Final Report

DIAMOND DA42, REGISTRATION N181CW
DOOR DETACHMENT DURING TAKE-OFF

15 OCTOBER 2019

AIB/AAI/CAS.186

Transport Safety Investigation Bureau
Ministry of Transport
Singapore

8 October 2020

The Transport Safety Investigation Bureau of Singapore

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GLOSSARY OF ABBREVIATIONS

AMS	Avionics Master Switch
ATC	Air Traffic Control
PFD	Primary Flight Display

SYNOPSIS

On 15 October 2019, while a Diamond DA42 aircraft was rolling on the runway for take-off, a passenger door detached itself from the aircraft. The aircraft aborted the take-off and vacated the runway.

There was no injury to any person.

The Transport Safety Investigation Bureau classified this occurrence as a serious incident.

AIRCRAFT DETAILS

Aircraft type	:	Diamond DA42
Operator	:	Privately Owned
Aircraft registration	:	N181CW
Numbers and type of engines	:	Two x Austro Engine AE 300 turbocharged common-rail injected 2.0L diesel engine
Engine hours/cycles since new	:	528.4 hours
Engine hours/cycles since last shop visit	:	92.6 hours
Date and time of incident	:	15 October 2019, 0753 hours
Location of occurrence	:	Seletar Airport, Singapore
Type of flight	:	Non-scheduled
Persons on board	:	One

1 FACTUAL INFORMATION

All times used in this report are Singapore Local Time (LT) unless otherwise stated. Singapore Local Time is eight hours ahead of Coordinated Universal Time (UTC).

1.1 History of the flight

1.1.1 On 15 October 2019, the pilot of a Diamond DA42 aircraft planned to fly from Seletar Airport, Singapore, to Kuching, Malaysia. He arrived at the aircraft at about 0715LT. According to the pilot, he opened the passenger door to stow his baggage in the aircraft and then closed and latched the passenger door and checked that the door and door handle were flush with the fuselage. A licensed mechanic was in the vicinity to assist in the dispatching of the aircraft and who said he saw that the passenger door was closed[1].

1.1.2 After completing the walk-around check for the aircraft, the pilot got himself seated in the cockpit and closed the front canopy of the aircraft[2]. After completing the pre-flight checks, he called the Air Traffic Control (ATC) for engine start-up and taxi clearance. After starting the engine, he put on his headset[3]. He did not notice any visual "Door Open" warning on the Primary Flight Display (PFD) when he started the engines.

1.1.3 At about 0741LT, the ATC cleared the aircraft for taxi to Runway 03. The pilot executed the BEFORE TAXIING CHECKLIST before taxiing. One of this checklist's items was to switch on the Avionics Master Switch (AMS), which would energise the avionics bus and this bus would in turn power up the audio panel for the operation of the warning chime system.

1.1.4 While at the holding point, the pilot completed the BEFORE TAKE-OFF CHECKLIST. One of this checklist's items was to check that there was no indication of the "Door Open" warning on the PFD. The ATC cleared the aircraft for take-off at about 0750LT.

1.1.5 After lining up on the runway, the pilot applied power for the take-off. When the aircraft had reached about 40 knots during the take-off roll, he heard "Abort,

[1] The licensed mechanic was standing about 2.5 metres away from the aircraft and was at the pilot's eleven o'clock position.
[2] DA42 has a front canopy and a passenger door.
[3] Voice communications and warning chimes could be heard through the headset.

Abort" on his radio[4]. The pilot closed his throttles to abort the take-off. At the same time, he noticed the "Door Open" warning on the PFD but he could not recall hearing any warning chimes[5]. The pilot recalled that, glancing over his left shoulder, he could see the runway through an opening, and he thought that the passenger door had sprung open by itself. It did not occur to him that the door was altogether detached from the aircraft.

1.1.6 The aircraft slowed down, vacated the runway via Taxiway W3 on the left and stopped on Taxiway W3. The pilot shut down the engines and exited the cockpit. He then noticed that the passenger door was missing (see **Figure 1**).

Figure 1. Passenger door detached from aircraft

1.1.7 The detached passenger door was subsequently recovered from the runway (see **Figure 2**).

[4] The shout-out on the radio was from the pilot of an aircraft that had lined up behind. This pilot saw the passenger door of the incident aircraft opening and breaking off from the aircraft during the take-off roll. The last part to give way were the hinges with the rear hinge coming off last.

[5] If the AMS was switched on and if the front canopy and all the doors had been closed and latched, the opening of any of the doors, e.g. the passenger door, would result in a "Door Open" warning on the PFD, accompanied by repeating warning chimes. If the AMS was not switched on, there would still be a "Door Open" warning on the PFD, but no warning chime. More on this in paragraph 1.5.2.

Figure 2. Detached door found on the runway

1.2 Injuries to persons

1.2.1 The pilot was the only person on board the aircraft at the time of the incident. He was not injured.

1.3 Damage to aircraft

1.3.1 The passenger door, together with the forward door hinge and part of the aft door hinge, was completely torn off from the door frame (see **Figure 3**). Part of the aft door hinge remained on the door frame (see **Figure 4**).

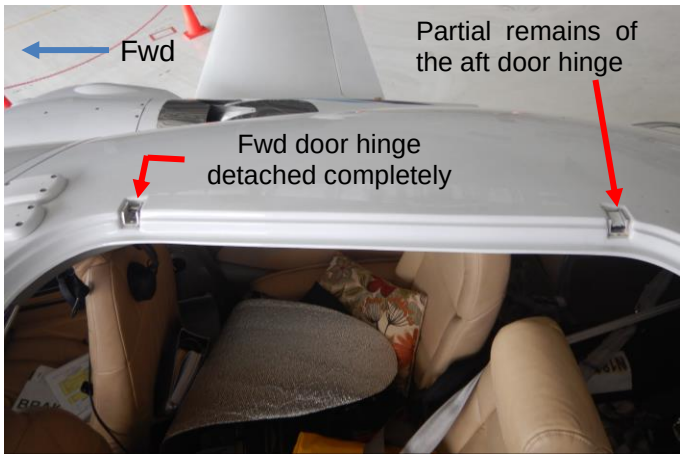

Figure 3. Damages on the hinges of the door

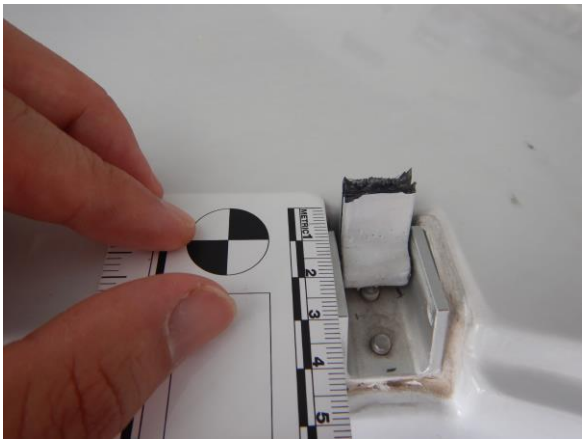

Figure 4. Close-up of the damage on the remaining aft hinge on the door frame

1.3.2 The compression gas spring strut connecting the passenger door to the door frame on the fuselage was broken (see **Figure 5**).

Figure 5. Gas spring strut detached from the door

1.3.4 The detached door and its locking mechanism were examined. Although the top surface of the door handle had signs of chafing against the door (see **Figure 6**), the door latch mechanism was smooth.

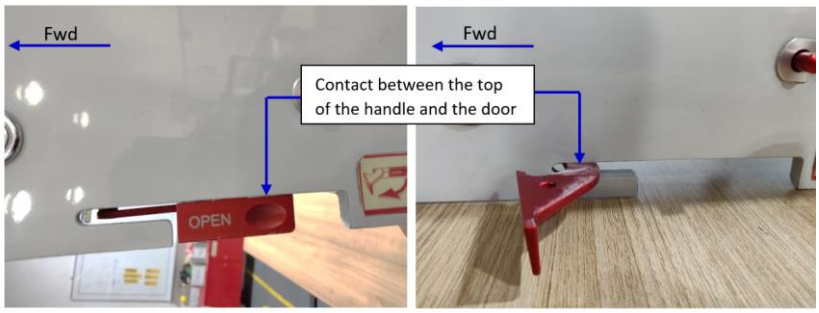

Figure 6. Signs of chafing between the top surface of the handle and door

1.4 Pilot information

Gender	Male
Age	63 years old
Type of Licence	Airline Transport Pilot Licence issued by the U.S. Federal Aviation Administration (FAA)
Licence validity	Nil
Aircraft rating	ATPL - Airplane Multi-engine Land CPL - Lighter than airship
Medical certification	FAA Medical Class 2 dated 18 July 2019
Total flying experience	6,437 hours (2,234 hours on civilian aircraft and 4,202 hours on military aircraft)
Total on type	538.0 hours
Flying in last 90 days	71.0 hours
Flying in last 28 days	60.3 hours
Flying in last 24 hours	0 hour
Rest period before flight	More than 8 hours

1.5 Aircraft information

1.5.1 Passenger door operation

1.5.1.1 The passenger door (see **Figure 7**) was on the left side of the fuselage, behind the pilot's seat, and was hinged at the top of the fuselage in the front and rear. The passenger door was opened by lifting the door handle at the bottom of the door to unlatch the door. When the handle was released, the door opened outwards and upwards and a gas spring strut prevented the door from lowering.

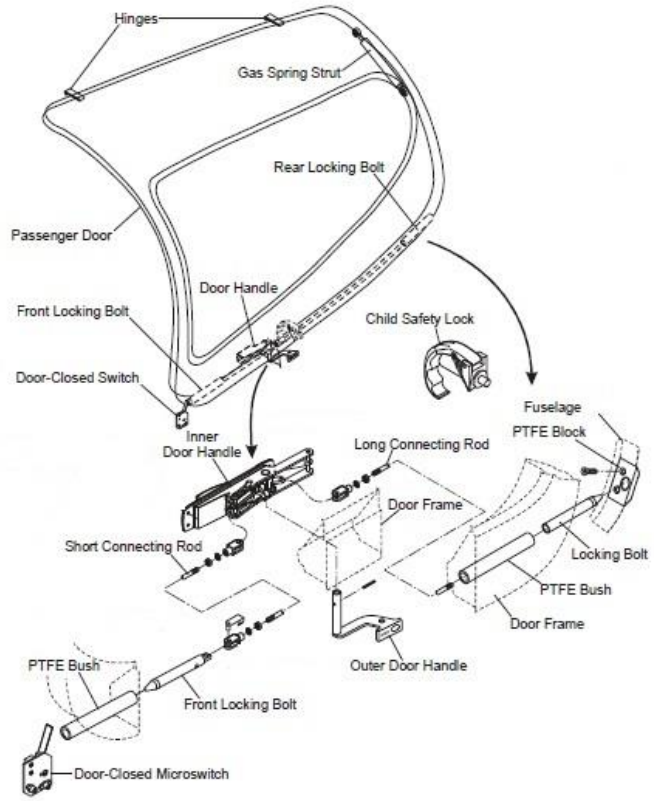

Figure 7. Parts of a Passenger Door

1.5.1.2 The passenger door was closed by lowering the door towards the door frame and pushing the door handle to flush with the passenger door. The pushing of the door handle extended the front and rear locking bolts located at the bottom of the door to engage into the front and rear PTFE[6] blocks on the fuselage respectively and latched the door. The front locking bolt would activate a door-

[6] PTFE is the abbreviation for polytetrafluoroethylene.

closed microswitch which would remove any “Door Open” warning on the PFD when extended into the front PTFE block if the canopy and the front baggage doors were already closed and latched[7].

1.5.1.3 The passenger door handle operated on a compression gas spring mechanism such that the door handle would snap into the close position by itself at least 10mm before reaching the end position.

1.5.1.4 Post-occurrence inspection revealed that the two locking bolts (see **Figure 8**) and the PTFE blocks (see **Figure 9**) on the passenger door had no signs of damage.

Figure 8. No damage on the locking bolts

[7] Door “latched” means the corresponding door-closed microswitch was activated.

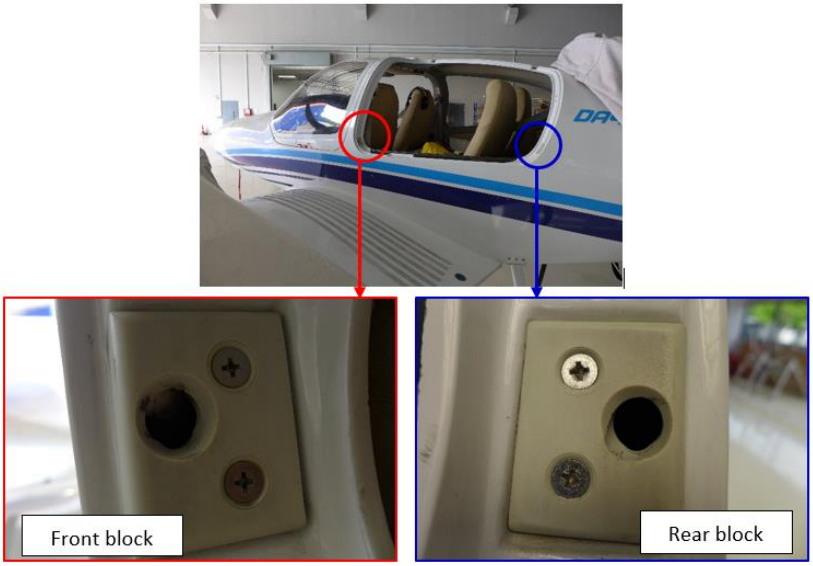

Figure 9. No damage on PTFE Blocks

1.5.1.5 The pilot recalled that he had closed the passenger door of the aircraft and a licensed mechanic also said he saw that the passenger door was closed and the door handle was flush with the fuselage.

1.5.2 Door warning system

1.5.2.1 The door warning system was made up of a visual “Door Open” warning on the PFD and an audio warning chime system.

Visual “Door Open” warning on the PFD

1.5.2.2 A visual “Door Open” warning would appear on the PFD (see **Figure 10**), whenever the front canopy, the passenger door or any of the cargo doors were not closed and latched.

Figure 10. "Door Open" warning on the PFD

1.5.2.3 The visual "Door Open" warning would disappear only if all the doors were closed and latched.

1.5.2.4 When the door warning chimes were activated by a door which had become unlatched, and even after the chimes were muted, the visual "Door Open" warning on the PFD would remain. The visual warning would disappear only if the door was closed and latched again, as mentioned in paragraph 1.5.2.3.

1.5.2.5 The triggering of the visual "Door Open" warning on the PFD did not depend on whether the AMS was switched on or not. In addition, if the AMS was not switched on, there would be multiple INOP flags on the PFD (see **Figure 11**) – the "*COM 2 – INOP*" flag, the "*Nav 2 – INOP*" flag, and the "*DME – INOP*" flag.

Figure 11. INOP flags on the PFD when the AMS is not switched on

Door aural warning chime system

1.5.2.6 The door aural warning chime system needed to be energised before it would provide warning chimes for a door-not-latched situation.

1.5.2.7 The door warning chime system would only be energised after all the aircraft doors (front canopy, passenger door and cargo doors) were closed and latched and the AMS was switched on.

1.5.2.8 The warning chimes could be heard from the cockpit loudspeaker and through the pilot's headset[8]. The chimes could be heard over environmental noise such as engine noise. The chimes would stop only when the pilot acknowledged the chime by pressing a key on the PFD or, if the unlatched door was latched again.

1.5.2.9 If any of the doors was closed but not latched, then even after the AMS was switched on, the door aural warning chime system would not be energised. If any of the doors subsequently became open, there would also be no warning chime as the system was not energised.

1.5.2.10 Post-incident tests on the audible warning chime system, including the headset, showed no anomaly.

1.6 Flight recorders

1.6.1 There was no flight recorder installed on this aircraft, nor was a flight recorder required to be installed for this category of aircraft.

1.7 Tests

1.7.1 To find out if the passenger door opening and detachment could have been initiated by the failure of the hinges, the detached passenger door was positioned back onto the aircraft door frame and latched.

1.7.2 The investigation team noted that the passenger door could not pivot/rotate around the locking bolts (i.e. if the door hinges had failed while the door was latched) without causing considerable damage to the door itself and to the aircraft door frame. It was also observed by the pilot in the aircraft lining up behind the incident aircraft that the latter's passenger door had rotated upwards.

[8] The volume of the warning chime that sounds through the cockpit loudspeaker is pre-set in factory and cannot be adjusted by the pilot. The volume of the warning chime that sounds through the pilot's headset can be adjusted by a volume control knob on the headset.

1.7.3 According to the aircraft manufacturer, if the passenger door hinges had already failed before the door opened and moved upwards, the force that was needed to push open the door would have been considerable and this would have resulted in extensive damage on the bottom side of the door frame, the bottom edge of the passenger door, the door locking bolts, and the PTFE blocks. However, the door and the fuselage of the incident aircraft did not exhibit such a degree of damage.

1.8 Previous detachment of DA42 passenger door

1.8.1 The aircraft manufacturer received reports of detachment of DA42 passenger door as far back as 2004, mainly in flight. The aircraft manufacturer had investigated these events and concluded the following:

(a) The door locking mechanism was robust and the door would not open by itself under flight loads.

(b) The detachment of the passenger door was due to improper locking of the door prior to a flight.

(c) Once the door was open, the door hinges would be damaged by external loads.

2 ANALYSIS

The investigation team looked into the following:

(a) Detachment of passenger door

(b) Door aural warning chime system

2.1 Detachment of passenger door

2.1.1 The investigation team believed that the passenger door was probably closed but not properly latched prior to the aircraft's departure, although the pilot and the licensed mechanic recalled that the passenger door was closed and latched. This is in the view of the following:

(a) As mentioned in paragraph 1.7.3, if the door had been latched, a considerable force would be needed to force the front and rear locking bolt out of the PTFE blocks and that would have resulted in substantial damage on the door frame and the fuselage. However, the bottom side of the door frame, the bottom edge of the passenger door and the door locking bolts and PTFE blocks on the fuselage did not exhibit such a degree of damage.

(b) Furthermore, if the door had been latched, then the door would have to rotate downwards around the locking bolts. However, as mentioned in paragraph 1.7.2, the pilot in the aircraft lining up behind the incident aircraft observed that the passenger door of the incident aircraft had rotated upwards at the hinges and the hinges were the last part that gave way. It seems to suggest that the door had opened upwards.

2.1.2 The investigation team further believed that, as the passenger door was closed but not properly latched, the movement during take-off roll could have caused the door to open and detach.

2.2 Door aural warning chime system

2.2.1 There are two interrelated issues: Whether all the doors were closed and latched before the pilot set off to depart, and whether the "Door Open" aural warning chime system was energised when the AMS was switched on.

2.2.2 The BEFORE TAXIING CHECKLIST required the pilot to switch on the AMS. The investigation team believed that the AMS had been switched on at the time of the incident, in view of the following:

(a) If the AMS had not been switched on, there would have been multiple INOP flags on the PFD that were unlikely to be missed by the pilot (see paragraph 1.5.2.5).

(b) The BEFORE TAXIING CHECKLIST executed by the pilot included switching on the AMS.

2.2.3 The switching on of the AMS alone would not ensure that the door warning chime system was energised. As mentioned in paragraph 1.5.2.7, the door warning chime system would only be energised after all the doors (front canopy, passenger door and cargo doors) were closed and latched and the AMS was switched on.

2.2.4 The investigation team believe that the door warning chime system was not energised after the AMS had been switched on, in view of the following:

(a) If all the doors had been closed and latched and the AMS was switched on, the warning chime system should have been energised. However, the investigation team would not be able to explain why the pilot did not hear any warning chimes when the passenger door had become open and detached. It could be argued that, when the passenger door had opened, the environmental noise (including the engine noise) could have been too loud for the pilot to hear the warning chimes. However, this did not correspond to the observation mentioned in paragraph 1.5.2.8 that warning chimes could be heard over environmental noise through the headset.

(b) If the passenger door was closed and not properly latched, then the door warning chime system would not have been energised and naturally there would not have been any warning chimes generated when the passenger door opened. If this had been the case, there would have been a visual “Door Open” warning on the PFD. This visual warning could have been missed by the pilot during the execution of the TAKE-OFF CHECKLIST.

2.2.5 The door aural warning chime system did not provide a warning when any of the doors was not closed and latched and this removed a layer of protection. The investigation team envisaged two possible ways of improving the aural “Door Open” warning chime system:

(A) To have an aural warning chime system that operates even if the AMS is not switched on.

(B) To have an aural warning chime system that will be energised once the engine is started, even if the AMS is not yet switched on.

2.2.6 The investigation team has noted the aircraft manufacturer's response to the suggestion in (A) as summarised in paragraphs 4.2 and 4.3. The investigation team is pursuing the suggestion in (B) as a safety recommendation in paragraph 5.1.

3 CONCLUSIONS

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 The passenger door was probably closed but not properly latched prior to the aircraft's departure which resulted in the door aural warning chime system not energised.

3.2 Even though the door aural warning chime system was not energised, an improper latched passenger door would still cause a "Door Open" visual warning on the PFD. The pilot could have missed this warning when performing the TAKE-OFF CHECKLIST.

3.3 The passenger door had become open during the take-off roll and detached from the aircraft.

4 SAFETY ACTIONS

As regards a safety action suggestion by the investigation team, the aircraft manufacturer shared its view.

4.1 The investigation team has suggested that the aircraft manufacturer consider an audible warning chime system that operates even if the AMS is not switched on, so that the chime will sound whenever a door is not closed and latched.

4.2 The aircraft manufacturer has responded to the investigation team that it had considered the suggestion but is inclined to not taking up the suggestion in view of the following:

(a) There is already a “Door Open” visual warning which will appear on the PFD even when the AMS is not yet switched on.

(b) It is a common practice that the flight preparation on the PFD is done with the front canopy and/or passenger door open (especially in warm weather) and with the AMS switched off. If the warning chime is made independent of the AMS, the warning chime will sound the whole time during the flight preparation, leading to the pilot muting the warning chime by acknowledging it with the acknowledge button on the PFD. So, the purpose of detecting a door-open situation will not be achieved.

5 SAFETY RECOMMENDATIONS

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

5.1 It is recommended that the aircraft manufacturer review the door aural warning chime system, so that there will be chimes whenever a door is not closed and latched after the engine starts. [TSIB RA-2020-008]