SERIOUS INCIDENT

Aircraft Type and Registration:	Aero AT-3 R100, G-TGUN
No & Type of Engines:	1 Rotax 912-S2 piston engine
Year of Manufacture:	2008
Date & Time (UTC):	12 June 2009 at 1640 hrs
Location:	Old Sarum Airfield, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Damage:	Damage to propeller, right wing and engine gearbox
Commander's Licence:	Private Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	192 hours (of which 7 were on type) Last 90 days - 5 hours Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

Synopsis

After engine start the aircraft moved forward and to the left and struck a fuel bowser, despite the pilot applying pressure to the toe brakes. It is probable that the parking brake lever had inadvertently been moved to the ON position, when the pilot exited the aircraft to refuel it, without hydraulic pressure being applied to the brakes at the time. This rendered the toe brakes inoperative, and prevented the pilot from being able to stop the aircraft. The AAIB makes three Safety Recommendations addressing the parking brake system design and information provided to the pilot about its limitations.

History of the flight

The Aero AT-3 is a low-wing two-seat aircraft certificated in the Very Light Aeroplane (VLA) category (Figure 1). After an uneventful local flight the pilot taxied the aircraft to the fuel bowser and parked alongside it. He shut down the engine and electrics and left the parking brake lever set to OFF. After uplifting 10 litres of fuel the pilot and his passenger climbed back into the aircraft and closed the canopy. After turning the battery and generator on, the pilot applied pressure to the toe brakes, set the throttle lever to ¼", called "clear prop" and turned the ignition key to START. The engine started, the aircraft moved forward and then turned sharply to the left. The pilot continued to apply pressure to the toe brakes but the brakes did not appear to work and after the aircraft had turned left through approximately

160° the propeller struck the fuel bowser, followed by the right wing. The engine stopped as a result of the propeller strike and the aircraft came to rest. The passenger vacated the aircraft first, followed by the pilot after he had turned off the switches. It was later determined that the parking brake lever had been upright, in the ON position.

Figure 1

Photograph of the incident aircraft, G-TGUN
(photograph courtesy Simon Palmer)

Description of the braking system

The Aero AT-3 has a hydraulic braking system that operates a disk brake on each main wheel using toe pressure on the rudder pedals. A parking brake lever is fitted to some aircraft, including G-TGUN, and is located on the right side of the pilot's footwell, as shown in Figure 2. The parking brake lever is off when it is in the horizontal position and on when it is in the vertical position. In order to set the parking brake the pilot needs to apply toe brake pressure before moving the lever to ON, because the lever works by trapping hydraulic pressure in the brake lines. The aircraft maintenance manual depicts two different versions of the braking system: Versions 1 and 2 as shown in Figure 3. Version 1 was fitted to early models of AT-3, while Version 2 was fitted to G-TGUN. In Version 1 there is one set of callipers per brake disk, and the left-seat and right-seat pedals operate the same pair of callipers. The brake pedals from both seats are routed

Figure 2

Parking brake lever in the horizontal OFF position; right side of left-seat footwell

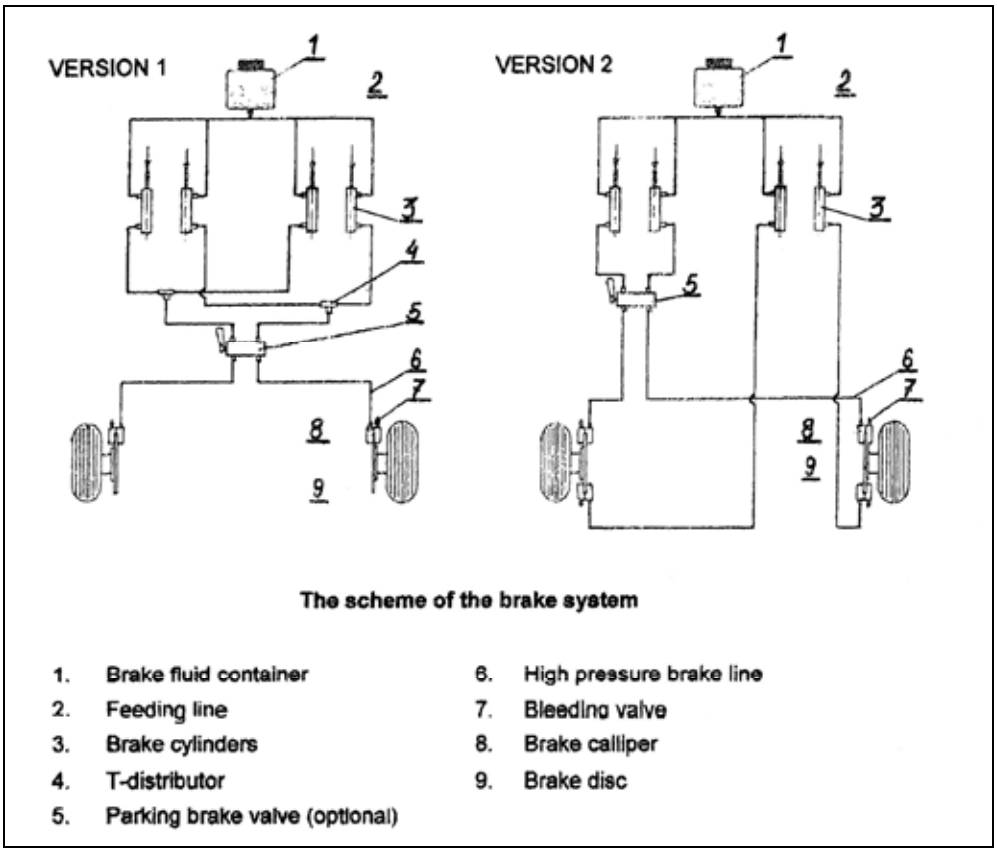

Figure 3

Brake system diagram extracted from Aero AT-3 Maintenance Manual
(G-TGUN brake system was as 'Version 2' above with optional parking brake valve)

through the parking brake valve, so either set of pedals can be used to apply the parking brake. In Version 2 there are two sets of callipers per brake disk, and the front callipers are operated by the left-seat pedals while the rear callipers are operated by the right-seat pedals. Only the left-seat pedals are routed through the parking brake lever, so only the left-seat pilot can apply pressure to operate the parking brake.

The parking brake lever can be moved to the 'ON' position and will stay in the 'ON' position even if no hydraulic pressure is applied to the brake pedals prior to moving the lever. In this situation the parking brake is off despite the parking brake lever indicating ON. Early versions of the parking brake valve incorporated a bypass valve, to enable the toe brakes to apply hydraulic pressure even when the parking brake lever was in the ON position. This particular type of valve suffered from leaks, so the aircraft manufacturer changed the valve to a new type that did not incorporate a bypass valve. The parking brake valve fitted to G-TGUN did not contain a bypass valve. Therefore, on G-TGUN if the parking brake lever was in the ON position, the toe brakes had no effect on braking.

Evaluation of the braking system by a CAA test pilot

Following the G-TGUN incident a test pilot from the Civil Aviation Authority performed a ground test of G-TGUN to evaluate its braking system. He determined

that the parking brake operated satisfactorily when the parking brake lever was moved to the ON position while applying foot pressure to the toe brakes. When the parking brake lever was moved to ON without applying foot pressure, the parking brake was not applied. He also determined that it was possible inadvertently to select the parking brake lever to the ON position. His report stated that:

> *'This was possible with both foot contact, or clothing contact, especially when exiting from the aircraft. Such contact could easily select the lever to the up (ON) position thereby trapping zero foot-motor pressure, the result would be to indicate a Parking Brake "ON" condition without any pressure at the brake which is UNACCEPTABLE.'*

In the test pilot's opinion this condition did not meet the intention of the EASA Certification Specification (CS) 1301 for VLA. CS-VLA 1301 states the following:

> ***'CS-VLA 1301 Function and installation***
>
> *Each item of installed equipment must –*
>
> *(a) Be of a kind and design appropriate to its intended function;*
>
> *(b) Be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors;*
>
> *(c) Be installed according to limitations specified for that equipment; and*
>
> *(d) Function properly when installed.'*

Further, the test pilot considered that pilots may reasonably expect that toe brakes will be available at all times. His report stated that:

> *'Using "trapped" pedal pressure to achieve a Parking Brake is a sensible design desire; however, rendering the foot brakes inoperative in the process is UNACCEPTABLE. It is recommended that the system be re-designed to function safely and provide continuous pressure at the foot brakes.'*

Regulations

CS-VLA 1309 on '*Equipment, systems and installations*' further states that:

> *'The equipment, systems, and installations must be designed to minimise hazards to the aeroplane in the event of a probable malfunction or failure.'*

There is no specific requirement in CS-VLA for an aircraft to be fitted with a parking brake. However, CS-VLA 735 states that *'brakes must be provided'*.

and it is logical that these brakes should be available at all times. In relation to the parking brake lever fitted to the AT-3, CS-VLA 777 on 'Cockpit controls' states that:

> *'Each cockpit control must be located to provide convenient operation, and to prevent confusion and inadvertent operation.'*

EASA Regulation Part 21, which is concerned with the certification of all aircraft types, states under section 21A.3B that the agency shall issue an airworthiness directive when:

> *'an unsafe condition has been determined by the Agency to exist in an aircraft…'*

Under the 'acceptable means of compliance' (AMC 21A.3B) section for unsafe conditions, it states that an unsafe condition exists, among other things, if there is an unacceptable risk of serious or fatal injury to persons other than occupants. Furthermore, an unsafe condition may exist even though the airworthiness requirements are complied with. Under the guidance material for this section (GM 21A.3B), it states:

> *'When an accident/incident does not involve any component malfunction or failure but when a crew human factor has been a contributing factor, this should be assessed from a man-machine interface standpoint to determine whether the design is adequate or not.'*

It further states that when establishing an unsafe condition on the basis of human factors aspects, the assessment should include:

> *'Characteristics of the design that allow or facilitate incorrect operation.'*

Flight Manual and checklists

The Flight Manual for G-TGUN (version from September 2004) contained a brief description of the braking system in the main body of the manual and a brief description of the parking brake in a supplement at the end of the manual. The accompanying diagram in both sections was for the 'Version 1' system, even though G-TGUN was fitted with the 'Version 2' system. This diagram gives the reader the incorrect impression that the parking brake could be applied from the right-seat pedals when that was not the case. The Flight Manual's description of the parking brake system did not include the information that the toe brakes would be rendered inoperative when the parking brake lever was in the ON position.

The checklist in the Flight Manual for G-TGUN did not contain references to the parking brake. The checklist called for wheel chocks to be positioned and brakes to be applied before starting the engine. The lack of reference to the parking brake could be due to the parking brake being optional on early models of aircraft.

The UK supplier of Aero AT-3s had provided the flying school, which operated G-TGUN and other AT-3s, with a modified checklist for the aircraft in September 2008. This checklist called for the parking brake to be set on before the walk-around checks, and for the parking brake to be selected off and toe brakes applied before engine start. The flying school did not adopt this practice but instead created a checklist that called for the parking brake to be on before engine start. This led to an incident where an AT-3 veered left immediately after engine start, because some of the trapped pressure in the parking brake valve had leaked out. Following this incident the flying school revised their checklist and training so that pilots started the engine with the parking brake off and toe brake pressure applied. The revised checklist included a check that the parking brake lever was off prior to the walk-around checks, and the 'Starting Engine' section was revised to include '*Toe Brakes – Hold On*'. The pilot of G-TGUN was using this checklist.

Following the G-TGUN incident the flying school added a second '*Parking Brake – Horizontal (Off)*' check at the beginning of the 'Starting Engine' section.

Aero AT-3 Service Letters

A few days after the G-TGUN incident, but unrelated to it, the aircraft manufacturer published Service Letter ATB3.10.L entitled '*Parking Brake Usage*' (Issue 1, 22/06/09). This Service Letter warned that it was not recommended to leave the aircraft for a period longer than a few hours with the parking brake engaged, because the braking force may drop due to internal leakage of the brake valve or a change in ambient temperature. It recommended that, for longer parking periods, the aircraft was either chocked or tied down. The Service Letter warned that:

> *'Parking brake must be disengaged and toe brakes applied prior to starting the engine!'*

It also recommended installing placards near the throttle levers which stated: 'BEFORE ENGINE START: - RELEASE PARKING BRAKE - APPLY TOE BRAKES.'

This letter was issued in response to incidents resulting from pilots starting the engine with the parking brake applied, and the aircraft suddenly moving or turning unexpectedly due to uneven parking brake pressure distribution to the wheels; the letter was not in response to the potential problem of starting the engine with no brake pressure in the parking brake system and inoperative toe brakes. The Service Letter did not include the information that on some models of AT-3 the toe brakes would be rendered inoperative when the parking brake lever was in the ON position. A revised Service Letter (Issue 2, 27/08/09) also did not explain the lack of a bypass valve or why the toe brakes would be rendered inoperative when the parking brake lever was in the ON position.

Updated AERO AT-3 Flight Manual

In October 2009 the aircraft manufacturer published an updated Flight Manual for the AERO AT-3. In the checklist section of the manual the words '*Parking brake (if installed) – OFF*' were added to the 'Before starting engine' checks. The braking system section of the manual was also amended to include diagrams of both the 'Version 1' and 'Version 2' braking systems. A note in bold typeface was also added stating that toe brake pressure must be applied before moving the parking brake lever to ON, and that the parking brake should not be used over a prolonged period of time due to a possible decrease in pressure in the brake lines.[1] However, the amended Flight Manual did not include the information that the toe brakes would be rendered inoperative when the parking brake lever was in the ON position.

Analysis

The pilot had intended to start the engine with the parking brake off, and was holding the toe brakes to prevent the aircraft from moving forwards after start. This was in accordance with the flying school's procedures and its checklist. The fact that the aircraft moved forwards after engine start, and did not respond to toe brake application, indicates that the parking brake lever was probably in the ON position and had been moved to the ON position without toe brake pressure applied. Based on the observations by the CAA test pilot, it is likely that the parking brake lever had been inadvertently moved to the ON position while the pilot was exiting the aircraft in order to refuel it – his right leg or clothing could have brushed against the lever and moved it.

Footnote

[1] These changes to the Aero AT-3 Flight Manual were incorporated in the 'August 2008' amendment, but this amendment was not published until October 2009.

If the pilot had checked the position of the parking brake lever prior to engine start the incident would probably have been avoided. However, his checklist did not include a parking brake lever check in the 'Starting Engine' section and, more importantly, the pilot was not aware that an inadvertent selection of the parking brake lever would render the toe brakes inoperative, because the Flight Manual did not explain this and there was no warning placard in the cockpit. The Flight Manual's description of the braking system was not adequate, and also incorrect in that it contained the wrong diagram for the type. An amended AT-3 Flight Manual, published in October 2009, incorporated the correct diagram, but still did not explain that selection of the parking brake lever would render the toe brakes inoperative.

It could be argued that when the aircraft started to roll forwards the pilot should have closed the throttle, but when an aircraft rolls forward unexpectedly a pilot tends to react instinctively, and the initial instinct is usually to apply, or press down harder on, the brakes. Therefore, the root of this serious incident was the parking brake system design. For safe manoeuvring of light aircraft on the ground, it is fundamental that the manual braking system should be available at all times. Therefore:

Safety Recommendation 2010-053

It is recommended that the European Aviation Safety Agency (EASA) require that the Aero AT-3 brake system be modified such that the toe brakes remain functional regardless of whether the parking brake is off or on.

In the interim, it is important both that the Flight Manual accurately reflect the design and function of the brake system installed and that this be reinforced by the provision of warning placards. Therefore, as an interim measure until the brake system is redesigned, the following two Safety Recommendations are made:

Safety Recommendation 2010-054

It is recommended that the European Aviation Safety Agency (EASA) require Aero Sp to update the Flight Manual for the Aero AT-3 to explain the operation of the braking system clearly and to include a warning that the toe brakes become inoperative when the parking brake lever is selected on.

Safety Recommendation 2010-055

It is recommended that the European Aviation Safety Agency (EASA) require Aero Sp to provide warning placards, to be installed in all affected Aero AT-3 aircraft, which state that the toe brakes become inoperative when the parking brake lever is selected on.

Safety Action

Following this investigation, the aircraft manufacturer stated that they intend to provide warning placards for all affected aircraft which state 'LEFT SEAT TOE BRAKES ARE INOPERATIVE WHEN PARKING BRAKE LEVER IS "ON"'. They also intend to amend the Flight Manual to include the same warning and additional information explaining the operation of the braking system.