

**SERIOUS INCIDENT**

<b>Aircraft Type and Registration:</b>	Airbus A320-214, OE-LOA
<b>No &amp; Type of Engines:</b>	2 CFM56-5B turbofan engines
<b>Year of Manufacture:</b>	2007
<b>Date &amp; Time (UTC):</b>	1 March 2019 at 2020 hrs
<b>Location:</b>	London Stansted Airport
<b>Type of Flight:</b>	Commercial Air Transport (Passenger)
<b>Persons on Board:</b>	Crew - 7                      Passengers - 169
<b>Injuries:</b>	Crew - None                      Passengers - 10 (Minor)
<b>Nature of Damage:</b>	Left engine contained failure
<b>Commander's Licence:</b>	Air Transport Pilot's Licence
<b>Commander's Age:</b>	44 years
<b>Commander's Flying Experience:</b>	14,128 hours (of which 10,308 were on type) Last 90 days - 195 hours Last 28 days - 71 hours
<b>Information Source:</b>	AAIB Field Investigation

**Synopsis**

The aircraft was on a scheduled flight from London Stansted Airport to Vienna International Airport, Austria. Shortly after the takeoff roll was commenced it was rejected, due to a contained failure of the left engine, and the aircraft was brought to a stop on the runway. Just as the flight crew were about to taxi the aircraft off the runway, an evacuation was commanded by the Senior Flight Attendant. The investigation identified several factors that contributed to this decision. Ten passengers were treated for minor injuries that occurred during the evacuation and there was a risk of serious injury due to one of the engines running during the evacuation. The operator has taken several safety actions, principally based around the training of its flight attendants. Two Safety Recommendations regarding passenger evacuation have been made in this report.

The left engine experienced a contained failure following the rupture and release of several blades from the first stage of the high-pressure compressor. The investigation found that the blades fractured as a result of high-cycle fatigue loading which initiated in the dovetail (part of the blade root), due to a once-per-revolution aerodynamic excitation. An inlet guide vane lever arm had been improperly assembled which led to aerodynamic excitation of the passing blades and the resulting forces exceeded the design loads of the blades.

## History of the flight

The aircraft was on a scheduled flight from London Stansted Airport to Vienna International Airport, Austria, having previously flown in from Vienna about an hour earlier. The commander was the PF for the sector and it was a line training sector for the co-pilot. There were five flight attendants<sup>1</sup> (FAs), including an additional crew member (ACM)<sup>2</sup>.

The aircraft pushed back and taxied out to Runway 22 without event. ATC clearance was then given for the aircraft to line up and take off. At the time it was dark outside, and the weather was clear with the wind from 160° at 5 kt. In the cabin, the lights had been dimmed for takeoff, as is normal practice.

### *Flight crew observations*

Having lined up on the runway, the commander set the throttles to FULL POWER/TOGA<sup>3</sup> and commenced the takeoff roll. About one second after the co-pilot said “THRUST SET”, at a groundspeed of 31 kt, a loud bang was heard and the aircraft immediately drifted towards the left of the runway. The commander said “STOP STOP STOP” and rejected the takeoff. The aircraft came to a stop between the centreline and the left side of the runway. The commander then set the parking brake, selected the public address system (PA) button and announced “ATTENTION CREW: ON STATION”<sup>4</sup> twice. The co-pilot then informed ATC that they were stopping on the runway and then completed the actions for ‘ENG 1 FAIL’ and ‘ENG 1 REVERSER UNLOCKED’ electronic centralised aircraft monitor (ECAM) messages; there were no fire indications. The left engine was shutdown at 2006:23 hrs.

After the ECAM messages had been actioned the commander contacted the RFFS, who were quickly on the scene, on frequency 121.6 MHz to confirm that there were no signs of fire visible from the outside. As a result, it was decided to vacate the runway using the thrust from the right engine and he asked ATC for clearance to do so.

At 2007:21 hrs, just as the commander was about to make a PA to instruct the FA to return to normal operations, he noticed an amber ‘DOOR L [LEFT] FWD [FORWARD] CABIN’ caution message illuminated on the ECAM. At first, he thought it was a fault but then saw the evacuation slide deployed at Door L1 out the left cockpit window and passengers moving across the front of the aircraft. The commander then had a conversation with the Senior Flight Attendant (SFA), over the interphone, during which the commander asked why the evacuation had been initiated. She replied that she believed he had ordered one, which he denied. After this conversation, the APU was started and the right engine, which was still operating while the evacuation was underway, was selected OFF at 2009:38 hrs.

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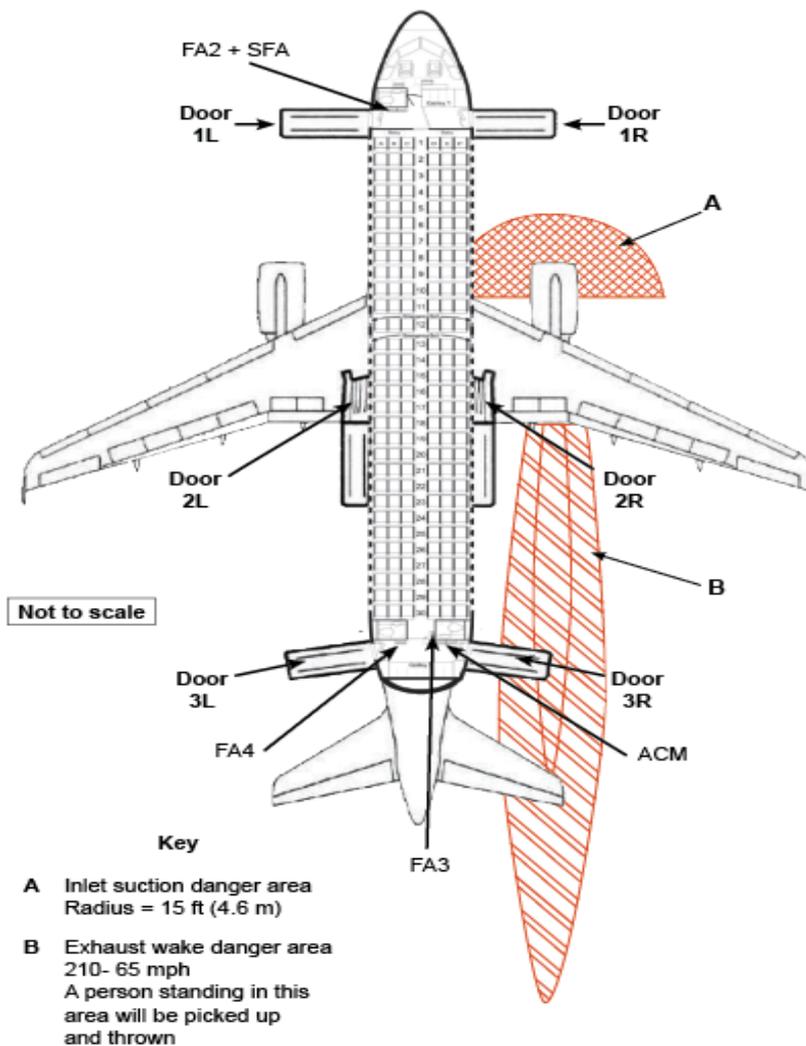
### Footnote

- <sup>1</sup> The operator refers to its cabin crew as flight attendants.
- <sup>2</sup> An ACM is a member of the flight attendant team who is not designated an operational role. She was having a familiarisation flight having recently completed her training.
- <sup>3</sup> It was a requirement of the operator to do a full power/TOGA takeoff, for maintenance purposes, on the first day of each month. The flight crew elected to carry this out on the sector from Stansted to Vienna.
- <sup>4</sup> In an emergency on the ground, this command is issued as an advance warning. Upon this command, flight attendants should immediately move to their doors, remain on high alert and wait for additional commands from the cockpit.

The co-pilot then went into the cabin while the commander stayed in the cockpit and maintained contact with ATC and the RFFS. In the cabin the co-pilot found no passengers but noted a lot of baggage near the exits. There were also only three of the five FA present, as two had left the aircraft to assist the passengers on the ground. The commander then requested they return to the aircraft, which they subsequently did.

#### *Flight attendants' observations*

Soon after the takeoff roll started, all the FAs heard a loud noise and felt the aircraft drift to the left before coming to a stop a few seconds later. All except the SFA heard the commander announce "ATTENTION CREW: ON STATION" over the PA after which they all stood up at their assigned exits. At the front of the cabin the SFA stood in the aisle facing rearwards, while FA2 looked out of the Door 1L window. At the rear of the aircraft FA4 and FA3 looked out of Door 3L and 3R respectively while the ACM stood in the middle. No danger was observed; they thus awaited further instructions from the commander. Figure 1 shows the location of the seating positions of the FAs and doors.



**Figure 1**

A320 doors, FA seating locations and engine hazard areas

The SFA then tried to call FA3, in the rear of the aircraft, using the interphone, to check if everything was alright. However, when FA3 stood up, his crew swivel seat displaced the attached handset from its stowage and its cable became trapped in the now folded seat<sup>5</sup>. This caused the crew high/low chime<sup>6</sup> in the cabin to be suppressed so it was difficult for the SFA to attract FA3's attention. There then followed an exchange between the SFA and FA3 which resulted in the SFA commanding an evacuation over the PA. See the *Flight attendants' comments* section for details of this exchange. Upon hearing the command, the FAs and passengers commenced the evacuation.

When FA3 opened Door 3R the escape slide inflated and floated in the air, close to the horizontal, but he did not understand why at the time. However, knowing it was unsafe to use, he blocked the exit. The slide at Door 3L inflated correctly and FA3 and 4 shouted their evacuation commands to the passengers as the passengers exited the aircraft. Several passengers brought hand baggage with them, but it was removed from them and placed by Door 3R. A similar situation with baggage occurred at Doors 1L and 1R. See the *Emergency evacuation* section for more on the evacuation.

Once all the passengers had left the aircraft, the FAs checked the cabin. FA3 then instructed the ACM to exit the aircraft to assist the passengers. He was about to follow her but the SFA instructed all the FAs to remain on the aircraft. Shortly thereafter the FAs found out that the evacuation was not necessary. As a result, FA3 left the aircraft to find the ACM to inform her to return to the aircraft.

The airport RFFS were quickly in attendance and were subsequently joined by local authority ambulances.

Two injured passengers were taken to hospital and several were treated for minor injuries at the scene. The passengers were subsequently taken to the airport terminal by buses. The majority of them were able to travel on to Vienna on a replacement aircraft later that evening.

The aircraft was subsequently towed off the runway to a remote parking position.

### **Flight attendants' comments**

All the FAs were initially interviewed by the AAIB the following day. Further interviews were later conducted with the SFA, FA3 and FA4.

#### *SFA's comments*

The SFA stated that the noise of the engine failure was very loud. The noise and the movement of the aircraft to the left scared her. She reported that her attention was focused on the noises made by the aircraft and she did not hear the commander announce "ATTENTION CREW: ON STATION" over the PA.

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#### **Footnote**

<sup>5</sup> See *FA3 crew seat and cabin interphones* section for more details.

<sup>6</sup> The high/low chime alerts the FAs that there is an incoming call on the interphone. Lights in the ceiling indicate who is calling.

The SFA reported that she stood up when the other FAs stood up. She was aware of all the passengers looking at her and felt under pressure because of this. She was feeling “shocked” and overwhelmed. She attempted to contact FA3 at the rear of the aircraft, initially without success. She reported that it felt like a long time that she was trying to contact FA3. There was confusion while they attempted to communicate using a combination of the interphone, hand signals and the PA. The darkness in the cabin made the use of hand signals difficult and she could not see well enough to understand signals given by FA3.

The SFA commented that she intended to obtain information from FA3 to help her decide whether an evacuation was needed. She added that FA3 said he had seen flames and sparks from the engine. Her impression was that FA3 was “scared and shocked” and FA2 was “completely shocked”. She stated she attempted to discuss what to do with FA3. However, at some point during this exchange she said “EVACUATE, EVACUATE, EVACUATE” over the interphone and subsequently over the PA.

The SFA stated that she knew the guidance from the operator’s flight safety manual about the circumstances to initiate an evacuation but was not thinking about this at the time. See *Flight attendants’ training and experience* section. The SFA explained that she generally had very limited interaction with the pilots and a limited understanding of their responsibilities in an emergency. She said, “For me, it was the door closed, I have nothing to do with them.” And she did not think about contacting the flight crew at any point.

#### *FA3’s comments*

FA3 reported that he heard a bang when the engine failed and saw red and yellow lights through the passenger windows for one or two seconds. He recalled that FA4 told him and the ACM to stay calm and expect instructions from the flight crew.

After the “ATTENTION CREW: ON STATION” announcement he fumbled with the seat when standing up. It closed very fast, knocking the interphone from its cradle. The interphone fell to the floor and the cable became trapped in the seat.

The next communication he was aware of was the SFA asking “Can you hear me?” over the PA. FA3 said he subsequently had difficulty freeing the interphone. He stated that when he was eventually able to speak to the SFA she said “evacuate, evacuate, evacuate”. He did not understand why she would command an evacuation over the interphone and felt he could not open the door alone, so he told her to announce it over the PA.

FA3 commented that in this situation “A few seconds feels like minutes” and it is difficult for FAs waiting after the “ATTENTION CREW: ON STATION” command because they do not know what is going on in the flight deck and feel responsibility for the passengers’ safety.

#### *FA4’s comments*

FA4 reported that she started briefing FA3 and the ACM after the engine failure. She told them to stay calm and wait for the “ATTENTION CREW: ON STATION” command and not to open the doors. She explained that she did this because she was aware of their inexperience and to keep herself calm.

She did not follow all the conversation between FA3 and the SFA, but she remembered FA3 saying that he had seen fire outside. She heard him tell the SFA to say the evacuation command “out loud”. She attempted to contact the SFA via the other interphone at the rear of the aircraft but was unsuccessful. Then the SFA announced “*EVACUATE, EVACUATE, EVACUATE*” over the PA.

FA4 initially hesitated to begin the evacuation but when she realised that FA3 had already opened the Door 3R, she opened Door 3L.

## **Emergency evacuation**

### *AAIB passenger questionnaire*

The airport operator commented that it has a requirement in its *Terminal Emergency Orders* for the AAIB’s passenger questionnaire to be distributed to passengers after an evacuation. However, none were given to the passengers on this occasion as an alternative aircraft had been sourced by the parent company of the operator. As a result, the airport operator’s staff were busy organising those passengers that wanted to complete their journey to Vienna. Most passengers subsequently completed their journey later that evening.

After the accident the AAIB emailed its *Passenger Questionnaire* to the 169 passengers; 46 (27%) were subsequently returned.

### *Injuries*

Local authority ambulances attended the scene. They reported that 10 patients were treated for minor injuries at the scene by paramedics. Most of the injuries were cuts, grazes, bruises and sprains. Two were subsequently taken to a local hospital for further treatment but were later discharged. While the physical injuries sustained were minor, a few passengers stated on the questionnaires that they have suffered from post-traumatic stress which they were receiving treatment for.

### *Passengers’ comments*

Several of the passengers commented that after the aircraft came to a stop the FAs seemed to have problems with the PA. Additionally, they used the PA to communicate between the front and rear of the aircraft in German. Four passengers commented that they either did not hear or did not fully understand the command to evacuate.

Numerous passengers also commented that the aisle and Doors 2L and 2R and the overwing exits, were impeded as people were trying to take their baggage from under seats and overhead bins. As a result, passengers were shouted at by some to leave their baggage behind. One passenger thought that about half of the passengers took their hand baggage with them. Images of passengers leaving the aircraft with baggage from the right overwing exit were captured by the RFFS’s onboard infrared CCTV camera (Figure 2).



**Figure 2**

RFFS infrared CCTV showing some passengers leaving with baggage

Of those passengers that used Door 2R, several commented that they were either nearly blown over, or were blown over several times by the jet exhaust from the right engine, with some of their belongings blown away. Figure 1 shows passengers crossing behind the engine exhaust could have been exposed to 'wind' speeds of 65 mph or greater, even with the engines running at idle.

#### *A320 emergency evacuation checklist*

The '*EMER[GENCY] EVAC[UATION]*' checklist from the A320 Quick Reference Handbook (QRH) (Figure 3) was what the flight crew would have actioned had the commander elected to command an evacuation.

[QRH] EMER EVAC	
Ident.: PRO-ABN-MISC-00012083.0001001 / 09 MAY 17	
Applicable to: ALL	
Apply this procedure when considering an emergency evacuation, or when required by the ECAM. Carefully analyze the situation before deciding to evacuate passengers. However do not waste valuable time.	
AIRCRAFT / PARKING BRK.....	STOP / ON
ATC (VHF1).....	NOTIFY
<i>Notify ATC of the nature of the emergency, and state intentions.</i>	
<i>Only VHF 1 is available on batteries.</i>	
CABIN CREW (PA).....	ALERT
<i>Make a short and precise announcement to warn that an emergency evacuation may be required.</i>	
$\Delta P$ (only if MAN CAB PR has been used).....	CHECK ZERO
<i>If <math>\Delta P</math> is not at zero, MODE selector on MAN and V/S CTL FULL UP, to fully open the outflow valve.</i>	
● <b>If <math>\Delta P</math> not at zero:</b>	
CAB PR MODE SEL.....	MAN
V/S CTL.....	FULL UP
ALL ENG MASTER.....	OFF
<i>Associated LP and HP valves close.</i>	
ALL FIRE pb (ENGs & APU).....	PUSH
ALL AGENTS (ENGs & APU).....	AS RQRD
<i>Engine Agent 2 is not available.</i>	
<i>The use of agents is required if the ENG FIRE or APU FIRE is displayed.</i>	
■ <b>If evacuation required:</b>	
EVACUATION.....	INITIATE
<i>Make a short and precise announcement to order the emergency evacuation.</i>	
<i>Press the EVAC COMMAND pb .</i>	
■ <b>If evacuation not required:</b>	
CABIN CREW AND PASSENGERS (PA).....	NOTIFY

**Figure 3**

A320 Evacuation checklist

*Safety studies regarding passenger behaviour during evacuation*

The issue of passengers taking baggage with them during an evacuation has been well documented.

An NTSB safety study on evacuation of commercial aircraft<sup>7</sup> stated that '*Passengers exiting with carry-on baggage were the most frequently cited obstruction to evacuation.*' The study collated questionnaires from passengers who had been evacuated and found that almost 50% attempted to remove a bag during the evacuation. The primary reason given was to keep hold of high value items in the bags such as money, keys and medicine.

**Footnote**

<sup>7</sup> National Transportation Safety Board (2000). Emergency Evacuation of Commercial Airplanes. Safety Study NTSB/SS-00/01. Washington, DC: NTSB <https://www.nts.gov/safety/safety-studies/Documents/SS0001.pdf> [Accessed July 2020]

A similar safety study by the Transportation Safety Board (TSB) of Canada<sup>8</sup> studied 21 evacuations and found nine in which passengers stopped to retrieve carry-on baggage and attempted to take it with them as they exited the aircraft, despite being told not to by the flight attendants.

An EASA-sponsored study on CS-25 cabin safety requirements published in 2009<sup>9</sup> identified 13 evacuations in which evacuees attempted to collect cabin baggage and five where they carried baggage out of exits or down the slides.

In 2018 the Royal Aeronautical Society published a paper entitled '*Emergency Evacuation of Commercial Passenger Aeroplanes*<sup>10</sup>'. It highlighted many of the factors that influence the success of an evacuation, including the tendency for passengers to take baggage with them. The paper identified six accidents where passengers evacuated with baggage.

These studies identified accidents and incidents where passengers evacuated with baggage. Appendix 1 provides a list of those cases where the full report was available online and described the issues with the passengers' behaviour.

The Royal Aeronautical Society commented '*This trend appears to be increasing and can only be exacerbated by the increasing volume of cabin baggage being permitted by some operators for commercial reasons.*'

The paper stated that operator practice of charging for hold baggage has resulted in there being more baggage in the cabin and an increased number of passengers travelling with only cabin baggage.

The Royal Aeronautical Society paper emphasises the point that passenger behaviour is not strongly influenced by briefing or flight attendant instructions and recommends:

*'Aviation authorities should consider the feasibility of introducing a certification requirement for a means of remotely locking, from the flight deck, overhead bins in passenger cabins that do not contain emergency equipment, for taxi, take-off and landing.'*

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#### Footnote

<sup>8</sup> Transportation Safety Board Canada (2013). Aviation Safety Study SA9501: A safety study of evacuations of large passenger carrying aircraft. <https://skybrary.aero/bookshelf/books/2699.pdf> [Accessed July 2020]

<sup>9</sup> European Aviation Safety Agency (2009). Project EASA.2008.C18 Study on CS-25 Cabin Safety Requirements. <https://www.easa.europa.eu/sites/default/files/dfu/1%20-%20Study%20on%20CS-25%20Cabin%20Safety%20Requirements-easa.2008.c18.pdf> [Accessed July 2020]

<sup>10</sup> Royal aeronautical society (2018). *Emergency Evacuation of Commercial Passenger Aeroplanes*. <https://www.aerosociety.com/media/8534/emergency-evacuation-of-commercial-passenger-aeroplanes-paper.pdf> [Accessed July 2020]

### *Safety recommendations following previous evacuations*

On 16 April 2012 an Airbus A330, registration G-VSXY<sup>11</sup>, was en route from London Gatwick Airport to McCoy International Airport in Orlando, USA, when a smoke warning in the aft cargo compartment illuminated. After a successful emergency landing an emergency evacuation was ordered. The AAIB report concluded that some passengers slowed their own evacuation due to issues with cabin baggage. As a result, the following Safety Recommendation was made:

#### **Safety Recommendation 2014-005**

It is recommended that the European Aviation Safety Agency amend AMC1 CAT.OP.MPA.170, 'Passenger briefing', to ensure briefings emphasise the importance of leaving hand baggage behind in an evacuation.

The EASA's response to this Safety Recommendation was that it had evaluated this safety issue within the framework of rulemaking tasks RMT.0516 and RMT.0517 *Updating Air OPS Regulation (EU) No 965/2012/Implementing Rules and related Acceptable Means of Compliance (AMC) & Guidance Material (GM)*.

The outcome of the evaluation was contained in EASA Executive Director (ED) Decision 2017/008/R, which was published on the EASA website on 30 March 2017.

The ED Decision introduced new text under AMC1 CAT.OP.MPA.170 on 'passenger briefing' which states that, before takeoff and before landing, passengers should be briefed on/ reminded of the importance of leaving hand baggage behind in case of evacuation. This is stated in Section 1.2.12, *Passenger briefing*, of the operator's *Flight Safety Manual*.

The ED Decision also introduced guidance under GM2 CAT.OP.MPA.170, (f)(5)(vi) *Passenger briefing - safety briefing material* which states that the operator should consider including information on leaving hand baggage behind, in its safety briefing material on emergency exits. The operator of OE-LOA had this information on its passenger safety cards that were in each seat pocket of the aircraft and in Section 1.1.12.4, *Safety card*, of its *Flight Safety Manual*.

The EASA stated that emergency evacuations had also been captured as a candidate safety issue within their safety risk portfolio for commercial air transport (fixed wing), as part of the EASA's safety risk management process.

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#### **Footnote**

<sup>11</sup> The full report into the accident involving G-VSXY can be found here: <https://www.gov.uk/aaib-reports/1-2014-g-vsxy-16-april-2012> [Accessed July 2020]

### *CS-25 requirements for evacuation emergency demonstration*

CS-25.803<sup>12</sup> requires that all passengers and crew can be evacuated within 90 seconds and compliance must be shown using a demonstration. Appendix J of CS-25 specifies test criteria and procedures for the demonstration. It must be conducted in the dark with a certain mixture of passengers in terms of age and gender. It requires a proportion of cabin baggage and other items to be placed in the cabin to act as minor obstructions. It does not require any of the simulated passengers to retrieve their own baggage and attempt to leave the aircraft with it.

### **Flight attendants' training and experience**

The SFA initially qualified as a FA in May 2017 and flew from then until November 2017 for the previous operator<sup>13</sup>. Between December 2017 and March 2018 she did not fly due to the previous operator going bankrupt and the current operator commencing operations. She resumed working for the current operator who had taken over as the AOC holder. She completed SFA training and was promoted to SFA in May 2018.

FA4 also worked for the previous operator and had a period of not flying between December 2017 and March 2018. All the other FAs were recruited after this. The ACM was completing her first familiarisation flight following her initial training.

The operator reported that the initial FA training course was designed for 20 to 25 trainees, though there was no formal limit. It consisted of a six-week classroom-based course and practical training using a Cabin Emergency Evacuation Trainer (CEET)<sup>14</sup>. The SFA's initial FA course was attended by 39 trainees. Her SFA course was a five-day classroom-based course.

Though the SFA and FA4 were initially trained by a previous operator, there was a lot of continuity of practice and staff between the previous and current operators. All practical training scenarios in the CEET resulted in a simulated evacuation. The initial and senior training received by these FAs did not include examples of the pilots' activities when responding to an emergency or the potential effects of startle and surprise on FA performance.

The operator did not have their own FA simulation training facility and relied on the use of a facility owned by another operator.

All FA training met the relevant requirements and was approved by the national aviation authority.

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#### **Footnote**

<sup>12</sup> European Union Aviation Safety Agency (2020) *Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes CS-25*. Amendment 24, 10 January 2020. <https://www.easa.europa.eu/sites/default/files/dfu/CS-25%20Amendment%2024.pdf> accessed on 30 March 2020.

<sup>13</sup> The current operator started on 1 March 2018. All references in this report to the 'operator' refer to this current operator unless they are specifically identified as the 'previous operator'.

<sup>14</sup> A simulation device that approximates the passenger cabin environment and equipment to enable practical emergency scenarios to be trained.

### *Organisational information*

The operator's Operations Manual, Part A, stated: '*the designated senior flight attendant must have at least one year's experience as an operating cabin crew member.*'

The operator did not have any requirements for the composition of the FA team in terms of experience.

### **Emergency evacuation initiation**

Normally the commander would initiate an emergency evacuation using the PA. However, FAs can command an evacuation under certain circumstances. These are stated in the operator's *Flight Safety Manual*:

#### **'1.16.1 Carrying out an evacuation**

...

*If no evacuation command is issued from the cockpit, and there is no doubt that an evacuation is necessary, the Senior FA or any other FA can initiate an evacuation under the following conditions:*

- a) Immediate danger (fire, smoke, explosion, water etc.)**
- b) Cockpit crew is incapacitated (injured, not on board)**
- c) Communications down due to heavy damage to aircraft'**

### **Aircraft information**

#### *Evacuation routes*

The slides available on the aircraft are shown in Figure 1. FAs do not supervise the overwing exits but give a brief to those passengers adjacent to them about their duties in the event of an evacuation before departure.

#### *FA3 crew seat and cabin interphones*

There were three interphone handsets located in the aircraft; one at the front and two at the rear.

A rear aisle swivel seat folded away from the wall and locked into position to provide a forward-facing view into the passenger cabin. When the release latch was lifted, the seat automatically folded back into the stowed position (Figure 4).

The rear interphone intended for use by FA3 was located on the aisle swivel seat.



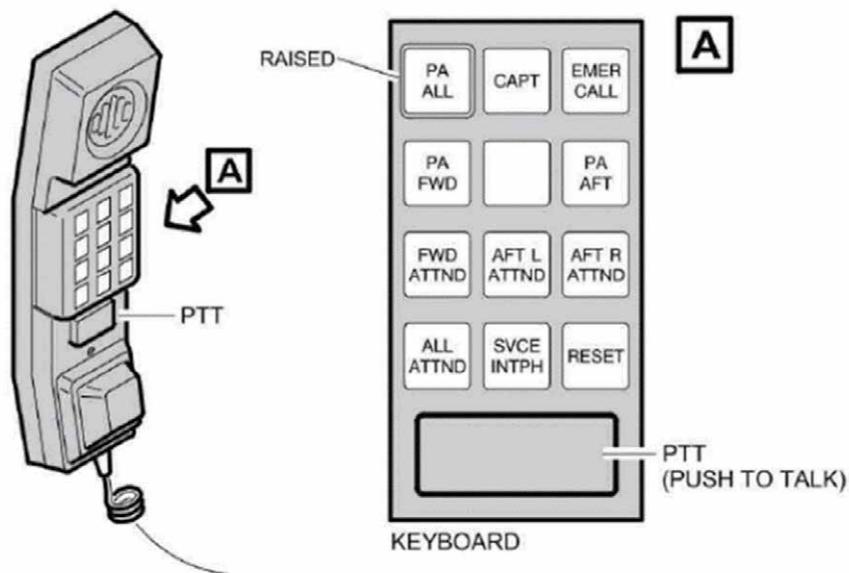
**Figure 4**

Rear aisle swivel seat in stowed (left) and forward-facing (right) positions



**Figure 5**

Example picture of interphone dislodged from the cradle and trapped in the stowed seat



**Figure 6**  
Interphone handset

Figure 6 shows the buttons available on the passenger cabin interphones. It was possible to call the FA3 interphone handset individually from the front handset using the AFT R[IGHT] ATTND [FLIGHT ATTENDANT] button or to call all handsets together using the ALL ATTND button. If the handset was called individually, and it was not fitted on its cradle, the attention getters of the chime and panel lights would not activate.

According to the FAs, it was common for the interphone handsets to fall from their cradles. The aircraft was serviceable and there were no entries in the aircraft technical log or cabin log about the interphone. An example interphone on the folding seat was inspected in the CEET during the investigation and it was easily dislodged from the cradle when the seat was released to fold back. The equipment manufacturer was informed about this during the investigation. There were no previous reports in their in-service experience database of seat-mounted cabin interphones becoming dislodged when the seat was released.

#### *Evacuation signal*

The aircraft was fitted with an evacuation signal. The operator's procedure was for the evacuation signal to be set only to be activated from the cockpit and not from the passenger cabin.

#### **Recorded information**

The FDR and CVR were recovered from the aircraft and downloaded at the AAIB. Both recorders captured the event and the recordings have been used to help write the *History of the flight* section. The CVR contained a number of discussions between the flight crew and the FA, but not the PA in the cabin.

The CVR is a 4-channel recorder which records audio from the commander, co-pilot, cockpit third occupant station and the Cockpit Area Microphone (CAM). Each of the occupants can control their audio (and subsequent CVR recording) using a dedicated Audio Control Panel (ACP). If the PA RECEP[ION] is selected on an ACP, the CVR will record any PA announcements.

The operator's FCOM contains a number of the checklist items required to be completed prior to each flight. One of these items is to ensure the third occupants ACP is set to enable audio from the PA system so the CVR will record it:

#### **THIRD OCCUPANT AUDIO CONTROL PANEL**

PA knob.....RECIEPT

- *This allows cabin attendant announcements to be recorded on the CVR.*
- *For proper recording, set volume at or above medium range.*

The co-pilot stated that he checked this item before the flight.

It is believed RECEP is deselected when there is a third occupant, as this avoids all PA announcements being heard through their headset.

A check of the system by the operator's engineers found it to be serviceable.

### **Engine aspects**

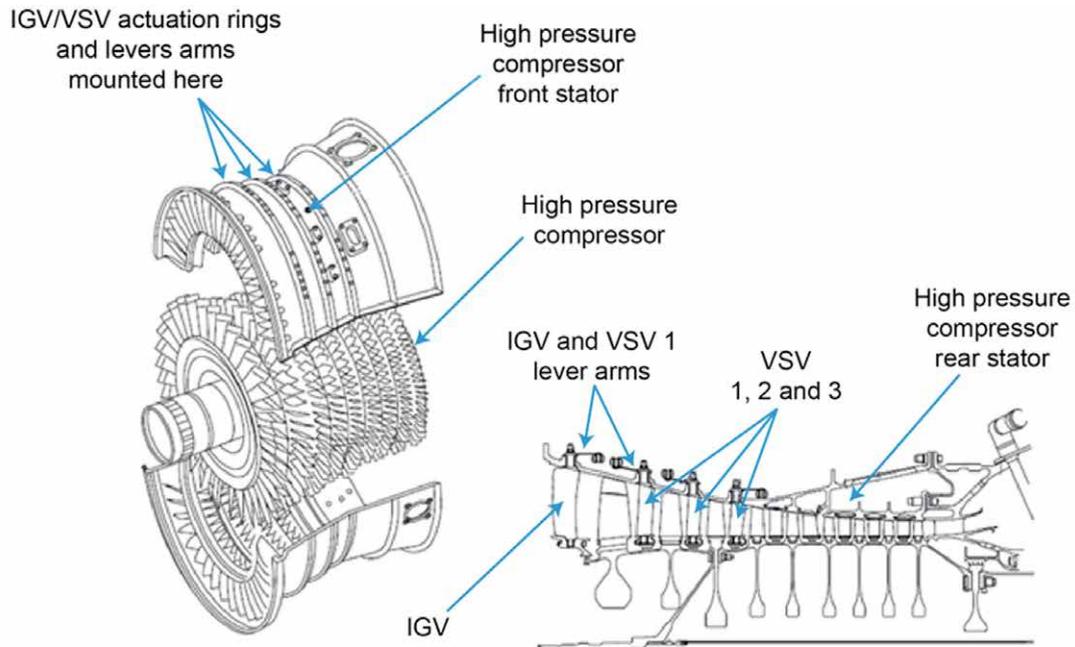
#### *General description*

The CFM 56-5B engine is a two spool, high bypass ratio turbofan engine. It has a single-stage fan and a four-stage booster which together comprise the LP compressor (LPC) and a nine-stage HP compressor (HPC). The LPC is driven by a four-stage LP turbine and the HPC is driven by a single-stage HP turbine. It has a Full Authority Digital Engine Control (FADEC) which provides engine control and monitoring via the Engine Control Unit.

The HPC increases the pressure of the air as it passes from stage to stage, in order to supply the combustor section. It is comprised of a rotor, front stator and rear stator. The Variable Stator Vane (VSV) system, located at the forward end of the HPC (Figure 8), positions the Inlet Guide Vanes (IGV) and the stage 1, 2 and 3 stator vanes to the appropriate angle to optimise the airflow over the HPC rotor blades (Figure 9).

The VSV actuation system consists of two hydraulic actuators located at the 2 o'clock and 8 o'clock positions, a series of bellcranks, tie rods and four actuation rings (one for each stage) made in two halves. The actuation ring halves are connected at the split-line of the compressor casing by a connecting link, to which the actuator tie rods are connected. Each vane is connected to the actuation ring by a lever arm. The connecting links and actuation rings rotate circumferentially about the horizontal axis of the compressor in response to actuator inputs and this movement is transmitted through the lever arms to change the angular position of the vanes.

The Variable Bleed Valve (VBV) system is located forward of the HPC. It regulates the amount of air discharged from the LPC into the HPC.



**Figure 8**

Section of High Pressure Compressor showing rotor, IGVs and VSVs



**Figure 9**

Example High Pressure Compressor rotor blade

### *Engine maintenance history*

The left engine, engine serial number (ESN) 697283, was manufactured in 2007 and had been fitted to the aircraft since new. The aircraft had been leased to an Indonesian operator prior to entering service with the current operator. During the return-from-lease inspection several defects were identified with the engine which resulted in its removal and subsequent repair at an engine overhaul facility in Indonesia. During the repair process, the IGV and VSV actuation rings were split to remove the top half of the HPC case (front stator), allowing access to replace two damaged HPC blades. This involved disassembly of the connecting links on the IGV and VSV actuation rings.

The IGV and VSV actuation rings and connecting links were reassembled after reinstallation of the HPC case. No defects were noted during the post-repair inspections or the subsequent engine test cell runs and the engine was refitted to the aircraft.

The operator took delivery of the aircraft, registered as OE-LOA, on 22 December 2018. No maintenance was performed on the left engine between then and the accident, other than routine oil replenishment, and there were no relevant defects in the technical log. At the time of the accident the engine had accumulated 513 operating hours and 220 cycles since the engine repair.

### **Engine examination**

The aircraft had been moved from the runway but debris which had exited the left engine was collected from the runway by the Airport Authority and provided to the AAIB (Figure 10). The items collected included multiple IGVs, fragments of compressor blades and fragments of engine acoustic liner.



**Figure 10**

Items collected from the runway

(Note: the yellow items are frangible links from the emergency evacuation slides)

Preliminary examination of the engine identified that the engine casing had not been breached but that engine parts, predominantly IGVs, had exited the engine through the VBV louvre panels. Other parts, later identified as IGV vanes and HP compressor stage 1 blade fragments, had collected in the VBV sumps. The engine centrebody exhibited a circumferential crack running around approximately 270° of its diameter.

Debris retrieved from inside the engine cowlings was identified as fragments of washers and bushings from the IGV and variable stator vane (VSV) actuation rings.

### **Engine borescope inspection**

An engine borescope inspection identified that the fan blades and LPC booster stages 1 to 3 were undamaged but the trailing edges of all LPC stage 4 blades and stators exhibited substantial impact damage including dents, tears and missing material. The HPC rotor could not be rotated, but it was evident that all IGVs were missing and extensive damage had been sustained by all HPC stage 1 blades. The downstream stages of the HPC exhibited extensive damage and some stage 1 VSVs were missing.

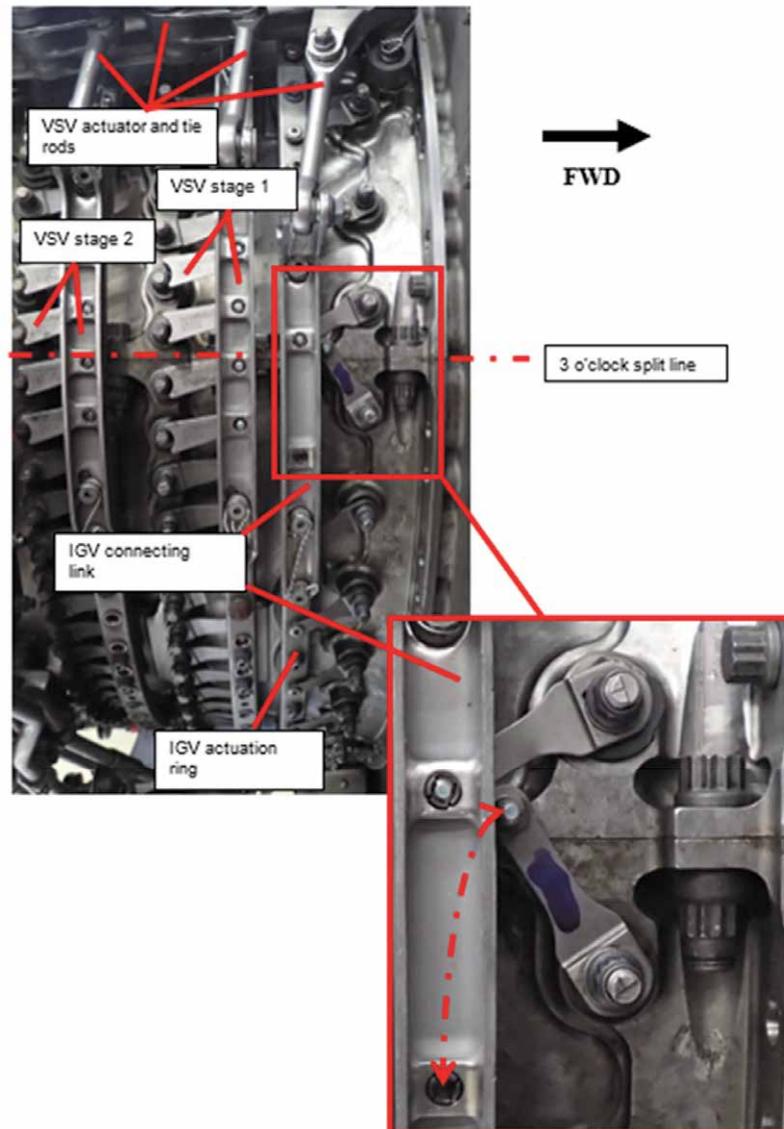
### **Engine strip examination**

#### *General*

An engine strip examination was conducted at an approved engine overhaul facility under the supervision of the AAIB.

#### *External examination*

A single IGV lever arm in the 3 o'clock position (aft looking forward) immediately below the split-line of the HPC case, was found to be disengaged from the connecting link on the IGV actuation ring (Figure 11). This lever exhibited no distortion or damage but did have a small impact mark on its forward edge, which coincided with where the lever arm could come in to contact with the HPC case if it was not connected to the connecting link. There was no corresponding mark on the HPC case. Approximately half of the remaining IGV lever arms were bent or distorted and many of the bushings in the IGV actuation ring were absent or damaged.



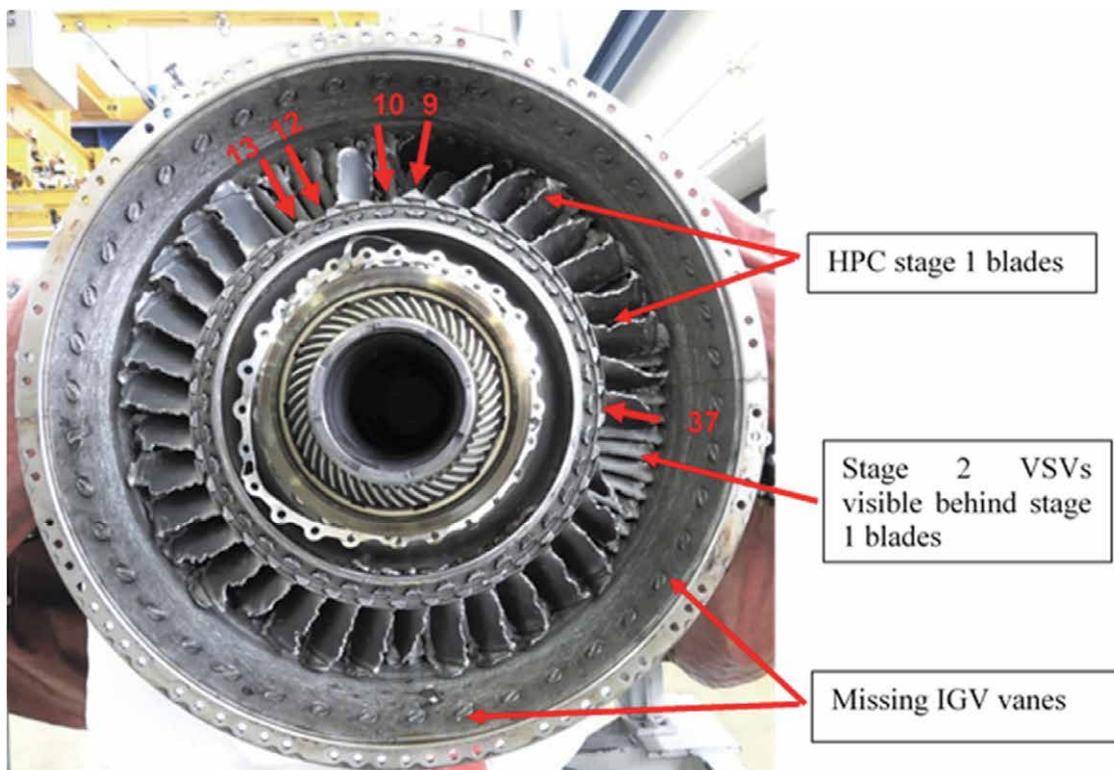
**Figure 11**

Lever arm disconnected from connecting link on IGV actuation ring

#### *Internal examination of the HPC module*

Disassembly of the HPC module showed that all the IGVs had sheared at their outer platform. All 38 HPC stage 1 blades were damaged. Four blades (Nos 10, 12, 13 and 37) had ruptured below the blade platform and one blade (No 9) had separated above the blade platform, releasing the remainder of the blade (Figure 12). Another three blades exhibited cracking below the platform.

The damage to HPC stator vanes and blades downstream of stage 1 was consistent with secondary impact damage from the release of the stage 1 blades and the resulting rotor imbalance.



**Figure 12**

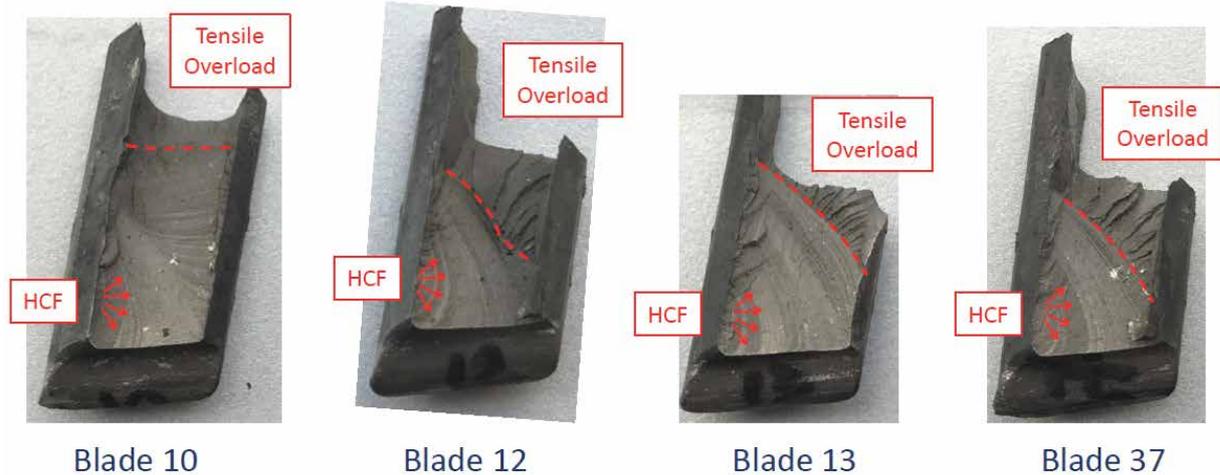
HPC module showing missing IGVs and damaged stage 1 blades

Detailed examination of the fracture surfaces of the HPC stage 1 blades which had separated below the platform, showed initiation of high-cycle fatigue (HCF) above the pressure surface on the concave side of the blade, near the leading edge. The fatigue had propagated downward and through the thickness of the blade. Beyond the area of HCF, the fracture surface was consistent with tensile overload. Blade 10, which exhibited the greatest area of fatigue, was most likely the first blade to be released (Figure 13). The fracture surface of the blade which had failed above the platform was consistent with tensile overload and had been heavily smeared, which was indicative of secondary damage.

On the blades which exhibited below-platform cracking, the cracking was consistent with the initiation of HCF in the blade dovetail, but the fatigue had not yet propagated to the point of tensile overload.

#### *Detailed component examination – IGV hardware*

The IGV connecting link exhibited no damage. Approximately half of the lever arms were bent or distorted, including several immediately adjacent to the disconnected lever arm. The disconnected lever arm, which was free to rotate exhibited a contact mark, most likely from contact with the HPC case.



**Figure 13**

Fracture surfaces of blades exhibiting below-platform liberation

### Known effects of disengaged IGV/VSV lever arm

The engine manufacturer advised that a disengaged, bent or broken IGV or VSV lever arm will result in an off-schedule variable vane which does not move in unison with the other vanes. This will cause variation in the airflow around the vane, and lead to a once-per-revolution (1/rev) excitation of the adjacent blades as they rotate past the vane. The force of the excitation is proportional to the angle of the off-schedule vane. The excitation creates stresses in the blade which are beyond the design limit. This phenomenon typically results in below-platform fracture in the blade dovetail, caused by a fatigue crack which initiates on the concave face of the blade and propagates towards the convex face. The crack grows with every loading cycle (aerodynamic excitation) and as it does, the load-carrying capability of the blade reduces, until ultimately it fails in tensile overload.

The engine manufacturer determined that the blade fracture surfaces from this event, were consistent with its experience of previous events where 1/rev aerodynamic excitation had occurred as a result of one or more disengaged, bent or broken IGV/VSV lever arms.

The engine manufacturer is aware of approximately 200 off-schedule VSV findings and/or events, of which 22 were attributed to improper engagement of lever arms in the connecting links. Thirteen of those, including this event resulted in HPC blade release. Of those, ESN 697283 had the lowest cycles to failure (220 cycles) and was among those with lowest time to failure (513 hours). The remaining nine occurrences were detected before blade release occurred.

The previous thirteen events have shown that the time to blade release is variable and can be influenced by the magnitude of the excitation force, the individual blade material properties and the nature of the improper engagement of the lever arm.

## Other findings during engine disassembly

During the engine examination several non-conformances were noted with components which may have been disturbed during the recent engine repair, but these were not considered causal or contributory to the engine failure. Non-conformances were also noted with engine components which were not disturbed during the recent repair and it was outside the scope of this investigation to determine when these non-conformances had occurred.

## Maintenance documentation

CFM56 Engine Shop Manual (ESM) task 72-00-32-430-001 '*Compressor Front Stator Assembly – Installation*' includes the following instructions to verify that the IGV and VSV lever arms are correctly installed in the connecting links.

*'... **CAUTION:** HIGH PRESSURE COMPRESSOR BLADE DAMAGE WILL OCCUR IF THE LEVER ARM PINS ARE NOT CORRECTLY ENGAGED INTO THE CONNECTING LINKS AND ACTUATION RING BUSHINGS.*

- (6) *Do a visual inspection to make sure all of the lever arm pins are correctly engaged as follows:*
- (a) *Verify the lever arm pins are properly installed into each of the connecting links.*
    - 1 *Place a white stripe across four IGV lever arm pins and bushings (2 each side). Use a temporary marking pen.*
    - 2 *Place a white stripe across eight stage 1, 2 and 3 lever arm pins and bushings (4 each side). Use a temporary marking pen.*
  - (b) *Verify that all IGV and stage 1, 2 and 3 lever arm pins are engaged around the entire VSV system.'*

## Information from the engine maintenance facility

Personnel from the engine overhaul facility were interviewed on behalf of the AAIB by the Indonesian National Transportation Safety Committee.

The mechanic who installed the IGV and VSV connecting links, reported that although access was difficult in some places, he did not find any discrepancies with the lever arms when performing the task. Similarly, the certifying engineer who inspected the installation of the IGV and VSV connecting links and those involved in other related tasks on the VSV actuation system, did not note any discrepancies with the lever arms. Additionally, no defects were identified during the post-maintenance inspections. The maintenance job card for the installation of the IGV and VSV connecting links referenced the relevant ESM task and was stamped as having been completed and inspected. When asked about what circumstances might have contributed to the IGV lever arm not being attached to the connecting link, the mechanic involved stated that he did not know how this occurred, but that since there are several external accessories that needed to be moved for access, it might be possible to

overlook tightening a lever arm. The certifying engineer indicated his belief that if an IGV was not secure, an engine surge or stall would occur during the post-maintenance engine run or post maintenance check flight.

ESN 697283 was the first CFM56-5 engine that the engine overhaul facility had worked on, but the engineers working on ESN 697283 had undertaken CFM-56-5 training and were accustomed to working on CFM56-3 and CFM56-7 engines. They reported that they did not encounter any significant differences or difficulties working the IGV/VSV system.

The engineers reported that there were no issues with workload, overtime or night working during the engine repair, as all maintenance tasks were planned to be completed within a day shift. They indicated that they had good access to tools and that the ESM was available at every workstation.

## Analysis

### *Flight crew aspects*

After the failure of the left engine the flight crew responded correctly by rejecting the takeoff, bringing the aircraft to a stop and announcing "ATTENTION CREW: ON STATION" to the FAs and actioning the ECAM checklist. As the engine failure was secured by the crew actioning the ECAM checklist and there were no other causes for concern, the decision to vacate the runway under the power of the right engine was appropriate.

The crew were subsequently surprised to see a cabin door open, a slide deployed and passengers walking in front of the aircraft. The commander then contacted the SFA to ask why an evacuation had been initiated. After this exchange he realised that passengers were going towards the right engine, which was still operating. Had any of them entered the right engine's inlet suction danger area (Figure 1, Area A), it is possible that they could have been sucked into the engine. The right engine was shutdown 2 minutes after the commander noticed that Door 1L was open.

Once they had noticed that an evacuation had commenced there was realistically no way that the flight crew would have been able to recover the situation. It may have been prudent to action the *EMER EVAC* checklist to ensure that the aircraft systems were all in as safe a state as possible for the passengers to exit the aircraft. However, given that passengers were potentially going to encroach into the right engine's inlet suction danger area it was probably quicker to select the ENG MASTER to OFF. Had the commander prioritised shutting down the engine and thus had a more succinct discussion with the SFA, the right engine could have been shut down sooner.

### *Flight attendant aspects*

All evacuations carry risk of passenger injury so flight attendants should not command an evacuation unless there is no doubt that it is required. The operator's *Flight Safety Manual* listed the circumstances when flight attendants should initiate an evacuation and none of these criteria applied. A combination of factors combined to overwhelm the SFA and cause her to command the evacuation over the PA.

At the front of the aircraft, the noise of the engine failure sounded very loud to the two FAs. The SFA was startled by the noise of the engine failure and the movement of the aircraft to the side of the runway. This appears to have caused her to narrow her attention to the aircraft sounds so that she did not hear the “ATTENTION CREW: ON STATION” command. The other FAs all heard it and were not aware that she had not.

Initially it was organised and calm in the cabin at the rear of the aircraft. The crew members there were helped by the calming influence of FA4 who was more experienced. Also FA3 and the ACM were recent recruits and may have benefitted from the recency of their training.

Communication between the SFA and FA3 was not effective in either means or content. The crew members’ and passengers’ accounts suggested that communication was attempted using a combination of the PA system, the interphone, shouting and hand gestures. A combination of English and German language was used.

The interphone at the FA3 seat was knocked off by the force of the folding seat closing. This resulted in the attention-getting chime and lights being inhibited so there was a delay between the SFA calling and establishing communication. The FAs reported that the handsets were prone to falling out of the cradle.

It was dark outside, and the cabin lights were dimmed for takeoff. The lack of light in the cabin made it difficult to see what was happening at the rear of the aircraft so communication by hand signals was not effective and the SFA could not see that the interphone was stuck.

The communication difficulty meant that the SFA could not establish whether the situation was safe at the rear of the aircraft. The SFA formed the impression that all the other flight attendants were scared. Only one minute and twenty seconds elapsed between the “ATTENTION CREW: ON STATION” command and the ‘evacuate’ command by the SFA. It would have felt like much longer to the flight attendants, especially the SFA who had heard nothing from the cockpit and felt under pressure from the passengers. Altogether this increased her anxiety and uncertainty and contributed to her commanding the evacuation.

Any FA could have contacted the cockpit during this time. The FAs who heard the “ATTENTION CREW: ON STATION” command would have been unlikely to do so because they understood the procedure to wait. The SFA had not heard this command but it did not occur to her to contact the pilots. As well as her emotional state, this may have been partly because her interactions with them were so limited under normal circumstances. The operator did not provide training for FAs and pilots designed to increase their interaction and understanding of each other’s roles. All FAs had been trained that the pilots would be busy in an emergency, but they had no understanding of the tasks the pilots were doing or how long they would take.

Not all passengers heard the evacuation command on the PA. If the evacuation signal had been used the passenger response and the overall evacuation may have been quicker. However, this was not available to the FAs and the pilots were unlikely to operate it given they had not commanded the evacuation.

The SFA had recently been promoted after a relatively short time as an FA. During her time as FA, there was a period where she did not fly due to the operator's bankruptcy. As a result, she did not meet the operator's requirement for promotion in terms of duration of operational experience. Her initial training course as an FA was within a large group which may have resulted in aspects not being fully explained or understood by all that attended. The pressure to have staff operationally available for flights after the bankruptcy and change of operator meant that the subsequent training for SFA was purely theoretical and short in comparison to the operator's more recent practice. These factors may have meant that the SFA was not well prepared for her role in the emergency.

All FA practical training for emergencies involved a practice evacuation. None of them had practiced a return to normal operation. This may have resulted in a false expectation that all emergencies would result in an evacuation.

Overall, it seems that the SFA's emotional response to the emergency was aggravated by her general inexperience and the communication difficulties the FAs encountered. Despite meeting regulatory requirements, there were weaknesses in her training that meant she was not well prepared for the situation. Together this resulted in an overwhelming 'flight' response in which she felt the need for herself and everyone else in the cabin to escape the situation as quickly as possible. She did not contact the pilots and ended up commanding an evacuation. The operator has undertaken to implement a range of improvements to FA training and to instruct FAs to attempt to establish communication with the flight deck before commanding an evacuation.

#### *The evacuation*

Once the evacuation was commenced it was important that it proceeded in as safe and efficient a manner as possible to minimise the risk of passenger injury. In general, the evacuation proceeded swiftly, without significant panic or delay. The event provided an opportunity to learn about factors that influence a safe and efficient evacuation.

Many passengers in this evacuation collected their bags and attempted to leave the aircraft with them. At the supervised doors, the FAs removed baggage from them. At the unsupervised overwing exits passengers with bags could exit unchallenged. Baggage brought to the exits created difficulty for the FAs who then needed to remove it and store it somewhere which could have created an obstruction. The carried baggage probably slowed the evacuation and had the potential to damage the escape slides or injure other passengers on the slides. It was not possible to determine how long the evacuation took compared to the CS-25 requirement of 90 seconds.

The safety studies by the NTSB, TSB Canada, EASA and the Royal Aeronautical Society show that carried baggage has long been an issue. Appendix 1 lists many of the evacuation events identified in these four studies and provides additional details. It shows that it is extremely common for passengers to carry off bags in evacuations, even when there is a clear and immediate threat to life from remaining on board the aircraft. One of the events shows that even trained flight crew are not immune from the compulsion to keep their possessions with them. There were several examples where witnesses reported that

this passenger behaviour slowed the evacuation or that the evacuation took longer than 90 seconds.

The Royal Aeronautical Society commented that:

*'This trend appears to be increasing and can only be exacerbated by the increasing volume of cabin baggage being permitted by some operators for commercial reasons.'*

The Society made a recommendation to consider physical means of preventing passengers retrieving their baggage:

*'Aviation authorities should consider the feasibility of introducing a certification requirement for a means of remotely locking, from the flight deck, overhead bins in passenger cabins that do not contain emergency equipment, for taxi, take-off and landing.'*

Current mitigations for the issue include passenger briefing and printed instructions on the cabin safety card. However, the motivation for passengers to remain united with their baggage is extremely powerful and, in some cases, the danger is not immediately apparent to passengers. These factors may lead passengers to feel it is safe to pause and collect baggage and for the evacuation to proceed at a slower pace. For a high proportion of passengers, briefing and instruction by FAs does not overcome this.

The EASA addressed previous Safety Recommendation 2014-005 and published new acceptable means of compliance in AMC1 CAT.OP.MPA.170 on '*passenger briefing*' and new guidance material in GM2 CAT.OP.MPA.170, (f)(5)(vi) '*Passenger briefing - safety briefing material*' almost two years before this accident. The operator was compliant with the new material but, despite these improvements, the instructions about baggage still did not influence this behaviour for a high percentage of passengers.

The evidence from this accident, in combination with the collated evidence from previous cases shows that, even despite recent improvements, it remains the case that passenger briefing, safety cards and FA instructions are insufficient to stop passengers retrieving cabin baggage during an evacuation. This hazard will still exist in future emergencies unless additional measures are taken to either reduce the impact of that behaviour on the safety and speed of an evacuation or to prevent passengers evacuating with baggage. Therefore, the following Safety Recommendation is made:

#### **Safety Recommendation 2020-018**

It is recommended that the European Union Aviation Safety Agency commission research to determine how to prevent passengers from obstructing aircraft evacuations by retrieving carry-on baggage.

This incident has shown once again that, during an emergency evacuation, a proportion of passengers will attempt to leave the aircraft with their carry-on baggage slowing the evacuation process. The emergency evacuation demonstrations conducted to show compliance with CS-25 do not include a realistic simulation of this aspect of passenger behaviour which will slow down the evacuation and increase the risk of injury. Therefore, the following Safety Recommendation is made:

**Safety Recommendation 2020-019**

It is recommended that the European Union Aviation Safety Agency consider including a more realistic simulation of passenger behaviour in regard to carry-on baggage in the test criteria and procedures for the emergency demonstration in CS-25.

*Engine failure*

The left engine experienced a contained failure as a result of the release of several HPC stage 1 blades. The blade failures were caused by crack progression due to HCF with final failure due to tensile overload. Several other blades also exhibited fatigue initiation in the blade dovetail. The fatigue failures on the liberated blade fracture surfaces were consistent with failure due to a known aerodynamic excitation phenomenon which results from an off-schedule IGV/VSV condition and creates stresses in the blade which are beyond the design limit. One IGV lever arm was found disconnected from the connecting link on the IGV actuating ring and would have provided the stimulus for the aerodynamic excitation.

In comparison with other blade liberation events arising from improper engagement of IGV/VSV lever arms with the connecting link, ESN 697283 demonstrated a low time to failure. The magnitude of the excitation force, and therefore the time to failure, depends on the extent to which the affected vane is off-schedule (the angle between it and the other vanes). The fact that the lever arm was fully disengaged from the connecting link and the vane was therefore free to move, may have influenced the comparatively low time to failure.

The release of the HPC stage 1 blades resulted in separation of all the IGVs and the forces experienced by the vanes would have been transmitted through the lever arms and into the actuation ring. The absence of damage on the disconnected lever arm indicates that it was disconnected from the connecting link prior to, and not as a result of, the engine failure.

The IGV actuation ring connecting links were removed and reassembled during the recent engine repair, and it is probable that mis-assembly of the lever arm occurred at this time. The relevant ESM task contains instructions for a visual inspection to verify proper installation of the lever arms. But the mis-assembly was not identified by maintenance staff during installation of the IGV connecting link, visual inspection, or during other maintenance conducted in the immediate vicinity of the lever arm.

As reassembly of the engine progressed, it is unlikely that the disconnected IGV lever arm could have been easily detected as it would have been obscured by the external hoses, pipes and brackets. It is also highly unlikely that post-maintenance engine-runs would have detected an improperly assembled IGV lever arm.

The time elapsed between the engine repair and the subsequent investigation and the absence of anything particularly memorable about the installation of the connecting links, meant that there was limited information available regarding the factors which may have contributed to the IGV lever arm mis-assembly.

The engine manufacturer commented that it considered incomplete installation of components as “a common skill-based error”. Additional training or revisions to maintenance documentation have typically been shown to be ineffective in preventing improper component installation. In general, such occurrences can only be reliably prevented by design solutions, or an error-tolerant design from the outset.

The engine manufacturer has considered these aspects and determined that the addition of further instructions in the ESM is not likely to be an effective mitigation. Mitigating or eliminating the possibility of an improperly assembled IGV/VSV lever would require an engine redesign which it does not consider feasible based on the low rate of occurrence. It further indicated that the limited space, concentration of moving parts and engine temperatures in the vicinity of the IGV/VSV actuation rings would preclude the installation of a placard to highlight the correct assembly of the IGV/VSV connecting links.

The engine manufacturer presented on the subject of improper IGV/VSV lever arm assembly and its consequences at an All Operators Conference in June 2019 and published an article in its monthly publication *'Fleet Highlites'*, available to all CFM operators and approved overhaul facilities, in January of 2020. It also intends to highlight this subject during calls with its field service representatives for onward dissemination to operators and overhaul facilities.

There is currently no means, other than visual inspection, to detect improper lever arm assembly. The engine manufacturer has recently implemented an HPC performance analytic tool that is designed to detect shifts in HPC efficiency. Relevant alerts from the analytic tool are notified to operators. While there is not currently enough experience with the analytic tool to determine if the effects of a mis-assembled lever arm could manifest as a detectable shift in engine performance, the engine manufacturer intends to evaluate this possibility as experience with the tool increases.

### **CVR**

Discussions between the flight crew and FAs were captured on the CVR which aided the investigation. However, the PA announcements were not recorded which would have provided useful information for this investigation. The operator's pre-flight checklist required ACP selections to ensure the PA was recorded. It was not established why the CVR did not record the PA audio.

### **Conclusions**

The left engine experienced a contained engine failure. All the damage found in the engine was consistent with the release of one or more high-pressure compressor stage 1 blades as a result of high-cycle fatigue arising from aerodynamic excitation of the blades. A single inlet guide vane lever arm, which had been improperly assembled in the connecting

link on the inlet guide vane actuation ring, was identified as the source of the stimulus that resulted in the blade release.

As a result of the engine failure and subsequent rejected takeoff, the Senior Flight Attendant commanded an emergency evacuation that was not necessary in the circumstances. This was probably the result of a combination of factors that heightened her emotional response to the event and affected her decision making. The factors included inexperience as a flight attendant, weaknesses in her training and communication difficulties during the event.

As a result of the flight crew not being consulted before the evacuation was commenced, the right engine remained running for the first few minutes of the evacuation. This led to an increased risk of serious injury to those passengers that evacuated on the right side of the aircraft. Indeed, several passengers sustained minor injuries having been blown over by the exhaust.

During the evacuation several passengers hindered the evacuation by taking their cabin baggage with them. While some were removed by the flight attendants at the supervised exits, this was not possible at the overwing exits. Two Safety Recommendations are made regarding passengers evacuating with carry-on baggage.

### Safety actions

As a result of this event the operator has stated that several safety actions have been or will be completed, including:

#### *Procedures*

- The operator sent a Memo, on 19 May 2020, to all its Airbus pilots instructing them to ensure the PA RECEIPT is selected on an Audio Control Panel, thus ensuring the CVR records any PA announcements.
- The operator's *Flight Safety Manual* will be amended to instruct the Flight Attendants to attempt to establish communications with the flight crew to check that an evacuation is safe and necessary before commanding it independently.

#### *Training*

The operator has taken the following safety actions in relation to its flight attendant training. The operator has:

- Augmented the team responsible for training with the addition of a deputy manager of flight attendant training.
- Introduced a maximum limit of 25 trainees in initial flight attendant training courses. After approval from the operator's competent authority, it was subsequently increased to 30 in April 2020.

- Added practical training in the CEET to the senior flight attendant course as standard. Practical training has also been incorporated in their annual recurrent training.
- Improved variety of training scenarios in the CEET, including scenarios that result in a return to normal operations rather than an evacuation.
- Improved the syllabus of flight attendant training to include the performance effects of startle, an improved 30-second review<sup>15</sup> technique and enhanced communication training.
- Produced a video training aid that will introduce flight attendants to the actions of the flight crew after a rejected takeoff.
- Extended the aeroplane familiarisation phase during initial training with additional familiarisation flights.

#### *Crew composition*

- The operator has introduced a requirement in the *Operations Manual* regarding flight attendant team composition. A minimum of two experienced flight attendants shall be part of the operating crew's complement. This is 50% of the operating crew members, as their A320s are operated with four flight attendants.

The engine manufacturer has stated the following safety actions have or will be taken:

- Provided a presentation on the subject of improper IGV/VSV lever arm assembly and its consequences at an All Operators Conference in June 2019 and published an article in its monthly publication '*Fleet Highlites*' in January 2020.
- Highlight the issue of improper IGV/VSV lever arm assembly during calls with its field service representatives for onward dissemination to operators and overhaul facilities.
- Evaluate the use of a HPC performance analytic tool to determine if the effects of a mis-assembled lever arm could be identified from a detectable shift in engine performance.

*Published: 6 August 2020.*

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#### **Footnote**

<sup>15</sup> A process where FA mentally rehearse the steps they would have to take during an evacuation before each takeoff and landing.

## Appendix 1

## Previous accidents and incidents where passengers evacuated with baggage

Aircraft type	Location	Date	Registration	Comments	Link
B747-200	London Gatwick, UK	07/08/1990	N303TW	Tailpipe fires in three engines. Witnesses reported that passengers attempted to carry hand baggage to the exits and to re-stow it in the overhead lockers when instructed not to take it. Some passengers carried baggage down the emergency slides. The time taken to complete the evacuation exceeded 90 seconds.	<a href="https://assets.publishing.service.gov.uk/media/5422fca2e5274a13170008ef/Boeing_747-200_N303TW_11-90.pdf">https://assets.publishing.service.gov.uk/media/5422fca2e5274a13170008ef/Boeing_747-200_N303TW_11-90.pdf</a>
McDonnell Douglas MD-80	San Francisco, USA	19/12/1997	N932AS	Noxious fumes during taxi. Flight attendants reported they had to remove carry-on baggage from passengers during the evacuation.	<a href="https://app.nts.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20001208X09328&amp;AKey=1&amp;RType=Final&amp;IType=IA">https://app.nts.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20001208X09328&amp;AKey=1&amp;RType=Final&amp;IType=IA</a>
McDonnell Douglas MD-11	Hong Kong	22/08/1999	B-150	Crashed on landing in poor weather, caught fire and became inverted. Some passengers commented that their evacuation was slowed by other passengers trying to recover their hand baggage.	<a href="https://reports.aviation-safety.net/1999/19990822-0_MD11_B-150.pdf">https://reports.aviation-safety.net/1999/19990822-0_MD11_B-150.pdf</a>
A330-243	Terceira-Lajes, Azores, Portugal	24/08/2001	C-GITS	Emergency landing after double engine failure due to fuel exhaustion. Many passengers attempted to leave with carry-on baggage.	<a href="https://reports.aviation-safety.net/2001/20010824-1_A332_C-GITS.pdf">https://reports.aviation-safety.net/2001/20010824-1_A332_C-GITS.pdf</a>
McDonnell Douglas MD-88	Groningen Airport, Netherlands	17/06/2003	TC-ONP	Rejected takeoff above decision speed and runway overrun. Most passengers took their hand baggage with them or re-entered the aircraft to retrieve their hand baggage. Some passengers reported that the evacuation took too much time and attributed this to people collecting their baggage before leaving. Identified in the EASA study as taking longer than 90 seconds to complete the evacuation.	<a href="https://www.onderzoekraad.nl/en/page/750/runway-overrun-after-rejected-take-off-md-88-groningen-airport-eelde">https://www.onderzoekraad.nl/en/page/750/runway-overrun-after-rejected-take-off-md-88-groningen-airport-eelde</a>

## Appendix 1 (Cont)

## Previous accidents and incidents where passengers evacuated with baggage

Aircraft type	Location	Date	Registration	Comments	Link
B747-438	Sydney, Australia	02/07/2003	VH-OJU	Landing gear fire. Some passengers evacuated with cabin baggage. Cabin crew reported they were unsure whether to remove baggage or not. Those that did remove baggage reported a build-up of baggage that potentially slowed passenger movement from the aircraft.	<a href="https://www.atsb.gov.au/media/24408/air200302980_001.pdf">https://www.atsb.gov.au/media/24408/air200302980_001.pdf</a>
DC10-10F	Memphis, Tennessee	18/12/2003	N364FE	Cargo flight, fire following a hard landing. Non-revenue pilots travelling as passengers threw their bags out during the evacuation because they contained travel documents, clothes and baggage.	<a href="https://www.nts.gov/investigations/accidentreports/reports/aar0501.pdf">https://www.nts.gov/investigations/accidentreports/reports/aar0501.pdf</a>
B737-406	Barcelona, Spain	28/11/2004	PH-BTC	Runway departure after a bird strike to the nosewheel. The report stated 'A lot of passengers took baggage and personal items with them despite of the commands and instructions of the cabin attendants. This somewhat delayed the evacuation'. Safety cards did not contain an instruction to leave baggage behind in an emergency and no specific pre-flight instructions were provided to that effect. Identified in the EASA study as taking longer than 90 seconds to complete the evacuation.	<a href="https://www.fss.aero/accident-reports/dvdfiles/ES/2004-11-28-ES.pdf">https://www.fss.aero/accident-reports/dvdfiles/ES/2004-11-28-ES.pdf</a>
A340-3300	Toronto, Canada	02/08/2005	F-GLZQ	Runway overrun and fire. TSB reported 49 percent of passengers stated they attempted to take carry-on baggage when leaving the aircraft and 48 percent reported that this slowed the evacuation. Identified in the EASA study as taking longer than 90 seconds to complete the evacuation.	<a href="https://www.tsb.gc.ca/eng/rappports-reports/aviation/2005/a05h0002/a05h0002.pdf">https://www.tsb.gc.ca/eng/rappports-reports/aviation/2005/a05h0002/a05h0002.pdf</a>

## Appendix 1 (Cont)

## Previous accidents and incidents where passengers evacuated with baggage

Aircraft type	Location	Date	Registration	Comments	Link
B737-319	Auckland, New Zealand	12/09/2006	ZK-NGJ	Electrical failure and smoke in the cabin on takeoff. Some passengers took their carry-on bags with them and were allowed to take them down the slides rather than block the exits with discarded bags. Identified in the EASA study as taking longer than 90 seconds to complete the evacuation.	<a href="https://www.taic.org.nz/sites/default/files/inquiry/documents/06-003.pdf">https://www.taic.org.nz/sites/default/files/inquiry/documents/06-003.pdf</a>
A330-300	London Gatwick, UK	16/04/2012	G-VSXY	Smoke warnings from the cargo hold. A number of passengers took their hand baggage with them and others commented that passengers retrieving hand baggage delayed the evacuation.	<a href="https://assets.publishing.service.gov.uk/media/54230155e5274a1314000a95/AAIB_1-2014_G-VSXY.pdf">https://assets.publishing.service.gov.uk/media/54230155e5274a1314000a95/AAIB_1-2014_G-VSXY.pdf</a>
A320-200	Halifax, Canada	29/03/2015	C-FTJP	Aircraft crashed landing short of the runway in bad weather. Despite a pre-departure briefing that included instructions to leave carry-on baggage behind and pictorial instructions on the safety card, some passengers exited the aircraft with their carry-on baggage.	<a href="https://www.tsb.gc.ca/eng/rappports-reports/aviation/2015/a15h0002/a15h0002.pdf">https://www.tsb.gc.ca/eng/rappports-reports/aviation/2015/a15h0002/a15h0002.pdf</a>
B777-200	Las Vegas, USA	08/09/2015	G-VIIO	Uncontained engine failure during takeoff roll and fire. Cabin crew reported that some passengers evacuated with carry-on baggage. It was not thought to slow the evacuation in this case, but the flight was only 55% percent full.	<a href="https://app.nts.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20150908X35241&amp;AKey=1&amp;RType=HTML&amp;IType=FA">https://app.nts.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20150908X35241&amp;AKey=1&amp;RType=HTML&amp;IType=FA</a>
B777-300	Dubai, Emirates	03/08/2016	A6-EMW	Aircraft crashed during attempted go-around with thrust at idle. Although passengers were instructed to leave their carry-on baggage behind and evacuate, several passengers exited with their carry-on baggage. The evacuation took approximately 6 minutes and 40 seconds for 298 passengers and flight crew.	<a href="https://www.gcaa.gov.ae/en/Publication/admin/iradmin/Lists/Incidents%20Investigation%20Reports/Attachments/125/2016-Published%20Final%20Report%20AIFN-0008-2016-UAE521%20on%206-Feb-2020.pdf">https://www.gcaa.gov.ae/en/Publication/admin/iradmin/Lists/Incidents%20Investigation%20Reports/Attachments/125/2016-Published%20Final%20Report%20AIFN-0008-2016-UAE521%20on%206-Feb-2020.pdf</a>