircraft information

This was the third incident involving G-TUIM in a week where similar indications of system degradation had occurred but it was the first where problems with the nose landing gear and nosewheel steering were indicated.

1. On 30 June 2018, on the base leg to LGW a SLATS PRIMARY FAIL message was displayed on the EICAS. The approach was continued to a normal landing and rollout.
2. On 4 July 2018, left downwind for Runway 09L, on selection of FLAPS 1, an EICAS message SLATS PRIMARY FAIL was displayed and the ECL actioned. On selection of FLAPS 5, the FLAPS PRIMARY FAIL caption was displayed. The approach was delayed and, after completion of the ECL and a recalculation of the landing distance required, a FLAPS 20 landing was carried out.

The engineering department carried out the required system and serviceability checks which were passed satisfactorily. It was decided to order a replacement Hydraulic Control Unit (HCU) and maintenance action was planned for the aircraft.

During the event on 6 July 2018 there were similar slats and flaps system failures but, additionally, there were GEAR DISAGREE and NOSE WHEEL STEERING EICAS messages. The reported failures also highlighted that the hydraulic synoptic page[4] displayed an 'amber cross' through the Nose Landing Gear Isolation Valve (NLGIV). The NLGIV subsequently failed a serviceability test and was replaced. The aircraft was returned to service and had not experienced any recurrence of the problem by the time of publication of this report.

Engineering

The incident was discussed with the operator's engineering reliability team, and the aircraft manufacturer was requested to examine the fault and to address concerns regarding the NLGIV, as well as system monitoring and functionality. As a result, the manufacturer considered whether a cold-soaked condition might affect the valve operation and considered a possible amendment and Fault Identification Manual (FIM) revision. The manufacturer also found that early in the Boeing 787 programme there were similar events that had been investigated. The root cause was found to be brinelling (an undesirable wear) of an internal component called the 'pintle' and 'coining' of a valve seat. This condition was not identified by the original Acceptance Test Procedure (ATP), so the ATP was altered to identify this condition. Manufacturing changes were also made to ensure that 'brinelling' did not occur on delivered parts.

Footnote

4 The EICAS displays general views (synoptics) of each aircraft system on system 'pages'.

A response from the manufacturer received on 10 October 2018 regarding the NLGIV advised that the NLGIV was cold tested to -40˚F. The unit failed to open under those conditions and the failure was repeatable. This finding will support future work and potential mitigating actions, which were being examined. A FIM revision is being made and an amendment to the Aircraft Maintenance Manual to add an operational test of the valve.

Analysis

The flight crew were confronted with an escalating degradation of normal systems that progressed from an initial failure of the primary slats and flaps systems. When the landing gear was selected DOWN, a GEAR DISAGREE message was displayed on the EICAS indicating that the nose landing gear had not achieved the selected position. The alternate landing gear lowering system was used to lower the nose landing gear into the correct position, but a further message indicated a fault with the nosewheel steering. ATC was used to assist the crew by directing them to fly orbits during which they were able to action the ECL and discuss their plan for the landing. The commander carried out a NITS brief for the SCCM, briefing a precautionary landing. With the additional problem of the nosewheel steering, however, this was upgraded to a briefing for an emergency landing, and the SCCM carried out the required cabin briefing and actions. When the SCCM realised that the aircraft was close to landing and no orders had been received from the flight deck, he issued the “BRACE, BRACE, HEADS DOWN, HEADS DOWN” command which ensured that those in the cabin were properly prepared. The landing rollout was safely accomplished using the rudder for aerodynamic directional control followed by differential braking to maintain the runway centreline. The engines were stopped on the runway and the aircraft towed to the parking stand and the passengers disembarked normally.

Conclusion

The incident was caused by the NLGIV failing to open when commanded which meant that the leading-edge slats, trailing edge flaps, nose landing gear and nosewheel steering would not operate normally. The alternate electrical system was used to select FLAPS 20 and lower the nose landing gear.

Safety Action

Following this incident, the aircraft manufacturer:

1. Introduced changes to the component Acceptance Test Procedure for the NLGIV
2. Made changes to the manufacturing procedures of the NLGIV to prevent brinelling.
3. Made amendments to the FIM and AMM to add operational tests of the NLGIV.

Bulletin addendum

An addendum was issued concerning this report on 11 April 2019 and can be viewed online. The addendum will also appear in the May 2019 Bulletin.

SERIOUS INCIDENT

Aircraft Type and Registration:	1) Cessna 182T Skylane, G-ORDM 2) Hercules C130J C Mk 4, ZH878
No & Type of Engines:	1) 1 Lycoming IO-540-AB1A5 piston engine 2) 4 AE2100D3 Turboprop
Year of Manufacture:	1) 2003 (Serial no: 18281206) 2) Not known
Date & Time (UTC):	20 July 2018 at 1215 hrs
Location:	RAF Brize Norton, Oxfordshire
Type of Flight:	1) Private 2) Military
Persons on Board:	1) Crew - 1 Passengers - None 2) Crew - 3 Passengers - None
Injuries:	1) Crew - None Passengers - N/A 2) Crew - None Passengers - N/A
Nature of Damage:	1) Airframe and engine damage 2) No damage
Commander's Licence:	1) Airline Transport Pilot's Licence 2) Airline Transport Pilot's Licence
Commander's Age:	1) 39 years 2) 48 years
Commander's Flying Experience:	1) 3,567 hours (of which 3 were on type) Last 90 days - 63 hours Last 28 days - 39 hours 2) 6,057 hours (of which 679 were on type) Last 90 days - 55 hours Last 28 days - 22 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and the report from the joint investigation conducted by the aircraft operator and the pilot's employer

Synopsis

While being positioned for pre-takeoff engine checks, G-ORDM, a Cessna 182, was caught in the propwash from a Hercules C-130J (ZH878) stationary at the runway holding point ahead. The Cessna was tipped onto its right wingtip and slid sideways for several metres before coming to rest on all three wheels. The pilot was uninjured and vacated the aircraft without external assistance.

History of the flight

G-ORDM had taxied behind ZH878 to Holding Point G (Golf) at RAF Brize Norton, with the pilot maintaining, what he assessed to be, 50 to 100 m separation behind the C-130J. He did not encounter any adverse propwash effects while taxiing to the holding point. On arrival at Golf, he began to turn his aircraft into wind to conduct engine power-up checks. At this point, ZH878 was stationary while the crew completed their Pre-Take Off checks unaware that G-ORDM was behind them (Figure 1). The last item in those checks was the Propeller Overspeed Check which required an increase in engine power from Ground to Flight Idle.

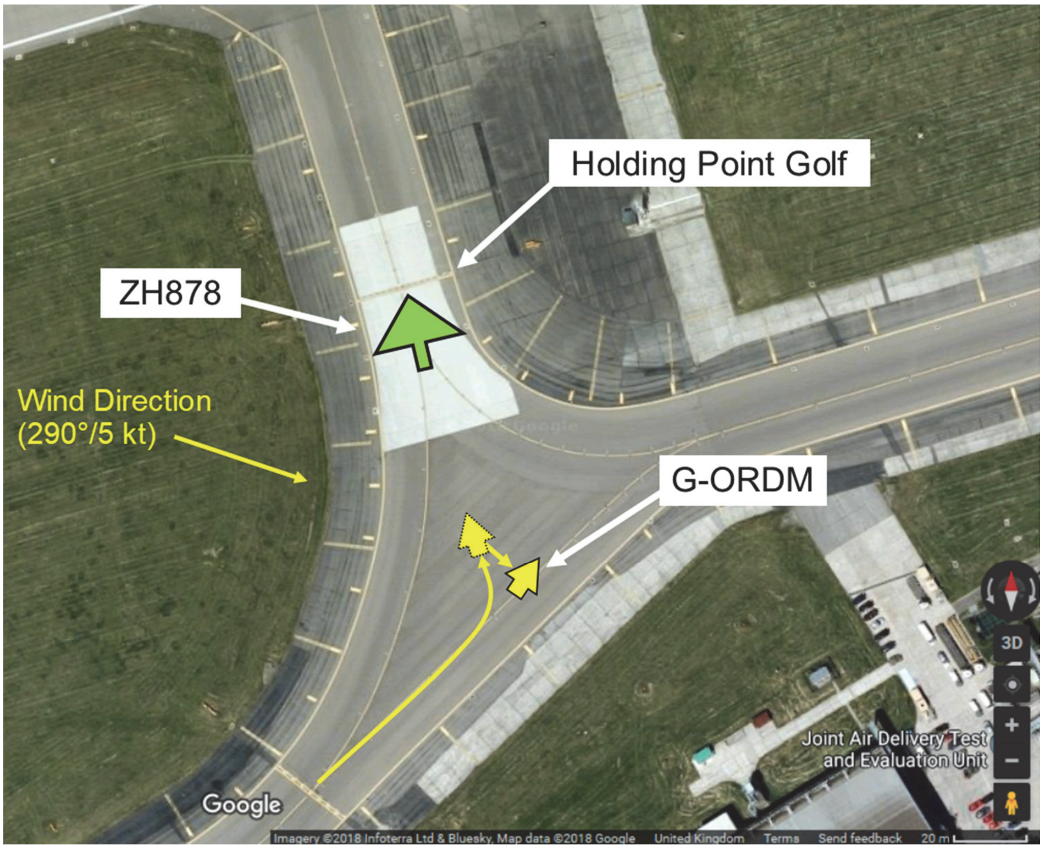

Figure 1

Relative positions of the aircraft at Golf and approximate ground track of G-ORDM

Midway through his positioning turn, the pilot of G-ORDM heard the C-130J's engine note increase and immediately felt violent buffet from its propwash. The turbulent airflow lifted the Cessna's nosewheel clear of the ground and its wings began to rock violently. Concerned that his aircraft might be flipped backwards, G-ORDM's pilot attempted to clear the propwash area by turning right. Despite the application of left aileron to hold the wing down, the aircraft was briefly lifted off the ground before being tipped onto its right wing. It then pivoted on the right mainwheel and nosewheel and was blown sideways for approximately 8 m before coming to rest upright, on all three wheels (Figure 2).

Figure 2
G-ORDM on the taxiway after the accident

During the sideways movement the propeller struck the ground numerous times before the engine failed (Figure 3). The pilot, who was uninjured, transmitted a Mayday call and vacated the aircraft unaided.

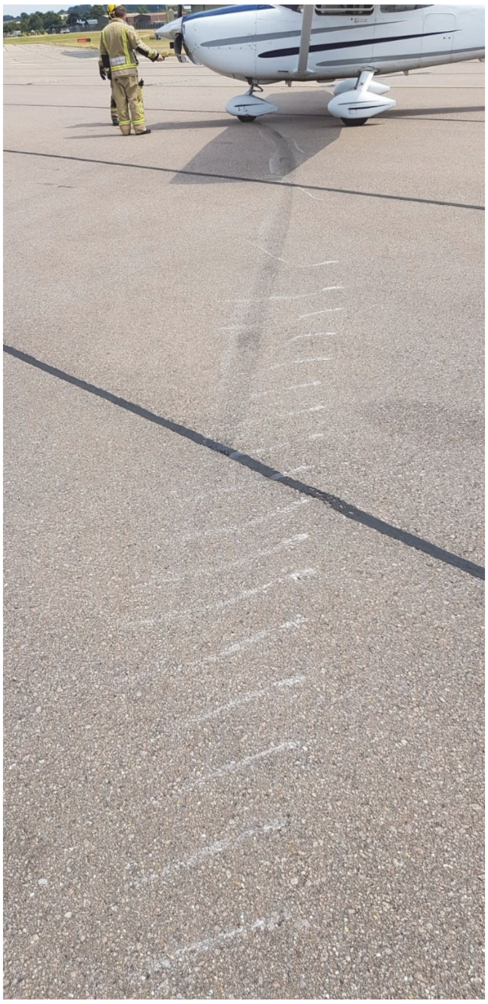

Figure 3
Witness marks on the taxiway from G-ORDM's nosewheel and propeller

Personnel

The accident pilot had spent most of his career flying large aircraft, including the C-130J, and had recently renewed his Single Engine Piston aircraft class rating.

Human factors

G-ORDM's pilot had used visual cues, based on the size of the C-130J ahead, to assess his taxi spacing. He believed that he had consistently maintained 50 to 100 m behind the other aircraft en route to the holding point. Analysis of the relative positions of the aircraft after the accident, supported by eye-witness testimony, suggested that the actual separation at the time of the propwash encounter was approximately 25 m. The pilot stated that while taxiing he did not experience any thrust effects from the preceding C-130J and, consequently, the separation distance achieved became his 'safe-norm' for the situation. Even though he was qualified on the C-130J, the pilot was surprised by the intensity and extent of the propwash hazard area. He further observed that Flight Idle thrust was significantly higher than the breakaway thrust requirement for even a fully-laden C-130J.

The C-130J commander considered it normal to conduct the propeller overspeed check at the runway holding point. He did not consider that it constituted a high-power ground run and therefore did not feel obliged to pre-warn ATC or other aircraft.

Other information

Company investigation

The Hercules and Cessna were operated by two different companies but within a parent business group. The Cessna pilot was employed by the Hercules operator and the aircraft was being flown in support of that company. Due to the interlinked nature of the flights, a joint investigation into the accident was undertaken by the Cessna's operator and the company employing the pilot.

The joint investigation noted that there was no promulgated data for C-130J propwash intensity, nor were there any associated warnings in the C-130J Aircrew Manual. While unable to determine a '*quantitively "safe" distance that the Cessna should have maintained*', the investigation determined that the accident was a result of insufficient separation between the two aircraft at Holding Point Golf.

The investigation report surmised that pilots flying light aircraft, but more familiar with operating larger aeroplanes, could become desensitised to the risks associated with jet blast and propwash. In relation to the C-130J propeller overspeed check, the report stated:

> *'the normalisation of conducting the test at the holding point may lead to C-130 crews not appreciating that the test is a "high-power pre-flight check" and considering a large enough safety margin behind the aircraft.'*

Large aircraft taxi-thrust requirements

Due to their inertia, ground manoeuvring can require increased thrust levels from large aircraft. Examples of situations where above-idle thrust can routinely be expected are: the use of breakaway thrust[1] to taxi off from a standstill or heavy aircraft making tight-radius turns.

Analysis

While generated for their internal audience, the companies' joint investigation report's conclusion has relevance for the wider aviation community. Pilots of light aircraft need to anticipate and, where possible, avoid areas where propwash and jet blast from large aircraft could be encountered during ground operations. The checklist item requiring increased power might not have been reasonably anticipated, but the potential for the C-130J to use increased thrust when taxiing forward to the runway remained.

In this accident, the increased thrust from the preceding aircraft was significantly higher than the breakaway requirement. Had the C-130J crew considered the check to be a high-power event it is likely they would have communicated their intent to ATC, thereby alerting the pilot of G-ORDM to their intentions.

While qualified on the C-130J, the accident pilot was nonetheless surprised by the extent and intensity of the propwash effects encountered.

Unless backed up by known distance markers, the assessment of taxi separation is subjective. On this occasion the pilot's perception of aircraft separation distance at the holding point appears to have been at least double that achieved.

Conclusion

This accident serves as a reminder to all pilots of light aircraft of the dangers of overestimating separation and underestimating thrust effects from larger aeroplanes. Where it is not possible to avoid taxiing behind other aircraft, separation distances should always err on the generous side. It can be anticipated that heavy aircraft may need to use increased thrust when moving from a standstill or conducting tight manoeuvres and spacing should be increased accordingly. By communicating their intent to increase thrust above normal ground manoeuvring levels, pilots of any sized aircraft can help others anticipate and avoid potential hazard areas.

Footnote

1 Increased engine power needed to initiate movement and reach taxiing speed.

ACCIDENT

Aircraft Type and Registration:	Pioneer 300 Pioneer, G-RABS
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2006 (Serial no: PFA 330-14563)
Date & Time (UTC):	11 November 2018 at 1105 hrs
Location:	Strathaven Airfield, South Lanarkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller and nose landing gear damage plus minor damage to lower cowlings and firewall
Commander's Licence:	Light Aircraft Pilot's Licence
Commander's Age:	75 years
Commander's Flying Experience:	1,011 hours (of which 462 were on type) Last 90 days - 7 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot had taken off from Strathaven Airfield for a local flight. Shortly after getting airborne the weather started to deteriorate, and the pilot decided to return to the airfield to land on grass Runway 09. The outside air temperature was about 8°C and light rain.

During the final stages of the approach the pilot selected the cabin heat ON. Shortly after, the inside of the windshield rapidly misted up, obscuring the pilots forward view. The pilot subsequently misjudged the flare and the aircraft landed heavily, causing the nose gear to collapse and the propeller to strike the runway. The aircraft came to a stop shortly after on the runway. The pilot was uninjured.

The pilot considered that the late application of cabin heat had most likely caused warm moist air within the cockpit to condense on the windscreen.

ACCIDENT

Aircraft Type and Registration:	Piper PA-24-250 Comanche, G-TALF
No & Type of Engines:	1 Lycoming O-540-A1B5 piston engine
Year of Manufacture:	1959 (Serial no: 24-1094)
Date & Time (UTC):	5 November 2018 at 1440 hrs
Location:	Tatenhill Airfield, Staffordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller and fuselage damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	232 hours (of which 11 were on type) Last 90 days - 2 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot intended to practise circuits and, after waiting for some low cloud to clear, he consulted with other pilots before deciding that the weather conditions were suitable for the flight.

Visibility became "noticeably poor" as he climbed out on the crosswind leg and, after turning downwind, he had difficulty remaining visual with the runway. He cut short the downwind leg and lowered the landing gear but, realising he was high, he elected to go around. Visibility was worse during the second circuit and the pilot believes that he became pre-occupied with the poor visibility, forgetting to complete his downwind checks and omitting to lower the landing gear. The aircraft touched down with the gear retracted and veered to the right, coming to rest on the edge of the runway. The pilot, who was uninjured, exited the aircraft without assistance.

ACCIDENT

Aircraft Type and Registration:	Sequoia Falco F8L, G-FATE	
No & Type of Engines:	1 Lycoming IO-360-B1B piston engine	
Year of Manufacture:	1998 (Serial no: 757)	
Date & Time (UTC):	12 September 2018 at 1241 hrs	
Location:	Wycombe Airpark, Buckinghamshire	
Type of Flight:	Training	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to landing gear, propeller blades, fuselage and flaps	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	72 years	
Commander's Flying Experience:	240 hours (of which n/k were on type) Last 90 days - n/k hours Last 28 days - n/k hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The pilot was completing some circuits as part of re-validating his SEP class rating. The first landing was "hard" so the pilot and instructor decided to taxi to a holding point and satisfy themselves that the aircraft was handling satisfactorily and the brakes were operational. There were no indications to suggest that there was any damage, so the intended exercises were resumed.

After takeoff, the landing gear was selected up and a normal circuit commenced. Both the pilot and instructor were satisfied that the landing gear had operated correctly. The pilot selected the landing gear down in preparation for landing and flew a normal approach. He flared the aircraft and as it settled onto the runway, he realised that the landing gear was not extended. The aircraft landed on its belly and skidded down the runway, coming to rest on the paved surface (Figure 1).

Examination of the aircraft after the accident found that the nose gear strut had deformed, likely because of the initial hard landing. This had caused the undercarriage to jam once it had been retracted.

Figure 1
G-FATE in situ once it had come to rest

ACCIDENT

Aircraft Type and Registration:	Aeroprakt A22-L Foxbat, G-CESI
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2007 (Serial no: PFA 317A-14643)
Date & Time (UTC):	22 October 2018 at 1553 hrs
Location:	Colwall Farmstrip, Herefordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to the nose landing gear, propeller, fire wall and tail wheel
Commander's Licence:	Private Pilot's Licence
Commander's Age:	63 years
Commander's Flying Experience:	531 hours (of which 185 were on type) Last 90 days - 6 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst landing, the aircraft struck a recently felled tree trunk causing the aircraft to pitch forward and land on its nosewheel.

History of the flight

The pilot was flying G-CESI (Figure 1) from RNAS Yeovilton to Colwall Farm in Herefordshire with one passenger onboard. Visibility was good with no significant cloud and a light northerly breeze.

Following a normal approach to the north-easterly runway, the pilot flared the aircraft but the tailwheel struck a recently felled tree trunk causing the aircraft to pitch forward and land on its nosewheel. The nose landing gear collapsed and the aircraft slid to a halt. The pilot and passenger were able to exit the aircraft without injury.

Prior to the flight, the pilot was aware that the tree had been felled recently and that the remains might present a hazard. However, the remaining tree trunk was obscured on approach by a hedgerow. The pilot reported that he had flown a lower approach than he had previously flown because the tree was no longer present; this brought his aiming point closer to the hedge. He further reported that low sun made the field appear shorter, which had encouraged him to land as short as possible. The shorter landing caused the aircraft to clip the obscured tree trunk.

Figure 1
G-CESI before the accident

Additionally, the pilot thought that a recent family bereavement may have affected his capacity during this flight.

This accident highlights the potential hazards of flying to farm strips. The CAA publishes guidance on flying to farm strips in the CAA Safety Sense Leaflet 12 - *'Strip Flying'*[1].

Footnote

1 http://publicapps.caa.co.uk/docs/33/20130121SSL12.pdf (assessed 4 December 2018)

ACCIDENT

Aircraft Type and Registration:	Cameron A-300 hot air balloon, G-VBAD	
No & Type of Engines:	N/A	
Year of Manufacture:	2012 (Serial no: 11623)	
Date & Time (UTC):	18 May 2018 at 1800 hrs	
Location:	Near Launceston, Cornwall	
Type of Flight	Commercial Air Transport (Passenger)	
Persons on Board:	Crew - 1	Passengers - 12
Injuries:	Crew - None	Passengers - 1 (Serious)
Nature of Damage:	None	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	56 years	
Commander's Flying Experience:	373 hours (of which 85 were on type) Last 90 days - 20 hours Last 28 days - 19 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB	

Synopsis

A passenger fell off the basket onto the ground whilst attempting to board before flight and was seriously injured.

The operator now briefs passengers to take extra care when climbing in or out of the basket and offers boarding before inflation for those they consider would benefit.

History of the flight

The pilot planned to operate a commercial flight with twelve passengers aboard. Prior to takeoff the pilot gave the passengers a safety briefing and offered to 'pre-load'[1] any passenger that felt they would not be able to climb into an upright basket; two passengers requested this. At the time the weather was clear with the wind from 320° at 5 kt.

The envelope was initially cold inflated[2], but was then deflated because the Velcro tabs that secure the parachute valve, at the top of the envelope, were not securing it enough for a successful inflation. After this was rectified, the envelope was re-inflated and the remaining passengers started to board. During this time the pilot, who was occupying the

Footnote

[1] Pre-loading is when passengers board the basket while it is on its side. The basket is then moved upright when the envelope is inflated.

[2] Cold inflation involves inflating the envelope with a large fan.

central compartment of the basket (Figure 1) was monitoring and controlling the envelope with the burners, while a member of ground crew, who was standing on the basket's rim, checked connections and the routing of control lines. When the penultimate passenger was climbing into the basket, the crew member briefly observed her and believed she was coping. However, she then fell from it, onto the ground, and was seriously injured.

The crew member quickly went to her assistance and, realising the severity of her injuries, informed the pilot that an ambulance would be required. The pilot deflated the envelope and went to assist the injured passenger, who was subsequently taken to hospital in an ambulance.

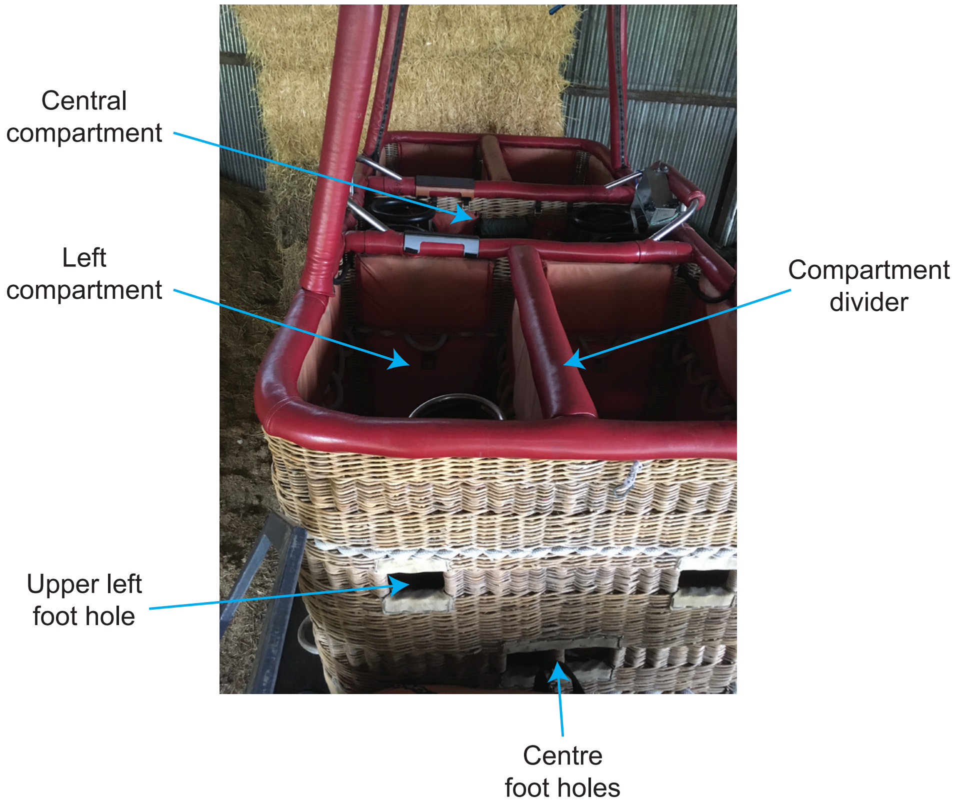

Figure 1
Layout of basket

Passengers' comments

As part of the investigation all the passengers were contacted by the AAIB.

Injured passenger and husband's comments

The injured passenger stated that she did not accept the offer to pre-load as she felt that she would be able to "comfortably climb in".

Her husband stated that after the second inflation the pilot seemed to be in a bit of a rush to get the passengers in the basket, as he believed the pilot wanted weight in it to avoid it moving. A few other passengers made similar comments.

The injured passenger commenced the climb into the basket with the intension of going into the left of the two passenger compartments. Her husband was next to her. Initially she put her right foot into the left of the two centre foot holes, followed by her left foot in the upper left foot hole, while holding on to the padded edge of the basket. He then helped her lift her right leg over the edge of the basket, which then went into the right compartment. She was now leaning over the left end and side of the basket with her left foot still in the upper left foot hole and her right leg in the right compartment. As she tried to move her right leg over the divider into the left compartment she lost her grip, rolled forward over the left edge and fell to the ground suffering a broken arm.

Discussion

The injured passenger appears to have had some difficulty climbing over the edge of the basket into her assigned compartment and subsequently lost her grip and fell to the ground. She may have felt some pressure to get in without delay. However, had she accepted the offer to pre-load, as two other passengers had, she may have found it less hazardous to board before the envelope was inflated.

Safety actions

> The operator has stated that it now briefs passengers to take extra care when climbing in or out of the basket and suggests to some passengers that pre-loading might be a better option for them than climbing in after the envelope has been inflated.

ACCIDENT

Aircraft Type and Registration:	Chaser S 447, G-MYYD	
No & Type of Engines:	1 Rotax 447 piston engine	
Year of Manufacture:	1995 (Serial no: CH7099)	
Date & Time (UTC):	18 July 2018 at 1700 hrs	
Location:	Barhams Mill Farm Airfield, Kent	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to wing keel tube and pylon connecting the wing to the trike	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	55 years	
Commander's Flying Experience:	292 hours (of which 10 minutes were on type) Last 90 days - 18 hours Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The pilot had difficulty controlling the microlight's direction after landing due to the position of the steering yoke relative to the throttle. This led to him over-correcting when the aircraft deviated to the right, causing it to tip over.

This was the pilot's first flight on the type and he considered the space around his legs and feet was restricted, contributing to his problems controlling the aircraft.

History of the flight

The pilot had flown from Barhams Mill Farm Airfield to a nearby airstrip in his own microlight, a Pegasus Quantum 912. At the airstrip he met with a colleague, the pilot of a Chaser microlight, and the two pilots then flew together in their respective aircraft to a third airstrip before going on to Barhams Mill Farm Airfield.

After landing at Barhams Mill Farm the pilot of the Chaser offered to let his colleague fly it. The Pegasus pilot reported that it was a tight fit for his legs and feet in the Chaser, but that he was able to make himself comfortable. He then made a short flight in the Chaser, which he reported was uneventful and the approach and touchdown were without incident. However, after landing, the aircraft started to deviate to the right, which the pilot tried to correct using the nosewheel steering yoke.

The yoke is operated using the feet and is connected to the nosewheel, allowing the aircraft to be steered on the ground. Pushing the yoke to the right steers the aircraft to the left and vice versa. The throttle control is positioned on the right-hand side of the yoke and the brake on the left, allowing these to be operated by the feet.

The pilot found that the footwell was sufficiently restricted in size that he was unable to steer left without increasing the throttle. In reducing pressure on the throttle again, the aircraft once more deviated to the right. The pilot again tried to correct this, but with the same outcome and this pattern repeated itself three times before the pilot over-corrected, causing the aircraft to tip onto its right side. Assistance was quickly on the scene and, despite the aircraft being damaged, the control frame was moved sufficiently for the pilot to get out of the trike unharmed.

The pilot considered he should have spent more time familiarising himself with the controls on the ground, especially considering the restricted legroom.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15, G-MYPX	
No & Type of Engines:	1 Rotax 582-40 piston engine	
Year of Manufacture:	1994 (Serial no: 6785)	
Date & Time (UTC):	26 September 2018 at 1750 hrs	
Location:	Halwell Airstrip, Devon	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Bent nosewheel, cracked pod, port washout tube broken, wing keel tube fractured at king post, bent wing spars	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	63 years	
Commander's Flying Experience:	372 hours (of which 105 were on type) Last 90 days - 8 hours Last 28 days - 6 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The Pegasus Quantum 15 microlight, G-MYPX, suffered damage on landing after encountering turbulence, which the pilot attributed to the wake from another microlight which had landed ahead.

History of the flight

The pilot of G-MYPX was flying a Pegasus Quantum 15 microlight and was returning from the northwest to land on Runway 09 at Halwell airstrip, a private farm grass-strip. The weather at the time of the accident was reported by the pilot as calm with visibility in excess of 10 km.

While on base leg, at about 800 ft, the pilot of G-MYPX saw another microlight ahead, which he estimated to be about 300 - 400 ft below and was making an approach to the same runway. (This microlight, G-CGHZ, a P&M QuikR, was making a precautionary approach due to suspected engine trouble. Its pilot had made a blind transmission[1] on the frequency used by the airfield but had received no response. The pilot of G-MYPX did not hear this

Footnote

[1] Blind Transmission - a transmission from one station to another station in circumstances where two-way communication cannot be established but where it is believed that the called station is able to receive the transmission (ICAO).

blind transmission because he was not using the radio; he had previously encountered transmission issues, although reception was unaffected.)

The pilot estimated that he began to flare G-MYPX about 30 seconds after G-CGHZ had landed, by which time the latter had reached the end of the runway. At this point the pilot believed that he encountered turbulence which resulted in the left wing-tip and left rear-wheel touching the ground. Ground markings indicated that G-MYXP became airborne again before landing once more and slewing 90º left, coming to a stop on the right wing's leading edge with the trike turned on its right-hand side and its engine still running.

Figure 1

G-MYPX suffered damage including a bent nosewheel, a cracked pod on the trike, and a broken port washout tube. The wing keel tube fractured at the point where the kingpost attaches to the wing. The wing spars were also subsequently discovered to be damaged. The pilot was unhurt.

Conclusion

The pilot of G-MYPX attributed the turbulence encountered to the wake of the microlight landing ahead and commented that in future he would leave greater spacing from aircraft landing ahead.

ACCIDENT

Aircraft Type and Registration:	Skyranger 912(2), G-CCMX
No & Type of Engines:	1 Rotax 912UL piston engine
Year of Manufacture:	2004 (Serial no: BMAA/HB/255)
Date & Time (UTC):	21 August 2018 at 1750 hrs
Location:	Manor Farm, Cheltenham, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Aircraft damaged beyond economical repair
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	130 hours (of which 61 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot flew a high approach and touched down midway along the runway. The aircraft bounced and the pilot commenced a go-around but, during the climb, the aircraft struck some trees. The pilot and passenger were uninjured.

History of the flight

The pilot reported that he was attending an evening fly-in at a local private airstrip near Cheltenham. The flight from his home airfield took approximately 15 minutes and he positioned the aircraft for a landing on Runway 26. There were trees situated at each end of the runway and the pilot stated that he flew a high approach to stay clear of the those. This meant that that the aircraft touched down halfway along the grass runway. It hit a bump and became airborne again, touched down on the nosewheel, and rocked back on to the mainwheels. The pilot was concerned by the oscillation in pitch that was starting to develop and therefore commenced a go-around. However, there was insufficient distance available to clear the trees at the end of the airstrip or to fly around them. As the aircraft approached the trees the pilot allowed the airspeed to reduce, and the aircraft stalled into the canopy.

Rescue and recovery

The aircraft came to rest in the canopy of the trees approximately 10 m above a footpath at the end of Runway 26 (Figure 1). The local Fire and Rescue Service attended the accident. They cut down adjacent trees in order to use an aerial platform to secure the aircraft and rescue the two occupants, who were uninjured.

The aircraft was relatively undamaged in the accident but was damaged beyond economical repair during the recovery operation.

Figure 1
Aircraft in tree canopy

Additional information

The distance between the trees at each end of the runway is approximately 500 m. At the point the pilot started the go-around there would have been less than 250 m between the aircraft and the trees at the end of the runway, which were over 10 m tall.

The pilot reported that this was the first time that he had visited this airstrip and that everything happened very quickly. Reflecting on the flight, he believes that he should have orbited the airfield in order to become familiar with its layout and to plan his approach. He also believes that he should have made an earlier decision to go-around.

The CAA publishes guidance on flying from airstrips in the CAA Safety Sense Leaflet 12 - *'Strip Flying'*[1].

Footnote

[1] http://publicapps.caa.co.uk/docs/33/20130121SSL12.pdf (assessed 4 December 2018)

Miscellaneous

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

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

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

2/2014 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
DME	Distance Measuring Equipment
EAS	equivalent airspeed
EASA	European Aviation Safety Agency
ECAM	Electronic Centralised Aircraft Monitoring
EGPWS	Enhanced GPWS
EGT	Exhaust Gas Temperature
EICAS	Engine Indication and Crew Alerting System
EPR	Engine Pressure Ratio
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration (USA)
FDR	Flight Data Recorder
FIR	Flight Information Region
FL	Flight Level
ft	feet
ft/min	feet per minute
g	acceleration due to Earth's gravity
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
hrs	hours (clock time as in 1200 hrs)
HP	high pressure
hPa	hectopascal (equivalent unit to mb)
IAS	indicated airspeed
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IP	Intermediate Pressure
IR	Instrument Rating
ISA	International Standard Atmosphere
kg	kilogram(s)
KCAS	knots calibrated airspeed
KIAS	knots indicated airspeed
KTAS	knots true airspeed
km	kilometre(s)
kt	knot(s)
lb	pound(s)
LP	low pressure
LAA	Light Aircraft Association
LDA	Landing Distance Available
LPC	Licence Proficiency Check
m	metre(s)
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
TGT	Turbine Gas Temperature
TODA	Takeoff Distance Available
UAS	Unmanned Aircraft System
UHF	Ultra High Frequency
USG	US gallons
UTC	Co-ordinated Universal Time (GMT)
V	Volt(s)
V_1	Takeoff decision speed
V_2	Takeoff safety speed
V_R	Rotation speed
V_{REF}	Reference airspeed (approach)
V_{NE}	Never Exceed airspeed
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional radio Range

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