Training to manage partial power events in single engine GA aeroplanes

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Introduction

Partial power loss is a recognised, historical problem across General Aviation. It can arise from a wide variety of technical causes and poses a particular danger in the moments immediately after take off. It is a causal factor in a large number of accidents and directly contributes to significant loss of life in GA every year. Due to the wide range of technical issues and aircraft it is a difficult issue to address through a technical response or type specific checklist drills. Changes to the way GA pilots are trained for such events offers an effective and cost-effective way of reducing loss of life.

ATSB Booklet Number 3

The ATSB first published Avoidable Accidents No. 3 in 2010. It reflected on research for the period 2000 to 2010 where there were nine fatal accidents as a result of response to a partial power loss. In the same time period, there were no fatalities from accidents where the engine had failed completely. The data indicated that a partial power loss was three time more likely to occur than a total loss.

In looking at the disparity in the statistics the booklet considered the more challenging nature of the decisions faced by pilots in a partial power event but concluded that this did not fully account for the difference. It further considered the issue of training. Engine failure handling is a defined exercise in PPL training and is practiced from the early stages of flying. While recognising the difficulty of training pilots for a situation with almost infinite variability of residual power and reliability the booklet nonetheless concluded the analysis supported the need to raise awareness of the hazards of partial power and to better train pilots for such eventualities. The booklet contained the following key messages:

Most fatal and serious injury accidents resulting from partial power loss after take off are avoidable. This booklet will show that you can prevent or significantly minimise the risk of bodily harm following a partial or complete engine power loss after take off by using the strategies below:

- *pre-flight decision making and planning for emergencies and abnormal situations for the particular aerodrome.*

- *conducting a thorough pre-flight and engine ground run to reduce the risk of a partial power loss occurring.*

- *taking positive action and maintaining aircraft control either when turning back to the aerodrome or conducting a forced landing until on the ground, while being aware of flare energy and aircraft stall speeds.*

Post the publication of the booklet partial power training was added to the Australian training syllabus.

AAIB Research

During the period 2011 - 2021 the AAIB investigated 16 accidents in which partial oss of power was involved. These 16 accidents resulted in 15 fatalities and 9 serious or life-threatening injuries. In two of these accidents there were no injuries as a result of the aircraft being flown under control to a successful forced landing or ditching. There were five attempted turnbacks, all of which resulted in fatalities or injuries.

The GA training focus is on total loss of power with the emphasis on positive control inputs to establish a safe glide speed. With an engine failure, while the initial situation is serious the decision for the pilot is relatively simple. Whilst off airfield landings can result in significant damage to the aircraft, the outcome for the occupants if the arrival is controlled is often a good one.

If a partial power event occurs soon after take off a pilot finds themselves at low speed, close to the ground with restricted performance and uncertainty about the future performance of the engine. The temptation is to try to return to the airfield via the circuit pattern or to attempt a turnback which can appear to be an appealing prospect. Such manoeuvres are not however, routinely taught to PPL students. Control of the aircraft poses many difficulties particularly if the engine has insufficient performance. Pilots can be tempted to reduce speed to control height. Load factor during the turn increases the stalling speed bringing the aircraft into a very precarious position close to the stall at low altitude. The pilot workload is high in simply trying to control the aircraft but there is a great temptation among pilots to attempt to resolve the technical issue and to conduct checklist drills or engine checks further increasing their workload. Furthermore, when forced into such unfamiliar situations pilots are faced with an unexpected perspective and may misjudge there position.

While arising from a technical cause the management of a partial event requires decisive action in a compressed timeframe. The decisions are much more complex than those presented with the complete loss of power. The partial power situation is perhaps further complicated by a strong desire amongst pilots to return to an airfield and avoid a field landing with the likely damage that would ensue. Unprepared for the extant challenges the pilot often finds themself in a situation which exceeds their capability to manage effectively, and a loss of control is the frequent outcome.

AAIB Case Study G-CJZU

G-CJZU was a Rogers Sky Prince, effectively a Jodel D150 made from plans translated from the original French by Frank Rogers in Australia. The aircraft suffered a partial power loss a few seconds after take off from Goodwood Airfield in June 2021. Analysis of the CCTV at the airfield initially showed the aircraft away from the runway normally before it could be seen to level off or descend slightly. On reaching a height of approximately 150 ft the aircraft then began to climb very slowly. After a further 26 seconds, having reached a maximum height of approximately 300 ft, the aircraft was seen to enter a turn to the left which then increased rapidly in angle with the nose dropping. A safe flying speed had not been maintained, and the aircraft departed from controlled flight at a height from which it was not possible to recover. The aircraft descended steeply and struck the ground nose first. The accident was not survivable and both aircraft occupants were fatally injured.

Figure 1
Composite image from CCTV showing G-CJZU flightpath (two-second spacing between aircraft)

Examination of the engine could not find any faults that could have caused or contributed to the loss of power. The aircraft had sufficient fuel for the flight. Insufficient supply of fuel to the engine from the tanks could have caused the power reduction but the damage to the aircraft meant that it was not possible to establish the condition of the fuel system or level of fuel supply. It is also possible that a fault in the ignition system could have contributed to the power reduction, but the damage from the post impact fire meant that the integrity of the electrical system could not be fully assessed. Weather conditions were also conducive to carburettor ice forming on the taxi out to the runway. It is possible that carburettor ice formation caused the engine to lose power after take off.

AAIB Case Study G-BBSA

G-BBSA was a Grumman AA5 which suffered a partial power loss a few seconds after take off at Teesside Airport in September 2021. 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.

Often very little data from GA aircraft is found to assist AAIB investigations but on G-BBSA the pilot carried an iPad which recorded the GPS path of the aircraft, one of the passengers was recording a video of the flight on a mobile phone and the accident was recorded by CCTV cameras at Teesside Airport. The audio track from the mobile phone was analysed and used to derive engine rpm information for the flight. Consequently a very detailed assessment of the event was possible.

ATC cleared the aircraft for take off and saw the departure. The take off roll appeared normal and the aircraft was airborne after only approximately 650 m of available 2291 m runway.

Approximately 14 seconds after becoming airborne, there was a significant change in the engine note. At this point the aircraft was passing intersection Bravo (Figure 2) 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.

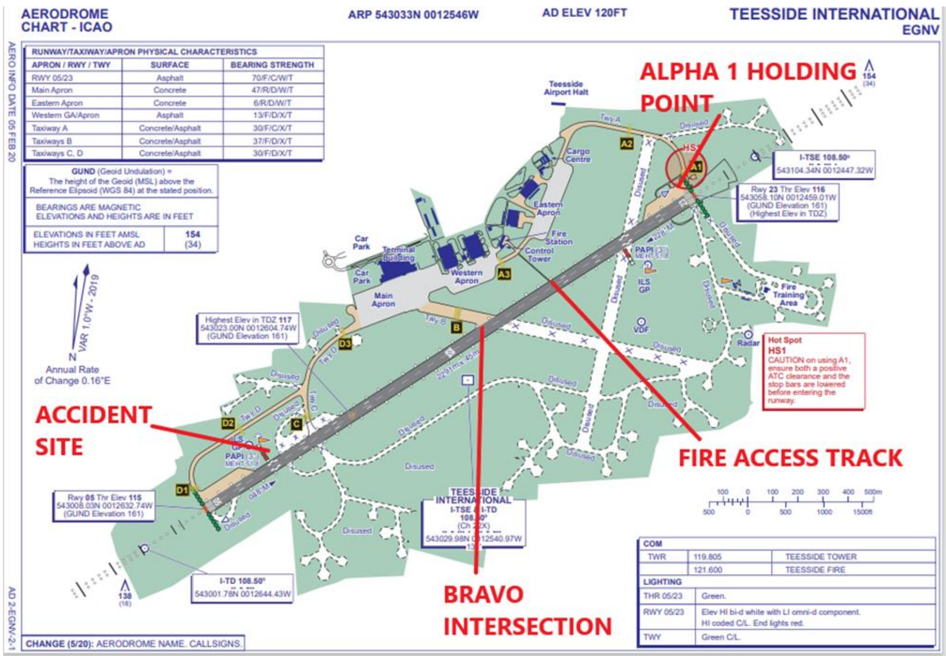

Figure 2
Teesside Airport

The data retrieved from the aircraft was used to make a composite picture of the short flight and overlayed onto a Google Earth Image of the airport (Figure 3).

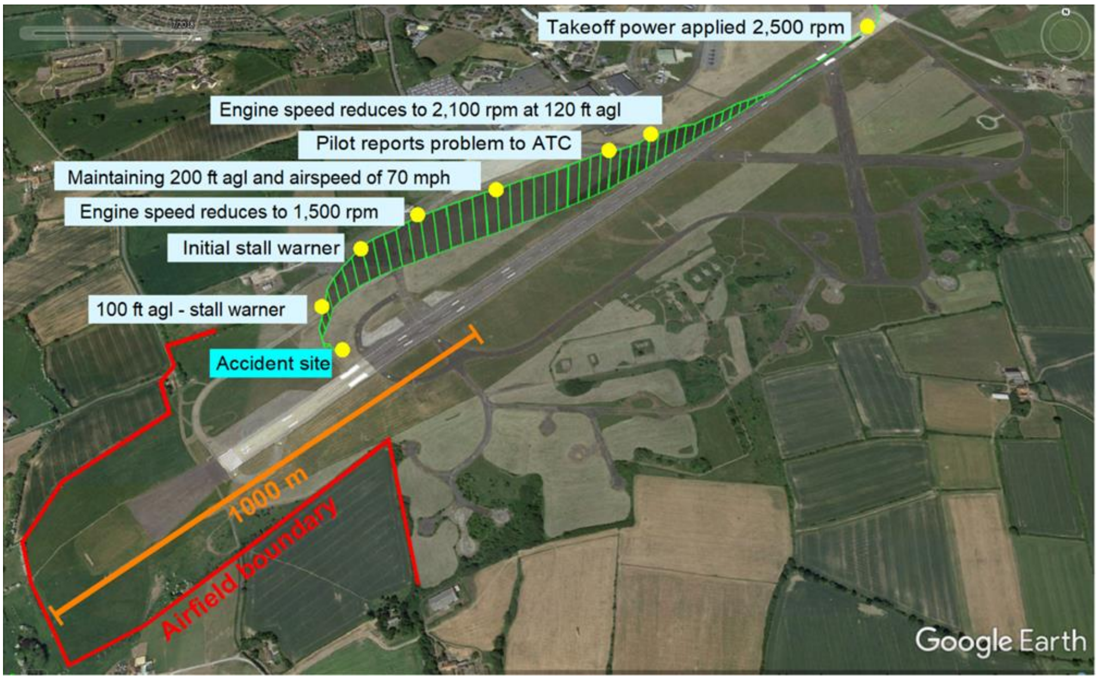

Figure 3

Composite of G-BBSA flight data.

The distances to the end of the runway and to the airfield boundary were tabulated for significant moments and this information is shown at Figure 4.

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°).

Figure 4

Table of runway length remaining

Contrary to the pilot's recollections the aircraft never passed the airfield boundary and up until the turn during which control was lost there still remained a distance of 1000 m to the airfield boundary. While at this point a landing ahead would have been off the runway it would likely have produced a better outcome for those on board.

Technical examination of the aircraft determined that a portion of the accelerator pump discharge tube that had released from the carburettor and been drawn into the cylinder No. 4 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.

UK Military Training – Partial Power and Turnbacks

The UK Armed Forces have addressed the issues of partial power and turnbacks in their flying training. The flight reference cards for military light aircraft contain a drill to attempt to diagnose partial power issues. The aircraft operating guide suggests that if sufficient power is available to establish a climb, then no fault diagnoses should be attempted until the aircraft reaches a safe height for abandonment and that a prospective forced landing should be considered throughout. If a climb cannot be established, then a landing ahead is recommended.

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 at an increased glide speed to reduce the chance of an accelerated stall in the turn. For training, the turnback is only carried out from 700 ft agl and under the supervision of an instructor. For any glide approach the manual directs that wings should be levelled by 200 ft agl.

Changing UK PPL Training

Making changes to the PPL syllabus in the UK is not an easy matter. The syllabus is defined by the Air Navigation Order, a legal statute, and change requires action by Parliament. Change therefore is not something which can be approached lightly or for trivial matters. Any suggestion of changes that would add to the cost of training are hotly contested and characterised by some GA lobbyists as ‘gold plating.’ However, as discussed here partial power events are a significant contributor to loss of life in UK GA. While the research reflected on here is confined to the UK and Australian it seems likely that the issue is relevant to all countries. The ATSB booklet emphasises the importance of considering options at an airfield prior to flight and preparing actions for partial power in advance. It also considers issues such as defining a minimum height for manoeuvre and conducting pre-departure emergencies briefings. Such predetermination in decisions and actions would reduce pilot workload in crisis and be liable to lead to more favourable outcomes.

The ATSB information is freely available but has gained limited traction in the UK. Some CAA Safety information does refer to the ATSB booklet as an information source for partial power issues but does not address the problem directly. However, the loss of life continues. Most tragically the loss of life is in most cases avoidable. The training syllabus devotes significant attention to engine failure but does not address the prospect of a partial power event which is in fact much more likely to occur and causes a greater number of fatalities. Two events which happened close together in 2021 focussed AAIB attention on the issue. As a result, the AAIB made the following Safety Recommendations to the UK CAA:

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.

It is not the role of the AAIB to specify the exact changes but rather to suggest a suitable direction. It is the hope of the AAIB that given appropriate consideration the relevant training could be introduced by amending rather than expanding the syllabus, thereby saving many lives for a very limited cost.