

FINAL REPORT

**AERO AT4, REGISTRATION 9M-EVA
VEERING OFF TAXIWAY**

7 October 2015

AIB/AAI/CAS.116

**Transport Safety Investigation Bureau
Ministry of Transport
Singapore**

7 February 2017

The Transport Safety Investigation Bureau

The Transport Safety Investigation Bureau (TSIB) is the air and marine accidents and incidents investigation authority in Singapore responsible to the Ministry of Transport. Its mission is to promote aviation and marine safety through the conduct of independent and objective investigations into air and marine accidents and incidents.

For aviation related investigations, the TSIB conducts the investigations in accordance with the Singapore Air Navigation (Investigation of Accidents and Incidents) Order 2003 and Annex 13 to the Convention on International Civil Aviation, which governs how member States of the International Civil Aviation Organization (ICAO) conduct aircraft accident investigations internationally.

In carrying out the investigations, the TSIB will adhere to ICAO's stated objective, which is as follows:

"The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability."

Accordingly, it is inappropriate that TSIB reports should be used to assign fault or blame or determine liability, since neither the safety investigation nor the reporting process has been undertaken for that purpose.

CONTENTS

	Page
GLOSSARY OF ABBREVIATIONS	3
SYNOPSIS	4
1 FACTUAL INFORMATION	5
1.1 History of the Flight	5
1.2 Injuries to Persons	6
1.3 Damage to Aircraft	6
1.4 Personnel Information	7
1.5 Aircraft Information	7
1.6 Meteorological Information	9
1.7 Medical and Pathological Information	9
1.8 Recorded Data	9
1.9 Tests and Research	10
1.10 Organisational and Management Information	10
1.11 Additional Information	11
2 DISCUSSION	12
2.1 Crosswind Effect	12
2.2 Locking of Left Wheel due to Seizure of Left Brake	12
2.3 Aircraft's Veering Off	14
2.4 Aircraft Maintenance	14
2.5 Airworthiness Requirements of Cross-border Flying	15
3 CONCLUSION	16
4 SAFETY RECOMMENDATIONS	17

GLOSSARY OF ABBREVIATIONS

ATC	: Air Traffic Control
ATS	: Air Traffic Services
CAAS	: Civil Aviation Authority of Singapore
CCTV	: Closed Circuit Television
CoA	: Certificate of Airworthiness
DCA	: Department of Civil Aviation, Malaysia
IPC	: Illustrated Parts Catalogue
LT	: Local Time
PPL	: Private Pilot License
PTF	: Permit-To-Fly

SYNOPSIS

On 7 October 2015, an Aero AT4 aircraft landed in Seletar Airport. As it was taxiing towards its assigned parking bay, the aircraft veered off the taxiway and came to rest on a grass patch. The nose landing gear broke off as a result.

There was no injury to any person.

The occurrence was classified as an accident.

AIRCRAFT DETAILS

Aircraft type	:	Aero AT4-LSA
Manufacturer	:	Aero AT Sp. z o. o. Poland
Operator	:	Private owner
Registration	:	9M-EVA
Engine details	:	1 x Bombardier Rotax 912 ULS
Date and time of occurrence	:	7 October 2015, 1157LT
Location of occurrence	:	Seletar Airport, Singapore
Type of flight	:	General aviation flight
Persons on board	:	1

prevent the aircraft from continuing to veer to the left. The aircraft eventually came to rest on a grass patch next to a drain (see **Figure 2**).



(a)



(b)



(c)

Figure 2: Aircraft final position

1.2 Injuries to Persons

1.2.1 The pilot was not injured.

1.3 Damage to Aircraft

1.3.1 The damage to the aircraft included the following:

- Sheared off nose gear
- Impact damage on left landing gear (misalignment of wheel, misalignment of brake disc relative to the brake caliper resulting in rub marks on the internal interface of the left forward brake caliper)
- Dents on leading edge of left wing
- Scratch marks on left wing tip
- Crack across canopy



Figure 3: Damage to the aircraft

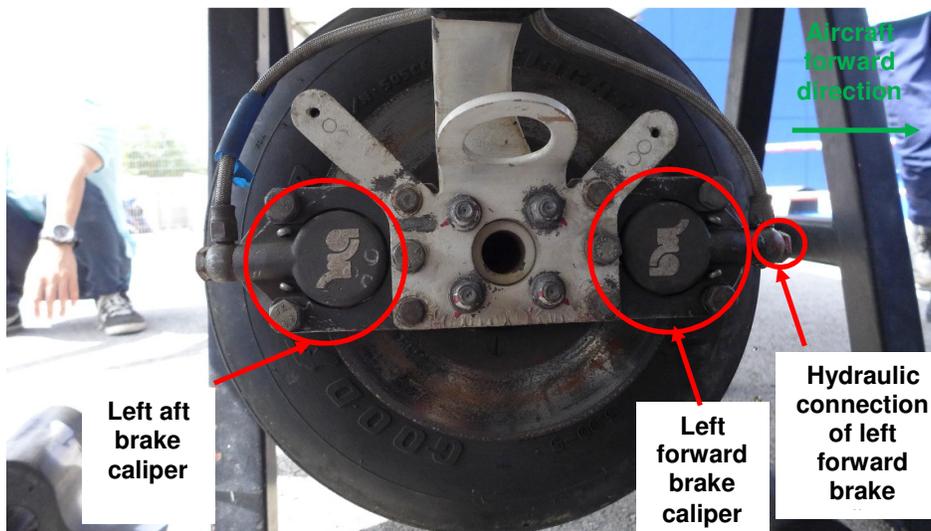


Figure 4: View looking inboard of left landing gear

1.4 Personnel information

1.4.1 Pilot's information (as of 7 October 2015)

Gender	Male
Age	46
License	Private Pilot License (PPL) issued by the Department of Civil Aviation of Malaysia Valid until 31 July 2016
Total Flying Experience	97 hours
Total on Aero AT4-LSA	60 hours

Flying in last 24 hours	0.7 hour
Flying in last 7 days	1.4 hours
Flying in last 28 days	2.7 hours
Flying in last 90 days	15.8 hours

1.5 Aircraft Information

1.5.1 Aircraft Ownership

1.5.1.1 The pilot's spouse is the owner of the aircraft. The aircraft was purchased brand new from the aircraft manufacturer in 2008 and leased to a flying club in Malaysia.

1.5.2 Certificate of Airworthiness

1.5.2.1 The aircraft did not have a Certificate of Airworthiness (CoA). It had a Permit-To-Fly (PTF) granted by the Department of Civil Aviation of Malaysia (DCA). The PTF allowed the aircraft to fly only in Malaysia.

1.5.3 Aircraft Maintenance

1.5.3.1 The flying club to which the aircraft was leased employed maintenance personnel licensed by DCA to maintain the aircraft.

1.5.3.2 Entries in the technical logbook showed that the left and right brake linings were last replaced on 31 March 2015. Since then, the aircraft had flown 32 sectors before the occurrence flight, with no problems reported.

1.5.3.3 There was no technical logbook entry related to brake anomaly since the aircraft's delivery in 2008 and the pilot did not experience any brake problems in previous flights.

1.5.4 Brake System

1.5.3.1 The foot pedals in each pilot position² are used for moving rudder as well as for applying brakes. When the upper portion of a foot pedal is depressed (using toe force), the foot pedal functions as a brake pedal. When the lower portion of the pedal is depressed (using heel force), the foot pedal functions as a rudder pedal (**Figure 5**).

² The aircraft is a twin-seater.

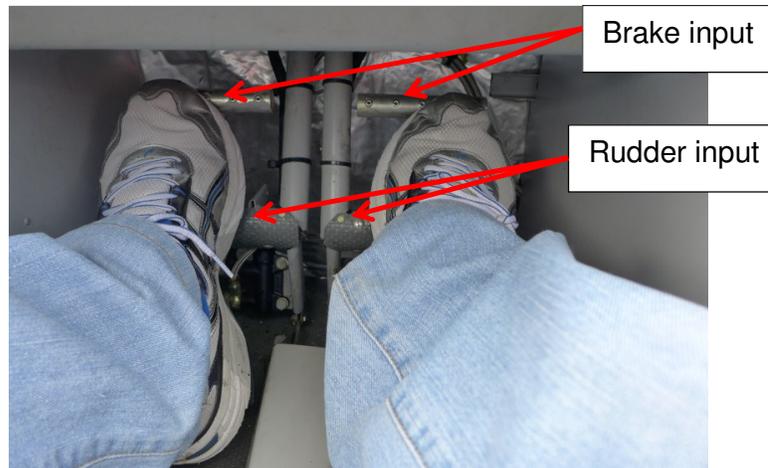


Figure 5: Position of rudder and toe brake pedals

1.5.4.2 The directional control of the aircraft during low speed taxiing is achieved through differential braking³.

1.5.4.3 If a pilot applies his foot control inappropriately, he may end up applying rudder control when he actually wants to apply brakes, and vice versa.

1.6 Meteorological Information

1.6.1 At the time of the occurrence, the runway was dry. There was no precipitation. Visibility was 7,000 m. The wind was 5 knots from a direction of 050.

1.7 Medical and Pathological Information

1.7.1 The pilot underwent a medical examination and toxicological tests following the occurrence. There was no evidence of any relevant medical or toxicological factors that could affect the performance of the pilot.

1.8 Recorded Data

1.8.1 The video footage from the Closed Circuit Television (CCTV) cameras facing the taxiway was retrieved from the aerodrome operator and the (ATC) audio recordings during the occurrence were also obtained from the Singapore air traffic services (ATS) provider. They provided useful information for establishing the sequence of events and estimating the aircraft's taxiing speed to be about 9-12 knots at about the time of the occurrence.

³ At higher speeds, directional control of the aircraft is achieved using the rudder.

- 1.8.2 There was no Cockpit Voice Recorder and Flight Data Recorder installed on the aircraft.
- 1.9 Tests and Research
- 1.9.1 The rudder, aileron and elevator control systems were examined following the occurrence. No anomaly was found.
- 1.9.2 Functional test of the brake system was carried out following the occurrence. The brake system functioned normally.
- 1.9.3 In the course of the inspection of the brake system, it was noted that the part number of the brake linings did not correspond to the part number recommended by the manufacturer and there was no evidence that these brake linings had been approved for use on this aircraft by the relevant authorities.
- 1.10 Organisational and Management Information
- 1.10.1 Regulatory Requirements for Aircraft Entering Singapore
- 1.10.1.1 According to the Civil Aviation Authority of Singapore (CAAS), for an aircraft to fly and land in Singapore, it is required, among others, to:
- File a flight plan
 - Be in possession of a CoA issued by the State of Registry, or a PTF issued by the CAAS
- 1.10.1.2 Flight plans are filed with the ATS provider in the country of departure, which will convey the flight plans to the country of destination concerned. In the case of the occurrence aircraft, flight plans were filed with the Malaysian ATS provider for the flights on 30 August 2015 and 4 October 2015. The Malaysian ATS provider conveyed the flight plans to the Singapore ATS provider. The flight plans were accepted by the Singapore ATS provider. A flight plan was also filed with the Singapore ATS provider for the navigation flight on 7 October 2015 departing from Singapore towards Kota Tinggi and Tebrau in Malaysia and returning to Singapore.
- 1.10.1.3 For an aircraft to fly to Singapore without a CoA, an application for a PTF would have to be made to CAAS at least five days before the intended flight. CAAS will make the necessary assessment and, if satisfied, issue a PTF to the aircraft which will be valid for no more than 14 days from the day the PTF is granted.
- 1.10.1.4 According to CAAS, no PTF application in respect of the aircraft had ever been received by CAAS although the aircraft had come to Singapore on three occasions. According to the pilot, he had assumed that acceptance of flight plans by the ATS providers in Malaysia and Singapore meant

permission for his aircraft to fly to Singapore.

1.11 Additional Information

1.11.1 The setting of the aircraft's parking brake is by the following actions:

- (a) Apply brake
- (b) Turn the parking brake lever to the ON position (Note: The parking brake lever is OFF when it is in the horizontal position and ON when it is in the vertical position.)

1.11.2 The parking brake lever of the aircraft was found to be rotating freely as a pin that holds the lever in place was missing (**Figures 6 and 7**). To set the parking brake, the pilot had been using an improvised method – by inserting a makeshift thin rod through the missing pin hole and then turning the lever.

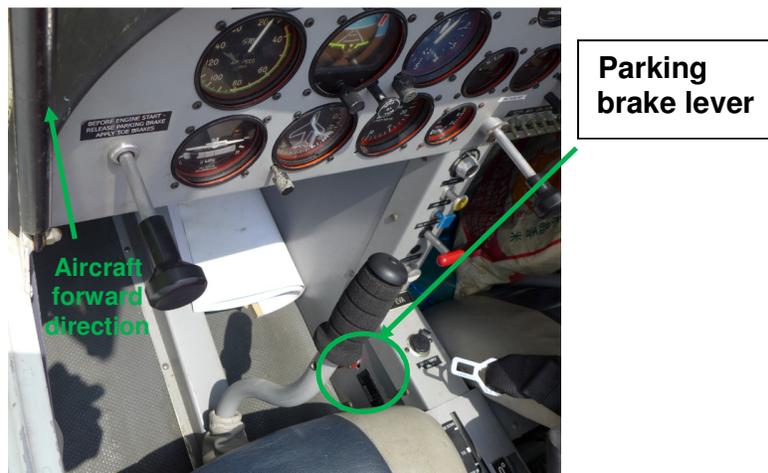


Figure 6: View of cockpit



Figure 7: Close up view of parking brake lever

2 DISCUSSION

The investigation team looked into the following possible causes of the aircraft's veering off:

- (a) Crosswind effect
- (b) Locking of the left wheel due to seizure of the left brake
- (c) Pilot action

In addition, the investigation team also looked into the issues below, although they were not contributing factors in this occurrence.

- (d) Aircraft maintenance
- (e) Airworthiness requirements for cross-border flying

2.1 Crosswind Effect

2.1.1 When wind blows onto the vertical stabiliser of an aircraft, the crosswind component of the wind may cause the aircraft to yaw.

2.1.2 At the time of the occurrence, a 5-knot wind was blowing from 050 degrees while the occurrence aircraft was taxiing at about 9 to 12 knots in the 030 degree heading. The crosswind component of the wind was about 2 knots⁴. It was highly improbable for the wind to have caused the aircraft to veer to the left.

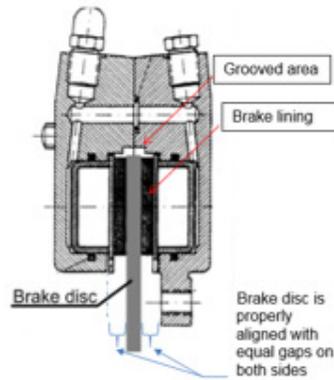
2.2 Locking of Left Wheel due to Seizure of Left Brake

2.2.1 If the left wheel was locked (i.e. prevented from rotating) or if the left wheel's rate of rotation was significantly lower than the right wheel's, the aircraft would veer to the left.

2.2.2 The investigation team considered the following scenarios that might result in a locked wheel situation due to the seizure of the left brake assembly:

- Misalignment of the brake disc in the left wheel brake calipers from the impact damage, causing internal rubbing within the caliper (**Figure 8**)
- Fusion of the brake disc with the brake linings of the calipers in the left landing gear during emergency braking operation

⁴ According to the aircraft manufacturer, correct aircraft handling characteristics have been demonstrated during take-off and landing with crosswind speed up to 11.7 knots.



Cross-section of Brake Caliper under normal operation condition

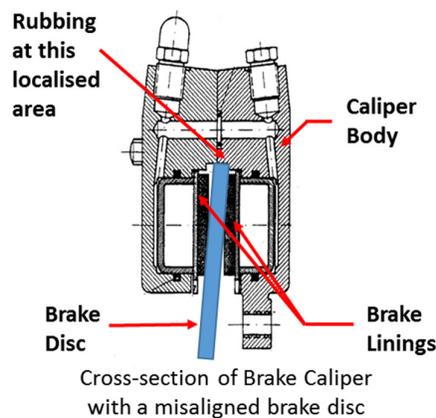


Figure 8: Cross section of a brake caliper

2.2.3 Misalignment of brake in left wheel

2.2.3.1 A high pitch screeching noise would have been produced if the brake disc had been in contact with the calipers while taxiing. The pilot did not recall hearing any such noise while operating the aircraft on 4 and 7 October 2015.

2.2.3.2 The rub marks on both of the left brake calipers could have been a result of towing of the aircraft after the occurrence with a misaligned left brake disc.

2.2.3.3 A locked wheel situation resulting from a misalignment of brake disc is highly unlikely.

2.2.4 Fusion of brake disc with braking lining

2.2.4.1 No brake system anomaly was found during the post-accident functional test of the aircraft's brake system. There were also no pilot reports of brake anomaly before 7 October 2015.

2.2.4.2 The inspection of the brake discs and brake linings also did not show any

evidence of fusion between the brake disc and brake linings.

2.2.4.3 The aircraft manufacturer had performed a test on the braking system of the aircraft in July 2015 in a simulated emergency braking situation. The test showed that fusion of the brake disc with brake linings would not occur even at aircraft speeds up to 50 knots. The aircraft taxi speed at about the time of the occurrence was only 9-12 knots.

2.2.5 In view of the above, the investigation team determined that a locked wheel situation resulting from misalignment of brake disc or fusion of brake disc with brake linings on the left landing gear wheel is highly unlikely.

2.3 Aircraft's Veering Off

2.3.1 The pilot mentioned to the investigation team that the right brake was not responsive when the aircraft was near the junction of Taxiway E3 and EP, and again when he was turning into Taxiway E2 at which moment the aircraft started to veer off. Owing to a lack of flight recorder data, the investigation team is unable to verify the pedal inputs by the pilot during the event.

2.3.2 One possibility is that the pilot might have inadvertently applied the right rudder input instead of depressing the right toe brake pedal. Under a low taxiing speed and a low wind speed condition, the deflection of the rudder would not have any effect on the direction of travel. If the pilot did apply inadvertently rudder pedal input instead of brake pedal input, it would be natural that there would be no braking action, as the pilot had perceived in this case. This may explain why the pilot felt that the right brake was not responsive. Without braking action on the right wheel but with braking action on the left wheel, the aircraft would veer to the left. The combination of left brake application and right rudder input would cause the aircraft to veer to the left.

2.3.3 To ascertain whether rudder pedal was applied, the investigation team attempted to determine from the CCTV video footage from the aerodrome operator whether there were rudder movements at and prior to the time of the aircraft's veering off. However, the resolution of the CCTV video footage was not sufficient for the investigation team to make such a determination.

2.4 Aircraft Maintenance

2.4.1 The part numbers of brake linings did not correspond to the part numbers recommended by the aircraft manufacturer. The part numbers of components and parts approved to be installed on aircraft were listed in the Illustrated Parts Catalogue (IPC) for the aircraft. According to the aircraft manufacturer, the IPC was delivered to the owner as part of the aircraft purchase.

- 2.4.2 Parts recommended for use by the aircraft manufacturer would have gone through the necessary tests and examinations to meet the aircraft certification requirements of and are approved for use by the State of Design of the aircraft (Poland in this case).
- 2.4.3 It is important that maintenance personnel use only approved parts for an aircraft during maintenance, to ensure the aircraft's airworthiness.
- 2.5 Airworthiness Requirements for Cross-border Flying
- 2.5.1 When a pilot intends to operate an aircraft to another country, the pilot would have to ensure that all the regulatory requirements of the country of destination are met. The pilot of the occurrence aircraft had assumed that acceptance of flight plans by the ATS providers of Malaysia and Singapore meant permission for the aircraft to fly to Singapore despite it having only a PTF issued by DCA which allowed the aircraft to fly only in Malaysia.
- 2.5.2 Flight plans are concerned with the scheduling of aircraft movements. A country of destination's acceptance of a cross-border flight plan does not automatically mean that the aircraft concerned has met all the regulatory requirements of the country of destination nor that the aircraft is permitted to enter the country of destination.
- 2.5.3 That the aircraft has flown into Singapore on three occasions in 2015 (on 30 August, 4 October and 7 October) without a Singapore PTF suggests that the GA sector might not have been aware of the fact that a PTF limited to fly only in one country is not automatically valid in another country. The country issuing PTFs may need to remind its pilots of this fact. A country receiving foreign aircraft may also wish to make sure foreign pilots are aware of this fact and of any additional requirements that the foreign pilots and aircraft need to comply with.
- 2.5.4 The CAAS should review its procedures to ensure that an aircraft without a valid CoA or PTF is prevented from flying into Singapore.

3 CONCLUSION

From the information gathered, the following findings are made. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- 3.1 Post-accident tests did not reveal any anomaly of the brake system. There is no evidence to suggest that the aircraft's veering to the left is a result of brake system problem. The wind condition at the time of the occurrence was also unlikely to have caused the veering off.
- 3.2 There is a possibility that the pilot might have inadvertently applied the right rudder input instead of depressing the right toe brake pedal. However, this cannot be ascertained.
- 3.3 The brake linings installed in the event aircraft's braking system were not parts recommended by the aircraft manufacturer.
- 3.4 The aircraft had a PTF that was valid only for flying within Malaysia. The pilot did not apply to CAAS for a PTF for flying in Singapore. He assumed the acceptance of a flight plan was an approval granted to land in Singapore.

4 SAFETY RECOMMENDATIONS

A safety recommendation is for the purpose of preventive action and shall in no case create a presumption of blame or liability.

It is recommended that:

- 4.1 The aircraft owner ensure that only parts recommended by the aircraft manufacturer or approved by DCA are used in the maintenance of the aircraft. [TSIB Recommendation RA-2017-001]
- 4.2 The flying club that maintain the aircraft ensure that only parts recommended by the aircraft manufacturer or approved by DCA are used in the maintenance of aircraft. [TSIB Recommendation RA-2017-002]
- 4.3 DCA ensure that the flying club use only parts recommended by the aircraft manufacturers or approved by DCA in the maintenance of aircraft. [TSIB Recommendation RA-2017-003]
- 4.4 DCA remind the general aviation pilots in Malaysia that a Permit-To-Fly granted by DCA does not authorise them to fly outside Malaysia. [TSIB Recommendation RA-2017-004]
- 4.5 DCA remind the general aviation pilots that acceptance of flight plans for flying into a foreign country does not constitute an approval for flying into that foreign country. [TSIB Recommendation RA-2017-005]
- 4.6 CAAS remind the general aviation pilots that acceptance of flight plans for flying into Singapore does not constitute an approval for flying into Singapore. [TSIB Recommendation RA-2017-006]
- 4.7 CAAS review how an aircraft without a valid Certificate of Airworthiness or Permit-To-Fly may be prevented from flying into Singapore. [TSIB Recommendation RA-2017-007]