Final Report

AIRBUS A319, REGISTRATION 9V-TRB
EXCESSIVE CABIN ALTITUDE

14 June 2019

AIB/AAI/CAS.181

Transport Safety Investigation Bureau
Ministry of Transport
Singapore

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The Transport Safety Investigation Bureau of Singapore

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

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SYNOPSIS

On 14 June 2019 at about 2137LT (Singapore time), an Airbus A319 experienced a slow increase in cabin altitude while descending through flight level (FL)[1] 290. The flight crew performed an emergency descent to 9,000 feet. Subsequently, the aircraft landed in Singapore Changi Airport.

There were no injuries to any persons and no damage to the aircraft. During the occurrence, PAN-PAN was declared and flight crew oxygen system was used.

The Transport Safety Investigation Bureau classified this occurrence as an incident.

AIRCRAFT DETAILS

Aircraft type	:	A319
Operator	:	Scoot
Aircraft registration	:	9V-TRB
Numbers and type of engines	:	2 IAE V2500
Date and time of incident	:	14 June 2019
Location of occurrence	:	During descent to Singapore Changi Airport
Type of flight	:	Scheduled Passenger
Persons on board	:	129

[1] Flight level (FL) is an aircraft's altitude expressed in hundreds of feet when the altimeter is set to 1013 millibars. FL290 corresponded to an altitude of 29,000 feet.

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 14 June 2019 at about 1900LT, an Airbus A319 departed Clark, the Philippines, for Singapore. The Pilot-In-Command (PIC) was the Pilot Flying and the First Officer (FO) was the Pilot Monitoring.

1.1.2 At 2134LT, the flight started its descent into Singapore Changi Airport from its cruise level of FL360. During the descent to FL320, the PIC felt a noticeable change of cabin pressure in her ears. She brought this to the attention of the FO.

1.1.3 At that time, the aircraft was descending at a rate of about 2,000 feet per minute (ft/min). The flight crew noticed from the Electronic Centralised Aircraft Monitoring (ECAM) CAB PRESS[2] PAGE that the cabin altitude[3] was increasing through 8,500 feet (ft)[4] and increasing at a rate of about 550ft/min[5]. As this was not normal, the flight crew responded by selecting a steeper rate of aircraft descent of about 4,000ft/min.

1.1.4 At 2137LT, the flight crew requested for a further descent and was cleared by Air Traffic Control (ATC) to FL260 and then to FL200[6]. Just when the FO was about to read back to ATC to acknowledge the clearance, the flight crew noticed the Cabin Pressurisation Warning[7]. They immediately donned the oxygen masks, which was the first action on the Cabin Pressure/Excess Cabin Altitude checklist (see para 1.5.3 for the full checklist). The FO then read back to ATC the descent clearance to FL200[8].

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[2] CAB PRESS = Cabin Pressurisation

[3] Cabin Altitude is the pressure in the aircraft cabin expressed as an equivalent altitude above sea level.

[4] During flight, the cabin altitude target is normally 8,000ft or less.

[5] During descent, the cabin altitude should decrease and the rate of decrease should be no more than 750ft/min.

[6] The flight crew did not mention the cabin pressurisation anomaly to ATC.

[7] A Cabin Pressurisation Warning is triggered when the cabin altitude exceeds 9,550ft. The warning is in the form of a colour change from green to red in the cabin altitude presentation on both the ECAM cruise page and cabin pressure page. According to FDR data, the Cabin Pressurisation Warning was triggered at 2137:35LT, while the flight was descending through FL294, and the cabin altitude had exceeded 9,550ft and was increasing at a rate of about 750ft/min.

[8] This was 15 seconds after ATC issued the clearance.

1.1.5 The flight crew then continued the Cabin Pressure/Excess Cabin Altitude checklist. They deployed the speed brake[9] and the aircraft's rate of descent increased to about 5,300ft/min.

1.1.6 Moments later, the FO declared PAN-PAN[10] to ATC. In response, ATC cleared the aircraft to altitude 10,000ft. According to the flight crew, the highest cabin altitude observed from ECAM CAB PRESS PAGE during the occurrence was about 13,500ft[11]. They did not manually activate the deployment of the passenger oxygen masks nor were the masks automatically deployed[12].

1.1.7 Before the aircraft reached 10,000ft, ATC cleared the aircraft to 9,000ft. After the aircraft had descended below 10,000ft, the flight crew removed their oxygen masks.

1.1.8 The flight crew then prepared the flight for landing, while the cabin crew carried out the post-cabin decompression duties[13] and prepared the cabin for landing. The aircraft landed at Changi Airport at 2202LT without further incidents.

1.2 Injuries to persons

1.2.1 There was no injury to any persons.

1.3 Damage to aircraft

1.3.1 There was no damage to the aircraft.

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[9] Speed brake is a type of flight control used to increase drag to slow down the aircraft and at the same time, increases the aircraft's rate of descent.

[10] PAN-PAN is the international standard urgency signal that someone aboard an aircraft uses to declare that they have an urgent situation, but which for the time being does not pose an immediate danger to anyone's life or to the aircraft itself.

[11] Flight data recorder (FDR) data showed that the highest cabin altitude recorded was 13,936ft.

[12] Passenger oxygen masks automatically deploy when the cabin altitude exceeds 14,000ft.

[13] Cabin crew post-cabin decompression duties are carried out after the aircraft has reached a safe altitude. These include checking on the flight crew and rendering the necessary assistance in the case of pilot incapacitation, checking on passengers for any injuries and providing first-aid and oxygen if necessary, as well as checking on the cabin for any damage.

1.4 Personnel information

1.4.1 Pilot-in-Command (PIC)

Gender	Female
Age	31
Licence	Airline Transport Pilot Licence
Issuing Authority	Civil Aviation Authority of Singapore
Licence validity	30 June 2019
Medical certificate	Class ONE Medical Certificate Restriction: Nil
Total flying experience	6,699 hours
Total hours on A320	6,467 hours
Flying in last 24 hours	7 hours 25 minutes
Flying in last 7 days	26 hours 37 minutes
Flying in last 28 days	55 hours 04 minutes
Flying in last 90 days	224 hours 09 minutes

1.4.2 First Officer (FO)

Gender	Male
Age	37
Licence	Airline Transport Pilot Licence
Issuing Authority	Civil Aviation Authority of Singapore
Licence validity	30 September 2019
Medical certificate	Class ONE Medical Certificate Restriction: Nil
Total flying experience	3,517 hours
Total hours on A320	924 hours
Flying in last 24 hours	7 hours 32 minutes
Flying in last 7 days	7 hours 32 minutes
Flying in last 28 days	35 hours 43 minutes
Flying in last 90 days	162 hours 24 minutes

1.5 Aircraft information

1.5.1 Cabin Pressurisation System

1.5.1.1 The cabin pressurisation system consists of:

- 2 cabin pressure controllers (CPC1 and CPC2),
- 1 residual pressure controller unit (RPCU),
- 1 outflow valve,
- 1 control panel, and
- 2 safety valves.

The outflow valve is driven by an actuator which has three motors – two for automatic operation (see para. 1.5.2 for CPC Automatic Operation) and one for manual operation.

1.5.1.2 The CPC controls the cabin altitude by operating the actuator's automatic motor to drive the outflow valve in order to regulate the cabin altitude to ensure the cabin altitude does not increase above 8,000ft and is comfortable for passengers and crew flying at high altitude.

1.5.1.3 The aircraft has two CPCs for redundancy. Only one of the two CPCs operates at any one time, while the other CPC serves as a standby. In this incident, CPC 2 was in control while CPC 1 was on standby.

1.5.2 CPC Automatic Operation

1.5.2.1 The cabin pressurisation system of the aircraft was in automatic operation throughout the incident.

1.5.2.2 During automatic operation, the flight crew monitored the operation of the cabin pressurisation system, but did not need to intervene with manual control. The indication of cabin vertical speed, cabin differential pressure, cabin altitude, active system indication, safety valve position and outflow valve position were displayed on the ECAM CAB PRESS PAGE.

1.5.2.3 When the aircraft is descending, the CPC in automatic mode would regulate the cabin altitude gradually towards the Landing Field Elevation (LFE)[14].

[14] Landing Field Elevation is the elevation (expressed in feet) of the landing airport above mean sea level. The CPC obtains the LFE from the Flight Management and Guidance Computer of the aircraft which is preset before departure.

1.5.3 Cabin Pressure/Excess Cabin Altitude Checklist

1.5.3.1 The Cabin Pressure/Excess Cabin Altitude checklist required the following:

a) If altitude above FL100, use crew oxygen mask

b) Turn on passenger seat belt signs

c) Initiate emergency descent

d) If auto thrust is not active, move thrust lever to idle[15]

e) Deploy full speekbrake

f) Adjust speed to maximum/as appropriate

g) Consider landing gear extension

h) Engine mode selector to IGN (Ignition)

i) Notify ATC

j) Announce emergency descent through passenger announcement

k) Consider setting ATC transponder code to 7700

l) Crew oxygen masks dilution to NORM (normal)

m) Max flight level: 10,000ft or Minimum Enroute Altitude (MEA)

n) If cabin altitude is above 14,000ft, press the Oxygen Passenger Mask Manual switch to ON

1.6 Meteorological information

1.6.1 There was no significant weather during the occurrence.

1.7 Flight recorders

1.7.1 The aircraft's Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) were successfully downloaded and analysed.

1.7.2 The operator also provided data from the aircraft's Quick Access Recorder (QAR) for analysis.

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[15] If auto thrust is active, the thrust goes automatically to idle if the aircraft is descending.

1.8 Tests and research

1.8.1 After the occurrence, the following systems and parts were examined:

- General airframe structure
- Cabin pressurisation system

1.8.2 General airframe structure

1.8.2.1 General airframe structure and door seals were inspected. No anomaly was found.

1.8.3 Cabin pressurisation system

1.8.3.1 After the incident flight, the aircraft was grounded and the pressurisation system was tested with no anomaly found. On 21 June 2019, the safety valves were checked and no anomaly was found.

1.8.3.2 On 27 June 2019, a ground cabin pressurisation test was carried out and the cabin pressure decay rate was found to be acceptable. The following day, the aircraft performed a ferry flight and there was no anomaly with the cabin pressurisation.

1.8.4 Examination of the CPCs

1.8.4.1 CPC 1 and CPC 2 were removed from the aircraft after the ferry flight and sent to the CPC manufacturer for detailed examination.

1.8.4.2 Presence of contamination and corrosion was noted during visual inspection of both the CPCs.

1.8.4.3 The examination revealed that a corrupted LFE value had triggered CPC 2 to activate the “landing at high altitude” procedure and was increasing the cabin altitude towards a higher LFE value than the correct one. The corrupted LFE value used by the CPC could not be determined.

1.8.4.4 The CPC manufacturer postulated that the corrupted LFE value was likely to have been caused by a fatigue solder joint on the CPC circuit board.

1.9 Additional Information

1.9.1 Previous similar incidents

1.9.1.1 The General Civil Aviation Authority (GCAA) of the United Arab Emirates conducted an investigation on an Etihad Airways A320 that experienced a slow increase in cabin altitude during its descent into Karachi International Airport on 5 March 2018. The GCAA investigation report indicated that the incident was due to a corrupted LFE value being processed in the CPC and the corrupted value was likely to have been caused either by solder joint fatigue on the CPC circuit board or by a Single Event Upset[16] (SEU) in one memory cell of CPC.

1.9.1.2 The CPC manufacturer indicated to the investigation team that there had been other past occurrences associated with LFE value corruption arising from fatigue solder joints and that, whenever a CPC was sent to them, any fatigue solder joint, if found present in the CPC, would be rectified.

1.9.1.3 The investigation team has understood from the GCAA investigation report as well as from the CPC manufacturer that the CPC manufacturer had included quality checks in the CPC's manufacturing process to detect a sub-standard solder joint.

1.9.1.4 According to the aircraft and CPC manufacturers, the design of the CPC has been improved since GCAA's investigation, such that it is less susceptible to corrupted LFE value input. The improved CPCs will be ready in the third quarter of 2020.

1.9.1.5 However, there was no plan for a programme to recall the existing CPCs that were installed on aircraft for repair or replacement with the improved CPCs.

1.9.1.6 Following its investigation, GCAA also recommended the aircraft manufacturer to explain the CPC issue as experienced in the incident to all affected operators via a technical publication.

1.9.1.7 The aircraft manufacturer decided not to inform operators about the incident as it deemed that the failure of a CPC was of low probability and that the Flight Control Operation Manual of the aircraft is sufficient for the crew to manage an excessive cabin altitude situation correctly.

[16] GCAA's investigation defined SEU as a bit-flip in a memory cell of a digital electronic device. Such phenomena can lead to corruption of data.

2 ANALYSIS

2.1 Cause of excessive cabin altitude

2.1.1 CPC 2 was in control during the incident. The CPC processing logic was working as designed during the incident.

2.1.2 The test by the CPC manufacturer conducted on the CPC 2 revealed that the incorrect increase of the cabin altitude arose from LFE value that was corrupted inside the CPC. The corruption of the LFE value was most likely caused by a fatigue solder joint on the CPC circuit board.

2.1.3 The CPC processing logic was such that, with the corrupted LFE value, the outflow valve would be opened more than it should be, resulting in an undesirable increase in the cabin altitude.

2.1.4 Currently, the CPCs are not able to detect corruption of LFE values by a fatigue solder joint.

2.2 Fatigue solder joint

2.2.1 Given that a fatigue solder joint in the CPC could cause corrupted LFE values which lead to an excessive increase in cabin altitude, it would be desirable for the aircraft manufacture to study the characteristics and impact of fatigue solder joint in order to develop mitigation strategy to prevent the same occurrence from happening.

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 likely cause of the excessive cabin altitude was a corruption of LFE in the CPC. The CPC manufacturer believed that the corruption arose from a fatigue solder joint on the CPC circuit board.

3.2 There had been past occurrences of excessive cabin altitude that were caused by a corruption of LFE value in the CPC, of which one was determined to have likely been caused by a fatigue solder joint, similar to this occurrence.

4 SAFETY ACTIONS

Arising from discussions with the investigation team, the aircraft manufacturer has taken the following safety action.

4.1 The aircraft manufacturer will launch a study with the CPC manufacturer to investigate all returned CPCs for corrupted LFEs in order to:

(a) Characterise the relation between corrupted LFE occurrences and CPC flight hours, and;

(b) Review the Component Maintenance Manual to ensure fatigue solder joints can be duly detected.

4.2 As mentioned in para 1.9.1.4, the aircraft and the CPC manufacturer had developed an improved version of CPC that is less susceptible to corrupted LFE value input. The improved CPCs will be ready in the third quarter of 2020.

4.3 Based on the study conducted in para 4.1, the aircraft manufacturer will define a mitigation strategy for repair or replacement of the affected CPCs.

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 to inform all affected operators as soon as possible of the study conducted on all returned CPCs for corrupted LFEs (see para 4.1). [TSIB Recommendation RA-2020-006]