ACCIDENT

Aircraft Type and Registration:	Grumman AA-5, G-BBSA
No & Type of Engines:	1 Lycoming O-320-E2G piston engine
Year of Manufacture:	1974 (Serial no: AA5-0472)
Date & Time (UTC):	25 September 2021 at 0837 hrs
Location:	Teesside International Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - 1 (Serious) Passengers - 2 (Serious)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Light Aircraft Pilot's Licence (A)
Commander's Age:	63 years
Commander's Flying Experience:	1,614 hours (of which 830 were on type)) Last 90 days - 79 hours Last 28 days - 29 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft suffered a partial loss of engine power very shortly after takeoff from Runway 23 at Teesside International Airport. The pilot, believing the aircraft was outside the airport boundary, attempted a turnback to the airport to land. The aircraft stalled during the turn and struck the ground west of the runway near the Runway 05 threshold. The three occupants all sustained serious injuries.

Three Safety Recommendations are made with respect to pilot training for partial engine power[1] loss events.

History of the flight

The aircraft was operated by a private syndicate of owners. It had returned to Teesside Airport on 21 September 2021 after undergoing an annual maintenance inspection at Sturgate Airfield, Lincolnshire. The flight from Sturgate to Teesside took approximately 45 minutes and was conducted by one of the syndicate members. After landing at Teesside, two other members of the syndicate took the aircraft on a local flight, again lasting approximately 45 minutes. None of these pilots reported any issues with the aircraft and described it as operating "as smoothly as it ever had."

Footnote

1 A situation where an engine provides less power than commanded by the pilot, but more power than idle thrust.

Usually, the aircraft was kept in a hangar at Teesside but, due to work being carried out there, it was parked outside after the flights on 21 September. On 24 September, the aircraft's fuel tanks were filled in preparation for flying that day. However, due to high winds that flying was cancelled.

On 25 September, the pilot had planned a local flight with two passengers. The pilot phoned Teesside ATC to book out for the flight and informed them that there would be three persons on board, gave a fuel endurance of five hours (reflecting the full fuel tanks), and a planned flight time of one hour. He also told ATC that the planned route was from Teesside to Middlesbrough and then route north to the River Tyne before returning to Teesside.

One passenger was seated in the front right seat and the second sat behind the pilot. The rear seat passenger recorded a video of the takeoff and short flight on a mobile phone. This recording was subsequently analysed, along with other sources, to assist in confirming the sequence of events. The aircraft started up normally and the pilot then called ATC for taxi clearance. He was cleared to taxi to the Alpha 1 Holding Point for Runway 23 (Figure 1). ATC saw the aircraft stop at Alpha 1 to conduct engine run up checks.

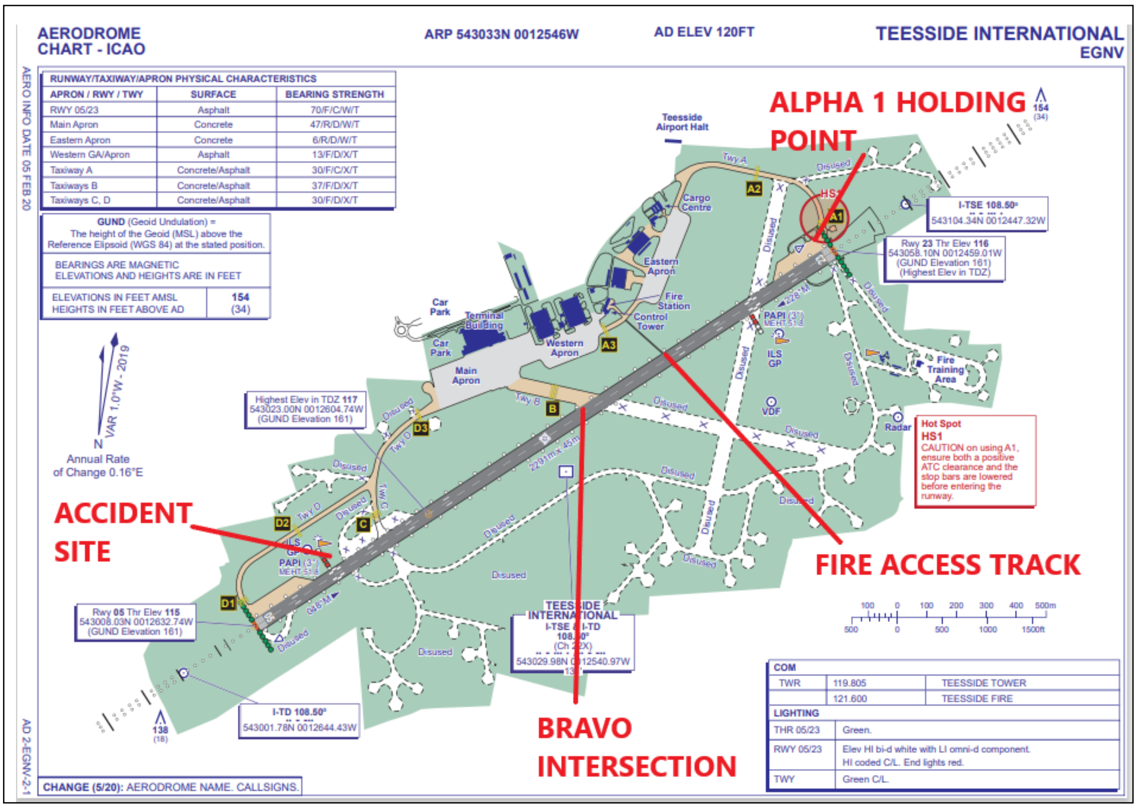

Figure 1

Teesside Airport chart

ATC cleared the aircraft for takeoff at 0834 hrs and saw the departure. The takeoff roll appeared normal and the aircraft was airborne abeam the Fire Access Track.

Approximately 14 seconds after becoming airborne, there was a significant change in the engine note. At this point the aircraft was passing intersection Bravo at a height of approximately 120 ft agl. ATC noticed its track was drifting to the right of the centreline of Runway 23 but otherwise considered that the departure looked normal.

As the aircraft reached approximately 170 ft agl, the pilot radioed ATC to report that he had suffered a loss of engine power and requested to land on Runway 05. There was another aircraft at two miles on final approach to Runway 23 and ATC directed this aircraft to go around before clearing G-BBSA to land on any runway. G-BBSA turned left towards Runway 05 and began to descend. During the turn, 57 seconds after becoming airborne, the aircraft audio stall warning began to sound. At approximately 60 ft agl, the left bank angle suddenly increased, and the aircraft descended rapidly, striking the ground 67 seconds after becoming airborne. The aircraft was extensively damaged.

On seeing the aircraft accident, ATC declared a Full Emergency and deployed the airport RFFS. One of the RFFS personnel had just completed a bird scaring run in a vehicle and was parked close to where the aircraft struck the ground. Observing the accident, he immediately moved to the aircraft where he entered the cockpit, switched off the fuel and battery master switch, and gave assistance to the occupants until the Emergency Services arrived.

ATC tried to contact the local authority Emergency Services by telephone but had some difficulties in making contact, stating "it took a long while to speak to someone," in order to request that the fire service attend the scene. The local authority Fire Service were informed at 0851 hrs.

ATC at Teesside have direct contact with the North-East Air Ambulance and asked them to attend. The Air Ambulance was airborne at 0845 hrs and landed on scene at 0847 hrs. All those on board sustained serious injuries and were evacuated to hospital.

Several witnesses saw the aircraft as it became airborne and all described the aircraft engine as sounding unusual shortly after takeoff.

Pilot recollections

As a result of his serious injuries, the pilot was in hospital for several months and could not be interviewed for a significant time after the accident. His recollections were that, before the accident flight, he conducted the external and internal checks as specified by the Pilot's Operating Handbook (POH), including a check of the fuel for water contamination. All checks were normal. When his passengers arrived at the airport, he collected them from the security checkpoint and took them to the aircraft where he then briefed them on entry/exit procedures and the use of the aircraft seat harnesses. He discussed the route for the flight with them and then passed that information to ATC by phone.

The pilot and passengers then boarded the aircraft. The pilot recalls that the engine start, taxi and engine run up checks were all normal. Once cleared to do so by ATC the pilot lined the aircraft up on the runway and accelerated the engine to 2,500 rpm. He stated that he raised the nose at 76 mph and that the initial stages of the climb were normal. At what the pilot recalled was around 400 ft agl he described the engine as losing all power and recalled lowering the pitch attitude to maintain speed. There was a field ahead which, on previous flights, he had considered in the event of a forced landing. However, it contained animals, farm vehicles and people, so he considered it unsuitable. The other terrain ahead was the River Tees and so, in the pilot's opinion, a landing ahead was not viable.

In response to the loss of power the pilot said that he carried out the POH ENGINE FAILURE checklist (Figure 2). These actions were outside of the field of view of the video recording made by the passenger in the rear seat.

ENGINE FAILURE

Engine failures are very rare in modern aircraft. Should an engine failure occur, the basic procedures listed below may be a useful guide:

1. Establish best glide speed of 83 MPH for best range.
2. Check wind direction for landing.
3. Pick a suitable landing area and plan an approach.
4. Check fuel and switch the tank selector to the opposite tank if it contains fuel. Check fuel pressure and turn on electric fuel pump if necessary.
   Mixture - Rich
   Carburetor heat - ON
   Magnetos - check right and left. If engine runs on either one, leave switch on that magneto.
5. If the engine does not start promptly, attention should be shifted to the forced landing procedure.
6. Notify ATC of your location and problem.
7. Fuel selector OFF; mixture to idle cut-off; turn ignition OFF; flaps as needed; and the master switch OFF.
8. Complete the landing and secure the aircraft. Notify ATC by telephone of your situation and location.

Figure 2

Engine Failure checklist

The checklist has several items, and it would have presented a significant workload. Believing he was outside the airfield boundary the pilot commenced a turn to return to the airport. As it came into view, he realised he had insufficient height to reach the runway and chose a green area in which to land stating "It looked good enough to land. Good area. I put it down there." His recollection was of flaring the aircraft to control the touchdown and that the stall warner sounded just before touchdown.

The pilot stated that he would not normally consider a turnback as an option but that he practised turnback manoeuvres three times in the year preceding the accident and that these were conducted with a 15° to 20° Angle of Bank (AOB). When asked about the option of landing ahead on the remaining runway, the pilot said that with the aircraft close to maximum takeoff weight, he felt he would have used a considerable length of runway to get airborne and climb to the height he recalled reaching. He therefore considered that landing ahead on the runway remaining was not an option.

Accident site

The aircraft came to rest on the grass to the west of the runway, close to the Runway 05 threshold (Figure 3).

Figure 3
Accident site, looking south with the Runway 05 threshold behind

The aircraft had struck the ground with its left wingtip and, following a significant nose impact, had then rotated approximately 180°, coming to rest 11 m beyond the main impact ground scar. There was a strong smell of fuel at the accident site, but the RFFS had sprayed the aircraft with foam shortly after their arrival and no fire had occurred. The flaps were up.

Airfield information

Teesside International Airport is a commercial airport located between Darlington and Stockton-on-Tees. It is about ten miles (16 km) south-west of Middlesbrough. The airport has one runway 05/23 which is 2,291 m long. Beyond the threshold there is 184 m of asphalt surface, which is not declared as part of the runway length and then a further 210 m of grass surface before the airport boundary fence.

Meteorology

The weather report for Teesside at 0820 hrs gave a wind of 180° at 3 kt, visibility greater than 10 km, a temperature of 16°C and a dewpoint of 14°C.

Weight and balance

With the full load of fuel and three passengers, the takeoff weight of the aircraft was 2,075 lbs. The MTOW for a Grumman AA-5 is 2,200 lbs. The calculated whole moment for the aircraft's load distribution was 182,490 lb-in. When plotted on the POH chart (Figure 4), the result shows that the aircraft was within its mass and C of G envelope.

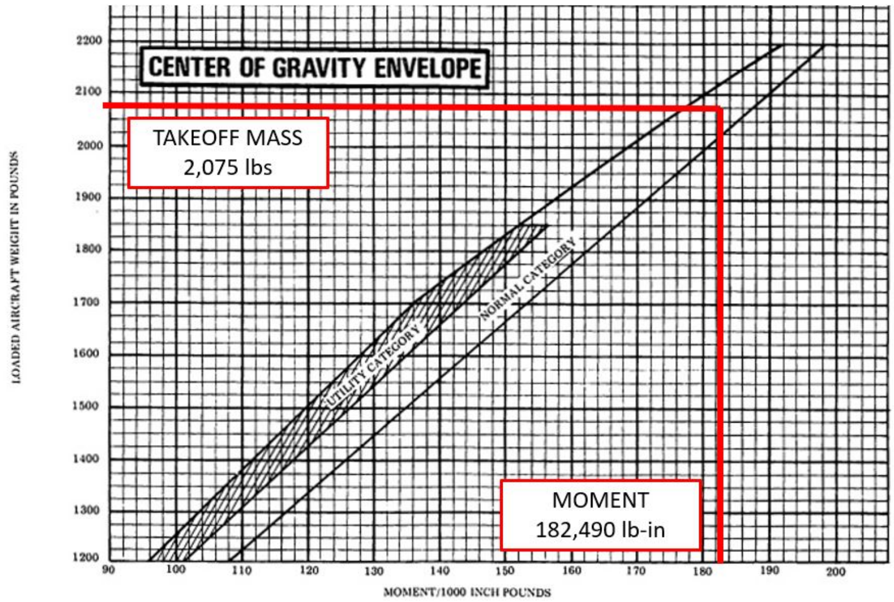

Figure 4

Centre of gravity envelope chart

Recorded information

Recorded information for the accident flight was available from the following sources:

- a tablet computer fitted in the cockpit of the aircraft, which had recorded the aircraft's Global Navigation Satellite System (GNSS) derived position and altitude,
- a video/audio recording made by the passenger seated in the rear of the aircraft using a mobile phone,
- closed-circuit television (CCTV) footage of the aircraft during the later stages of the flight, and
- RTF communications between the pilot and controller.

Summary of recorded data

Analysis of the audio from the mobile phone recording, in conjunction with the GNSS data, showed that, during the takeoff roll and initial climb, the aircraft's engine was operating at about 2,500 rpm, with the aircraft climbing at 500 fpm with an airspeed of 80 mph (70 kt)[2]. However, shortly after getting airborne, and at a height of 120 ft agl (Figure 5), the engine speed suddenly reduced to about 2,100 rpm. The aircraft continued to climb to 170 ft agl, by which time its airspeed had reduced to 70 mph (61 kt) and the aircraft started to level off. This coincided with the pilot advising ATC of the problem and asking to land on Runway 05, and with the aircraft starting to turn right onto a heading of about 245°.

Footnote

2 Derived from the recorded groundspeed and a reported wind from 180° at 3 kt.

The aircraft's engine continued to operate at about 2,100 rpm for the next 10 seconds, with the airspeed and height stabilised at about 70 mph (61 kt) and 200 ft agl respectively. However, when the aircraft was almost overhead the intersection of taxiways C and D, the engine speed further reduced to about 1,500 rpm and, whilst maintaining altitude, airspeed quickly reduced to about 64 mph (56 kt). This coincided with a brief activation of the stall warner in the cockpit. The aircraft then started to turn left towards the runway whilst descending. The aircraft's bank angle continued to increase, and its descent rate reached about 1,000 fpm. As the aircraft reached a height of about 100 ft agl, the stall warner activated again, and continued to sound, until the aircraft struck the ground five seconds later. It was estimated that the aircraft's bank angle had reached about 40° during the final descent.

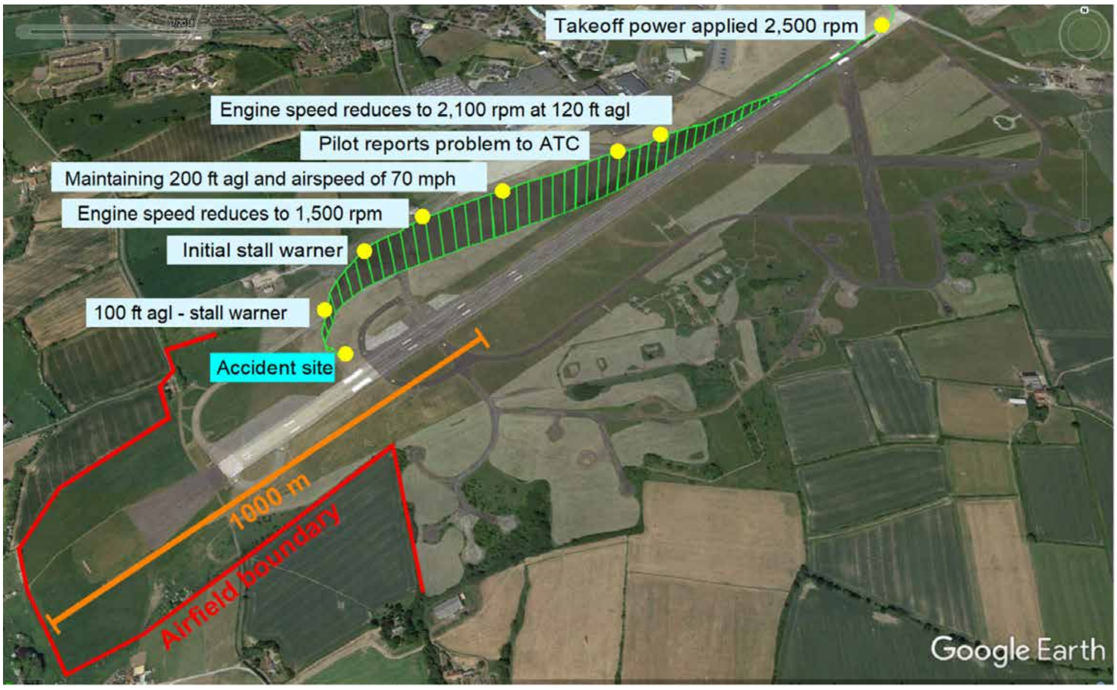

Figure 5

Aircraft flight path during the accident flight
© 2021 Google, Image © Maxar Technologies

Table 1 provides the runway length remaining to the end of Runway 23, and distance to the airport boundary, which is beyond the end of the runway, for key points during the takeoff.

Cockpit view during the accident flight

Analysis of the aircraft's flight path using a flight simulation, indicated:

- When the engine rpm initially reduced to about 2,100 rpm and given the aircraft's position and attitude at that time, the pilot would not have been able to see the runway ahead of him.
- As the aircraft climbed to a height of about 180 ft agl, given the aircraft's position and attitude at that time, the simulation indicated that the runway would have been visible with about 1,000 m of the runway remaining.

Engine speed / RTF communication	Aircraft position	Runway 23 length remaining
Engine speed reduced to 2,100 rpm.	120 ft agl overhead the right edge of the runway.	1,300 m of runway remaining (1,700 m to the airport boundary).
Pilot reports engine problem to ATC and starts to turn onto a heading of 245°.	170 ft agl and 25 m laterally from the right edge of Runway 23.	1,100 m of runway remaining (1,490 m to the airport boundary).
Engine speed reduced to 1,500 rpm.	200 ft agl and 140 m laterally from the right edge of Runway 23.	600 m to the airport boundary if its heading of 245° was maintained (1,000 m to the airport boundary for a heading of 225°).

Table 1

Aircraft position relative to end of Runway 23 and airport boundary

Aircraft information

The Grumman AA-5 is an all-metal low-wing four seat light aircraft fitted with a 150 HP Lycoming O-320-E2G piston engine. The aircraft had undergone a recent annual maintenance inspection that was completed on 21 September 2021, during which a new propeller and replacement nose landing gear torque tube were fitted, and the engine rocker covers and gaskets were replaced. The maintenance engineer who carried out the annual inspection stated that the carburettor and airbox were visually inspected, but not removed or disturbed, during this maintenance activity.

Carburettor

The aircraft's engine was fitted with a Precision Airmotive Corporation MA-4SPA carburettor. The aircraft's maintenance programme, approved by the aircraft's owners, stated a maximum time between overhaul of the carburettor of 2,000 flying hours or 12 years, whichever occurs first. The carburettor manufacturer stated, in Service Bulletin MSA-3[3], a maximum time between overhaul of the carburettor of 2,000 flying hours or 10 years, whichever occurred first.

At the time of the accident, the carburettor had accumulated 601 flying hours and six years in service.

Fuel is supplied to the carburettor from the engine-driven fuel pump and enters the induction airflow via the main jet, where it is mixed with the induction air. When the throttle is advanced, an accelerator pump within the carburettor supplies additional fuel to the induction air through an accelerator pump discharge tube (Figure 6).

Footnote

[3] Precision Airmotive Corporation Service Bulletin MSA-3 Revision 1, Overhaul Periods for Float Carburetors, 18 November 1991.

The accelerator pump discharge tube, which is made from brass, is a close fit to its mating bore in the carburettor body. It is secured to the carburettor body with adhesive4 when the carburettor is manufactured or overhauled.

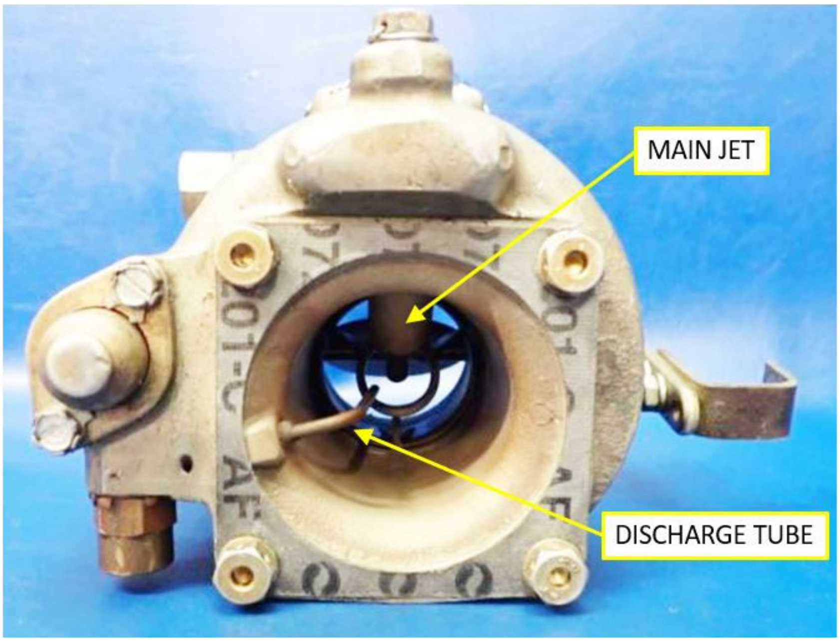

Figure 6
Reference image of an MA4-SPA carburettor (not G-BBSA carburettor)

Aircraft examination

The damage to the aircraft was consistent with a significant impact in a nose-down, left wing low attitude. The flaps were in the full UP position. The fuel selector valve was set to draw fuel from the left wing tank. The fuel feed pipe between the left wing and the fuselage had fractured and no fuel remained in the left wing tank. 32 litres of Avgas 100LL was recovered from the right wing tank.

The engine's crankshaft was free to rotate, and the crankcase was intact with all four cylinders securely attached. Both magnetos were securely fixed to the rear of the accessory case and the ignition harness was in good condition, with all ignition leads attached to their respective spark plugs. No engine oil leaks were evident, and the oil was of normal appearance. There was no deformation of any of inlet or exhaust valve pushrod tubes.

The fuel lines between the firewall and the engine were in good condition and all fuel fittings were tightly secured. The electric fuel boost pump was disassembled, and fuel was present in the pump and the fuel strainer mesh was clear of foreign objects. The engine-driven mechanical fuel pump was disassembled, and fuel was observed inside the pump. The pump's rubber diaphragm was in good condition.

Footnote

4 Loctite Retaining Compound RC-680.

The induction airbox was removed from the engine to provide access to the carburettor. The carburettor was securely screwed to the engine sump and the required gasket between the carburettor and sump was present. Fuel was present in the carburettor float bowl, with no evidence of contamination by water or debris. The carburettor throttle and mixture control linkages were securely attached to the cockpit control cables.

As the engine's crankshaft was free to rotate, the engine was removed from the aircraft and supported on a sling to allow a basic compression test to be performed. This involved disconnection of the ignition harness from the spark plugs and removal of the upper spark plug from each cylinder. Rotation of the crankshaft, whilst a thumb covered the upper spark plug hole, revealed a normal degree of compression on cylinder Nos 1, 2 and 3, but no compression on cylinder No 4[5]. The aircraft wreckage was then secured for transport to the AAIB's facility at Farnborough for detailed examination.

Engine examination

The engine basic compression test was repeated once the aircraft wreckage was recovered to the AAIB, but this time a normal degree of compression was noted on all four cylinders. Borescope inspection of cylinder No 4 revealed that a C-shaped foreign object was present in the cylinder (Figure 7). Witness marks were present on the exhaust valve seat faces caused by contact of a hard foreign object, which would have prevented the exhaust valve from closing correctly. It was considered likely that the C-shaped foreign object had been trapped beneath the exhaust valve when the engine was examined at the accident site, but that it had come loose during transportation to the AAIB.

Figure 7

Borescope images inside cylinder No 4

The No 4 cylinder was removed from the engine and the piston crown, inlet and exhaust valve surfaces were examined. Numerous hard-body impact marks were present on the piston crown, and the faces of the inlet and exhaust valves also showed impact marks where combustion residues had been removed from the valve faces (Figure 8). No such impact marks or foreign objects were observed in Nos 1, 2 or 3 cylinders.

Footnote

5 Cylinder 4 is the rear left cylinder, when viewing the engine from above.

Figure 8

Impact marks on cylinder No 4 piston crown, inlet and exhaust valves

The aircraft's exhaust muffler was cut open, but no additional foreign objects were identified within. The C-shaped foreign object was of tubular cross section which had been flattened due to impacts on the tube's outer diameter (Figure 9).

Figure 9

Foreign object recovered from No 4 cylinder

The foreign object was examined by a metallurgist who confirmed that it was a section of brass tube, composed of 'cartridge brass[6]', which the carburettor manufacturer confirmed was the same material specified for the accelerator pump discharge tube[7]. A section of the foreign object was subjected to a micro-hardness test, which showed an average hardness value of 95 HV[8]. The carburettor manufacturer stated that the hardness condition specified for the discharge tube material was ½ hard[9], which equates to approximately 126 HV. The metallurgist considered that the lower measured value of 95 HV is consistent with the foreign object being stress-relieved in the elevated temperatures of the engine's No 4 cylinder.

Footnote

6 Cartridge brass is an alloy of copper (70% by weight) and zinc (30% by weight).
7 SAE-CA260 or UNS C26000 seamless brass tube, ½ hard condition.
8 Hardness as measured by the Vickers Pyramid Hardness testing method.
9 ½ hard is a measure of material hardness, based on temper.

The ends of the foreign object were examined under a scanning electron microscope which showed fractures at either end of the tube fragment. One end of the object also showed evidence of partial shearing of the tube cross section.

The cross-sectional area of the foreign object's tube section was measured and found to match to the discharge tube section geometry specified by the carburettor manufacturer.

When G-BBSA's carburettor was examined, it was noted that the accelerator pump discharge tube was missing (Figure 10).

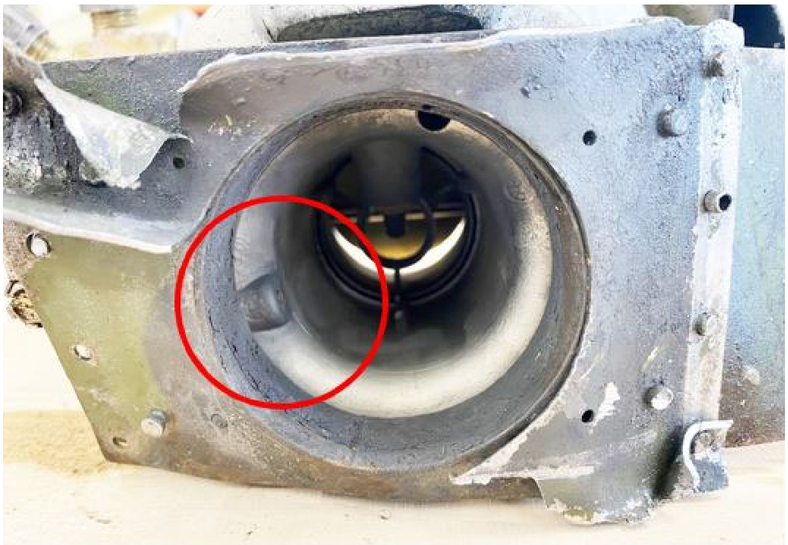

Figure 10

Missing accelerator pump discharge tube from G-BBSA carburettor

A search of the ECCAIRS[10] database did not return any records of carburettor accelerator pump discharge tube release events. An additional search of the FAA Service Difficulty Reporting System database returned three records, covering a total of five separate events of discharge tube release. These events all occurred to Lycoming O-320 powered aircraft, over the period between 2002 and 2014.

Although the issue of the release of the discharge tube does not appear to be a widespread problem, the CAA have agreed to discuss the airworthiness concerns relating to such events with the FAA, at their next joint Continued Operational Safety Working Group meeting. This will ensure that the FAA is aware of the findings of this investigation in their role as the regulator of the engine's Type Certificate holder.

Footnote

[10] European Co-ordination Centre for Accident and Incident Reporting Systems.

Aircraft performance

The POH gives the following information about stalling:

> *'The AA-5's stalling characteristics are conventional in all configurations. Elevator buffeting occurs approximately 3 mph above the stall and becomes more pronounced as the stall occurs. An audible warning horn begins to blow steadily 5 to 10 mph above the actual stall speed.'*

The stalling speed of the aircraft increases with increasing AOB. The POH contains the table (Figure 11) to indicate the relationship between AOB and stalling speed. Flaps are not used for takeoff.

STALL SPEEDS – MPH CAS

CONDITION	BANK ANGLE			
	0°	20°	40°	60°
FLAPS UP	62	64	71	88
FLAPS DOWN	58	60	66	82

2200 LBS. GROSS WEIGHT - POWER OFF - AFT CG LOADING

Figure 11

POH stall speeds

Australian Transport Safety Bureau Report

The Australian Transport Safety Bureau (ATSB) have published a booklet[11], '*Avoidable Accidents No. 3 - Managing partial power loss after takeoff in single-engine aircraft'* to raise awareness of issues relating to partial power loss.

In the research period, from 2000 to 2010, there were nine fatal accidents resulting from response to a partial power loss compared to no fatal accidents where the engine failed completely. The research data also indicated that a partial power loss was up to three times more likely to occur than a total loss.

A total loss of power is something for which pilots are regularly trained and for which there exists a simple set of checks and procedures. The training emphasises the limited time available and endeavours to make the pilot's response second nature. Following a total power loss, a forced landing is inevitable, whereas in the partial power case pilots are faced with a more complex decision of whether to continue the flight or to make an immediate forced landing. Training for partial loss of power is seldom conducted and not a requirement of the UK licencing syllabus.

Footnote

[11] https://www.atsb.gov.au/media/4115270/ar-2010-055_no3.pdf [accessed 13 May 2022].

In examining the response of pilots to partial power loss the booklet states:

> *'The course of action chosen following such a partial power loss after takeoff can be strongly influenced by the fact that the engine is still providing some power, but this power may be unreliable. As the pilot, you may also have a strong desire to return the aircraft to the runway to avoid aircraft damage associated with a forced landing on an unprepared surface. The complexity of decision making in such circumstances is further compounded by the general lack of discussion and training on this issue. In dealing with this, you will need to rely on your knowledge and experience.'*

In order to prepare for events such as partial power loss the booklet emphasises the importance of pre-flight planning and pilot self-briefing. It also states that the following factors should be considered before every flight:

- '» *the runway direction and the best direction of any turn*
- » *the local wind strength and direction on a particular day*
- » *terrain and obstacles*
- » *decision points (taking into account aircraft height and performance) where different landing options will be taken, such as:*
  - – *landing on the remaining runway or aerodrome*
  - – *landing outside the aerodrome*
  - – *conducting a turn back towards the aerodrome.'*

The booklet also suggests a list of initial actions in response to a partial loss of power:

- '» *Lower the nose to maintain the glide speed of the aircraft.*
- » *Conduct the basic initial engine trouble checks as per an engine failure in accordance with manufacturer's advice. However, this should be done only if there is sufficient time.*
- » *Maintain glide speed and assess whether the aircraft is maintaining, gaining or losing height to gauge current aircraft performance. This will help to inform the options available for landing.*
- » *Fly the aircraft to make a landing, given the aircraft's height and performance, and the pre-planned routes for the scenario. If turning is conducted, keep in mind an increased bank angle will increase the stall speed of the aircraft. Keeping the aircraft in balance will minimise rate of descent in any turn.*
- » *Re-assess landing options throughout any manoeuvres. Be decisive but be prepared to modify the plan if required.*
- » *Land the aircraft. Have a minimum height planned to roll wings level. It is suggested in Civil Aviation Safety Authority (CASA) documentation*

that turns should not be attempted below 200 feet. However, this will depend on the aircraft's roll rate, the present airspeed and personal experience. Maintain glide speed up to the point of flare; this will ensure that when flaring there is enough energy to arrest the vertical descent rate.'

Below the minimum turning height of 200 ft, the report suggests that a straight climb or a descent to land are the only options. ATSB occurrence statistics indicate that many partial power losses could have been prevented by thorough pre-flight engine checks. Some conditions reported as causing partial power loss after takeoff are fuel starvation, spark plug fouling, carburettor icing and pre-ignition conditions. In many cases, these conditions may have been identified throughout the pre-takeoff and on-takeoff check phases of the flight sequence.

The ATSB booklet also emphasises the importance of maintaining glide speed till the point of flare, stating:

'ATSB occurrence reports show that the initial actions taken by the pilot do not necessarily affect the final outcome — what is more important is that the primary focus be on maintaining airspeed to prevent stalling and also allow energy for flare, rather than diagnosing problems. Thought should be firmly on where the aircraft is going, maintaining control and situational awareness, and dealing with the situation at hand.'

CAA publication CAP 1535 - The Skyway Code, refers to the ATSB booklet in its section dealing with engine failure but otherwise contains relatively little information on the techniques required to manage partial power loss situations.

Other information

Although, before a flight, a pilot in command is required to give a briefing to any passengers on emergency equipment and procedures, there is no requirement to brief how engine malfunctions will be addressed.

An operator with a large fleet of light aircraft was consulted about the handling of engine failures or partial power loss after takeoff. In their opinion, a turnback from low height should only be attempted when no safe landing area is available within gliding range ahead. The objective of a turnback is to allow the aircraft to reach a safe landing area, not necessarily a reciprocal runway. Their procedures state that a turnback should only be considered above 500 ft agl and that the manoeuvre should be carried out using 45º AOB (to achieve a quicker rate of turn and thus minimise the height loss) and a gliding speed increased by 5 kt to reduce the chance of an accelerated stall[12] in the turn. For training, the turnback is only carried out from 700 ft agl and under the supervision of an instructor.

Footnote

[12] An accelerated stall is a stall that occurs at an airspeed higher than normal due to a higher load factor (g loading). When an aircraft is in a bank or when applying positive g, the wing has to create additional lift to support the aircraft since the load factor has increased.

The flying school at Teesside do not teach or conduct turnbacks, nor do they teach a pre-departure emergencies briefing. Such exercises are not required in the UK PPL syllabus. Other members of the syndicate that owned the aircraft were asked about turnbacks and stated that they had not considered them.

The Australian syllabus for PPL training[13] does include a specific exercise to address a partial power loss event, but not one that occurs immediately after takeoff. The issue is covered as part of a forced landing exercise, and contains the following elements:

'(i) identify partial power failure condition

(ii) perform recall actions

(iii) adjust flight controls to re-establish flight path that maximises performance for partial power condition and maintain a safe airspeed margin above stall speed

(iv) establish radio communications where possible

(v) perform partial engine failure actions

(vi) formulate a plan to recover aeroplane to a safe landing area or aerodrome, taking into account that partial failure might lead to a full power failure at any time

(vii) manoeuvre the aeroplane to a selected landing area or aerodrome using the remaining power to establish an optimal aircraft position for a safe landing

(viii) advise ATS or other agencies capable of providing assistance of situation and intentions

(ix) re-brief passengers about flight situation, brace position and harness security

(x) maintain a contingency plan for coping with a full power failure throughout the manoeuvre

(xi) when a safe landing position is established, shut down and secure engine and aeroplane.'

Previous AAIB investigations

During the period 2011 - 2021 the AAIB completed 16 field investigations in which the partial loss of power was involved. Arising from those 16 accidents, there were 15 fatalities and 9 serious or life-threatening injuries. In two of these accidents there were no injuries, and both were as a result of flying the aircraft under control to a successful forced landing or ditching. There were five attempted turnbacks, all of which resulted in fatalities or injuries.

Footnote

13 Part 61 Manual of Standards Instrument 2014 (legislation.gov.au), Volume 2, Paragraph 2.3 A6.3(b) (https://www.legislation.gov.au/Details/F2021C00449) [accessed 13 May 2022].

Analysis

Cause of the engine partial power loss

The foreign object found in the No 4 cylinder was a portion of the accelerator pump discharge tube that had released from the carburettor and been drawn into the cylinder by the induction airflow. The discharge tube had broken up due to contact with the inlet and exhaust valves, during which the ability to seal the cylinder during the engine power stroke was lost. The engine was therefore running on only three cylinders, resulting in high vibration and a considerable loss of power.

The abrupt nature of the engine power loss, following normal operation at full power during the initial stages of the takeoff, was not consistent with carburettor icing.

The reason for the release of the discharge tube was not established. Retention of the discharge tube within the carburettor relied on a bonded joint that had held for the previous six years and 601 flying hours. The discharge tube had not been disturbed during the recent annual maintenance inspection. Searches performed on the ECCAIRS and FAA Service Difficulty Reporting System databases returned relatively few records of similar previous occurrences, indicating that discharge tube release is an infrequent event.

Pilot's response to the loss of engine power

The pilot was presented with a challenging situation just a few seconds after takeoff and a decision of whether to land immediately or continue the flight, with an underperforming engine. At the point of the initial engine symptoms becoming evident, the aircraft was at 120 ft agl and there was 1,300 m of runway remaining. This would have been sufficient to descend and land on the runway. However, when the engine rpm reduced, the aircraft was in a climbing attitude and so the extent of runway remaining would not have been immediately evident to the pilot. The pilot reduced the nose-up attitude to maintain airspeed but the aircraft did not pitch down below a level attitude so the view of the runway would still have been obscured. The engine was still developing sufficient power to maintain airspeed and to make a shallow climb which continued up to 180 ft agl.

Approximately six seconds after the first engine symptoms, the pilot told ATC he wished to land on Runway 05, and this was coincident with the aircraft altering heading to the right to conduct a teardrop turn to the reciprocal heading. At this point, although the pilot believed he was outside the airfield boundary, his view of the runway would have remained at least partially obscured by the nose of the aircraft. There was approximately 1,100 m of runway left ahead of the aircraft and a landing on Runway 23 would have been possible. The engine continued to run at approximately 2,100 rpm for the next 10 seconds and the aircraft's speed and height stabilised at approximately 70 mph and 200 ft agl respectively.

The engine rpm then reduced further to 1,500 rpm. The aircraft was displaced approximately 140 m the right of the runway on a heading of 245° and at 200 ft agl. The airport boundary was 600 m ahead though a shallow left turn to 225° would have given a clear area of 1,000 m ahead and allowed a landing off the runway but across grass. Beyond the airfield boundary the land slopes down to the River Tees.

As suggested by the ATSB report, giving consideration to or briefing emergencies prior to takeoff would have helped anticipate the decision-making issues. With his knowledge of the aircraft's performance and of the geography of the airport, the pilot could have, prior to the flight, determined decision outcomes for a variety of heights rather than having to do so in a high workload, abnormal situation. This pre-determination could also have taken into account the inability to see the runway remaining.

When the engine rpm reduced for a second time the pilot was turning toward the runway but intending to land on the grass. Assessment of the CCTV indicates that the pilot used a bank angle of approximately 40°. From the POH table at 40° AOB the stalling speed is increased to 71 mph. As the aircraft began the turn its speed was 64 mph so, as the AOB increased, the stalling speed rose above the actual airspeed and the aircraft stalled. The ATSB report suggests that pilots should brief a minimum height below which they will not turn and suggests 200 ft agl below which a landing ahead or climb ahead are the only choices.

A lack of practice at conducting turnback manoeuvres would have made the pilot's workload extremely high. He was using a high AOB, close to the ground at low speeds whilst under significant pressure. His workload was further increased by conducting the ENGINE FAILURE checklist. These factors would have made a successful turnback with very limited power extremely challenging. It is likely that the attention of the pilot became focussed on achieving the required turn to reach his selected landing area and that he did not adjust the airspeed to avoid the accelerated stall.

Preparation for partial power loss events

A partial power loss event, in particular immediately after takeoff, presents the pilot with challenging, unfamiliar decisions in an environment where aircraft handling is demanding and the timeframe is short. Although addressed during Australian PPL training, the issue is not covered in the UK PPL syllabus, and current CAA Safety information only addresses the issue through reference to other documents. It is therefore not straightforward for pilots to prepare themselves appropriately to deal with such malfunctions. There are opportunities, both during ab initio training and, subsequently, during revalidation flights with an instructor/examiner, to cover this issue. Therefore, to assist pilots in preparing to deal with partial power loss events in an effective manner, the following Safety Recommendations are made:

Safety Recommendation 2022-005

It is recommended that the UK Civil Aviation Authority require ab initio pilots to undergo training in the management of partial power loss situations in single-engine fixed-wing aeroplanes.

Safety Recommendation 2022-006

It is recommended that the UK Civil Aviation Authority provide detailed guidance on techniques for managing partial power loss situations and to promote their use by instructors and examiners when conducting training for a rating revalidation in single-engine fixed-wing aeroplanes.

Safety Recommendation 2022-007

It is recommended that the UK Civil Aviation Authority updates its General Aviation safety promotions to include information for pilots regarding techniques for managing partial power loss situations in single-engine fixed-wing aeroplanes.

Conclusion

The engine suffered a partial loss of power during takeoff due to a portion of the accelerator pump discharge tube having been released from the carburettor into the No 4 cylinder. Following this partial loss of power at low altitude the pilot decided to turn back to land, although post-accident analysis of the circumstances shows there was a sufficiently clear area ahead in which to effect a landing. During the turn, at a low airspeed, the aircraft stalled and struck the ground. All three occupants sustained serious injuries in the impact.

Management of a partial power loss event is not covered in the PPL syllabus and there is limited information provided for pilots conducting renewal or revalidation of licences. Three Safety Recommendations are made to address these topics.

Safety action

The CAA has agreed to discuss the airworthiness concerns relating to discharge tube release events with the FAA, who are the regulator of the engine's Type Certificate holder.

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