AIRCRAFT SERIOUS INCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:	CA18/3/2/1421		
Aircraft Registration	**G-XLEH**	**Date of Serious Incident**	12 July 2023	**Time of Serious Incident**	1804Z	
Type of Aircraft	Airbus A380-841		**Type of Operation**	Air Transport (Part 121)		
Pilot-in-command Licence Type	Airline Transport Pilot Licence		**Age**	53	**Licence Valid**	Yes
Pilot-in-command Flying Experience	**Total Flying Hours**	20 000.0	**Hours on Type**	4 300.0		
Last Point of Departure	O.R. Tambo International Aerodrome (FAOR), South Africa					
Next Point of Intended Landing	Heathrow International Aerodrome (EGLL), United Kingdom					
Damage to Aircraft	Minor					
Location of the site concerning easily defined geographical points (GPS readings if possible)						
Approximately 60nm south of the ETMIT waypoint (GPS position: 24°12'32.23" South 027°45'36.32" East)						
Meteorological Information	Surface wind: 030°/11 knots, temperature: 11°C, dew point: 3°C, CAVOK					

Number of People On-board	3+21+429	**Number of People Injured**	0	**Number of People Killed**	0	**Other (On Ground)**	0

Synopsis

On Wednesday evening, 12 July 2023, an Airbus A380-841 with registration G-XLEH was engaged in flight BA56 from O.R. Tambo International Aerodrome (FAOR) in Johannesburg, South Africa, to Heathrow International Aerodrome (EGLL) in London, United Kingdom. Twenty-four (24) crew members and 429 passengers were on-board the aircraft. A flight plan was filed for this flight which was conducted under instrument flight rules (IFR) and under the provisions of Part 121 of the Civil Aviation Regulations (CAR) 2011 as amended.

The aircraft took off from Runway 03L at 1747Z. Whilst approximately 120 nautical miles (nm) north of FAOR and climbing through 25 170 feet (ft), the crew declared a Mayday due to a strong acrid smell in the cockpit and cabin areas. The crew immediately commenced a descent to 10 500 ft and returned to FAOR. Approximately 47 minutes after take-off, the aircraft landed on Runway 21R. The crew brought the aircraft to a stop on the runway and, thereafter, shut down the engines. The Aerodrome Rescue and Firefighting (ARFF) personnel inspected the aircraft for signs of external damage, and none was found. The emergency medical personnel attended to one of the passengers who was not feeling well. The remainder of the passengers and the crew were unharmed.

Probable Cause

The acrid smell that entered the cockpit and the cabin areas prompted the crew to declare a Mayday as well as request an air turnback due to the failure of the Air Cycle Machine (ACM) unit 2 that forms part of the Air Generation Unit 1. The fretting observed on the turbine end journal bearing was likely the source of the acrid smell. Failure of other components (fan end journal bearing, thrust bearings, compressor rotor and both turbine rotors) was associated with damage which led to the stoppage of the rotating system.

SRP date	13 August 2024	Publication date	19 August 2024

Occurrence Details

Reference Number	**:** CA18/3/2/1421
Occurrence Category	**:** Serious Incident (Category 1)
Type of Operation	**:** Air Transport Operations, Passengers (Part 121)
Name of the Operator	**:** British Airways
Aircraft Registration	**:** G-XLEH
Aircraft Make and Model	**:** Airbus A380-841
Nationality	**:** United Kingdom
Place	**:** Approximately 60nm south of the ETMIT waypoint
Date and Time	**:** 12 July 2023 at 1804Z
Injuries	**:** None
Damage	**:** Minor

Purpose of the Investigation

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or serious incidents and not apportion blame or liability.

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Investigation Process

The Accident and Incident Investigations Division (AIID) of the South African Civil Aviation Authority (SACAA) was notified of the occurrence on 13 July 2023. The occurrence was classified as a serious incident according to the CAR 2011 Part 12 and the International Civil Aviation Organisation (ICAO) STD Annex 13 definitions. Notifications were sent to the State of Registry and Operator in the United Kingdom (Air Accidents Investigation Branch) as well as the State of Design and Manufacturer in France (Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile) and Germany (Bundesstelle für Flugunfalluntersuchung) in accordance with the CAR 2011 Part 12 and the ICAO Annex 13 Chapter 4. The AAIB, BEA, BFU and NTSB appointed accredited representatives to this investigation, and Airbus appointed an advisor. Oversight was requested from the National Transportation Safety Board in the United States of America. The AIID acknowledges the assistance of the operator (British Airways) to this investigation.

Notes:

1. *Whenever the following words are mentioned in this report, they shall mean the following:*
   Serious Incident — this investigated serious incident
   Aircraft — the Airbus A380 was involved in this serious incident
   Investigation — the investigation into the circumstances of this serious incident
   Pilots — the pilots involved in this serious incident
   Report — this is a serious incident report

2. *Photos and figures used in this report were taken from different sources and may have been adjusted from the original for the sole purpose of improving the clarity of the report. Modifications to images used in this report were limited to cropping, magnification, file compression; enhancement of colour, brightness, and contrast; or addition of text boxes, arrows, or lines.*

Disclaimer

Table of Content

Abbreviation	Description
°	Degrees
°C	Degrees Celsius
AAIB	Air Accidents Investigation Branch (United Kingdom)
ACM	Air Cycle Machine
AIID	Accident and Incident Investigations Division
AGL	Above Ground Level
AGU	Air Generation Unit
AOC	Air Operating Certificate
ARFF	Aerodrome rescue and firefighting
ATC	Air Traffic Control
ATPL	Airline Transport Pilot Licence
BEA	Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (France)
BFU	Bundesstelle für Flugunfalluntersuchung (Germany)
CAR	Civil Aviation Regulations
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CRS	Certificate of Release to Service
CVR	Cockpit Voice Recorder
ECAM	Electronic Centralised Aircraft Monitor
EFIS	Electronic Flight Information System
EGLL	Heathrow International Aerodrome (ICAO designation)
FAA	Federal Aviation Administration
FAOR	O.R. Tambo International Aerodrome (ICAO designation)
FDR	Flight Data Recorder
FL	Flight Level
ft	Feet
ft/min	Feet per minute
GPS	Global Positioning System
hPa	Hectopascal
kt	Knots
m	Metres
MEL	Minimum Equipment List
METAR	Meteorological Aerodrome Report
MTOW	Maximum Take-off Weight
NTSB	National Transportation Safety Board
PF	Pilot Flying
PFD	Primary Flight Display
PIC	Pilot-in-Command
P/N	Part Number
QNH	Barometric Pressure Adjusted to Sea Level
QRH	Quick Reference Handbook
SACAA	South African Civil Aviation Authority
SCC	Senior Cabin Crew
TBO	Time Between Overhaul
UKCAA	United Kingdom Civil Aviation Authority
Z	Zulu (Term for Universal Co-ordinated Time - Zero Hours Greenwich)

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 On Wednesday evening, 12 July 2023, an Airbus A380-841 with registration G-XLEH was on a scheduled flight BA56 from O.R. Tambo International Aerodrome (FAOR) in Johannesburg, South Africa, to Heathrow International Aerodrome (EGLL) in London, United Kingdom. Twenty-four (24) crew members and 429 passengers were on-board the aircraft.

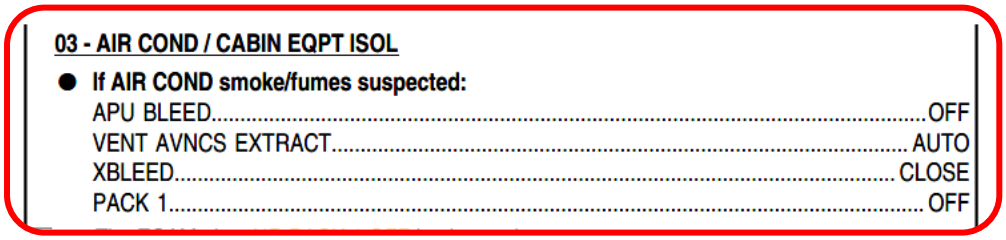
1.1.2 The aircraft was scheduled for departure at 1720Z. According to the preliminary radar and voice communication data, air traffic control (ATC) cleared the aircraft for take-off at 17:45:44Z, and the aircraft took off from Runway 03L at 17:47:02Z. At 18:01:23Z, the first officer (FO) who was the pilot flying (PF) asked the pilot-in-command (PIC): "*Do you smell that?"* To which he replied "*Yeah".* The FO then stated: "*That is quite a strong smell".* At 18:01:49Z, the PIC asked the senior cabin crew (SCC) member: *"Do you have any strange smells around, anywhere; anyone complaining? Can you have a check around and come back to me, please? We have a strange smell in here". The* PIC then asked the PF if "*it is getting better or worse",* to which he replied, "*it is the same, it is a burning smell, it is not an odour, it is a burning smell".*

1.1.3 At 18:04:30Z, with the aircraft approximately 120 nautical miles (nm) north of FAOR whilst climbing through 25 170 feet (ft), the PIC declared a Mayday call *(radio transmission from the flight crew indicating a potentially life-threatening emergency)* and requested an immediate return to FAOR. The PIC also informed ATC that they *"had fumes inside the aircraft, and we had a smell of fumes, and we needed to descend now to 10 000 feet, please".* Thereafter, ATC instructed the PIC to turn left on a heading of 190° and to descend to flight level (FL) 105 (10 500ft). At 18:04:45Z, the heading mode (HDG) was engaged (and the navigation [NAV] mode was disengaged). Roll and heading started to decrease which indicated a left turn, with the heading changing from 357° to 192°. The PF immediately commenced with the descent to FL105 (10 500 ft).

1.1.4 At 18:05:52Z, the PIC briefly spoke to the passengers; he stated: "*Ladies and gentlemen, Captain, we may have noted a strange smell in the cabin, we need to return to Joburg to have it checked out, please pay attention to everything the cabin crew tells you; I will get back to you when I can, thank you."* No smoke or fire warnings were triggered automatically on the centralised aircraft monitoring (ECAM) by any of the systems during the flight. The initial actions from the Quick Reference Handbook (QRH) procedure for SMOKE/FUMES *(see subheading 1.18.1 of the report)* were actioned by the crew and the PIC requested permission to return to FAOR as per the guidance/instructions of the QRH. At 18:06:45Z, the relief pilot asked the PIC: "*Are we going to protect ourselves?",* to which he replied: "*If you want to do it, please go ahead, I think we are okay, please keep an eye on us".* None of the pilots donned their oxygen masks at this time. The crew then continued to discuss where the

smell might have been coming from. The relief pilot mentioned that the SCC stated that a strange grinding noise was coming from the number 2 engine and haze was present in the upper and main decks. Galley power was also switched off whilst the cause was investigated. At 18:07:31Z, the PIC requested the relief pilot to *"go and have a look in the cabin and if you find something, please come back to the cockpit."*

1.1.5 At 18:08:02Z, with the aircraft's gross weight at 494 600 kilograms (kg) and 141 240kg of fuel on-board, the crew activated the fuel jettison system. At 18:08:10Z, the crew advised ATC that they were dumping fuel. Following a further discussion in the cockpit, the PIC followed page 3 of the A380 QRH SMOKE/FUMES procedure under the heading AIR COND / CABIN EQPT ISOL and switched off the air-conditioning pack 1 at 18:09:22Z.



03 - AIR COND / CABIN EQPT ISOL

- **If AIR COND smoke/fumes suspected:**

APU BLEED ..... OFF
VENT AVNCS EXTRACT ..... AUTO
XBLEED ..... CLOSE
PACK 1 ..... OFF

1.1.6 After some discussion amongst the crew on the approach and landing at FAOR, the PIC requested ATC at 18:12:30Z to land on Runway 21R as they needed the shortest possible route to get back on the ground. The request was granted, and they were asked to report 10 miles out. At 18:15:55Z, the PIC asked ATC if it would be possible to use *autoland*; this was approved. The crew also advised ATC that they would stop on the runway and switch off the engines, and that there was no intention to conduct an emergency evacuation. After further discussion in the cockpit, the PIC decided that he would perform a manual landing as they were not sure how the aircraft would react during autoland after the emergency. At 18:22:22Z, the PIC addressed the passengers and informed them that they would stop on the runway and that the aircraft would be inspected by emergency ground personnel with the possibility of the aircraft being taxied off or towed off the runway. At 18:25:53Z, the PIC mentioned "*again some smoke back again"* but there was no further discussion or elaboration on this amongst the crew. At 18:28:16Z, the radar controller advised the crew that all emergency services were ready on the ground, awaiting their arrival.

1.1.7 At 18:32:19Z, the fuel jettison procedure was stopped with the aircraft at 6 900ft and at a gross weight of 441 660kg. Fuel amounting to 53 240kg was dumped in 14 minutes and 17 seconds. At 18:33:38Z, with the aircraft at 1 000ft, the PIC informed the FO "*stable, visual, I have control".* At 18:33:53Z, the air-conditioning pack 2 was switched off.

1.1.8 At 18:34:39Z, the aircraft landed back (weight on wheels) at FAOR on Runway 21R; the aircraft was decelerated using maximum reverse thrust, followed by pedal braking. It came to a stop on the runway with the parking brake activated at 18:35:39Z. At 18:36:02Z, all four engines were shut down. At 18:38:12Z, the PIC spoke to Echo 1 from the Aerodrome Rescue

and Firefighting (ARFF) personnel who had taken up position before the arrival of the aircraft. The ARFF personnel approached and inspected the aircraft for damage; no external damage was observed. After approximately 30 minutes, the aircraft was towed off the runway to the apron. One of the passengers was not feeling well. Thus, the emergency medical personnel attended to the passenger. The rest of the passengers and the crew disembarked from the aircraft unassisted. The aircraft remained on the ground for about 30 hours as an overweight landing inspection and fault-finding procedure was conducted to determine the cause of the acrid smell that entered the cockpit and cabin areas during the flight.

1.1.9 The serious incident occurred at night whilst the aircraft was en route from FAOR to EGLL at Global Positioning System (GPS) co-ordinates determined to be 24°12'32.23" South 027°45'36.32" East.

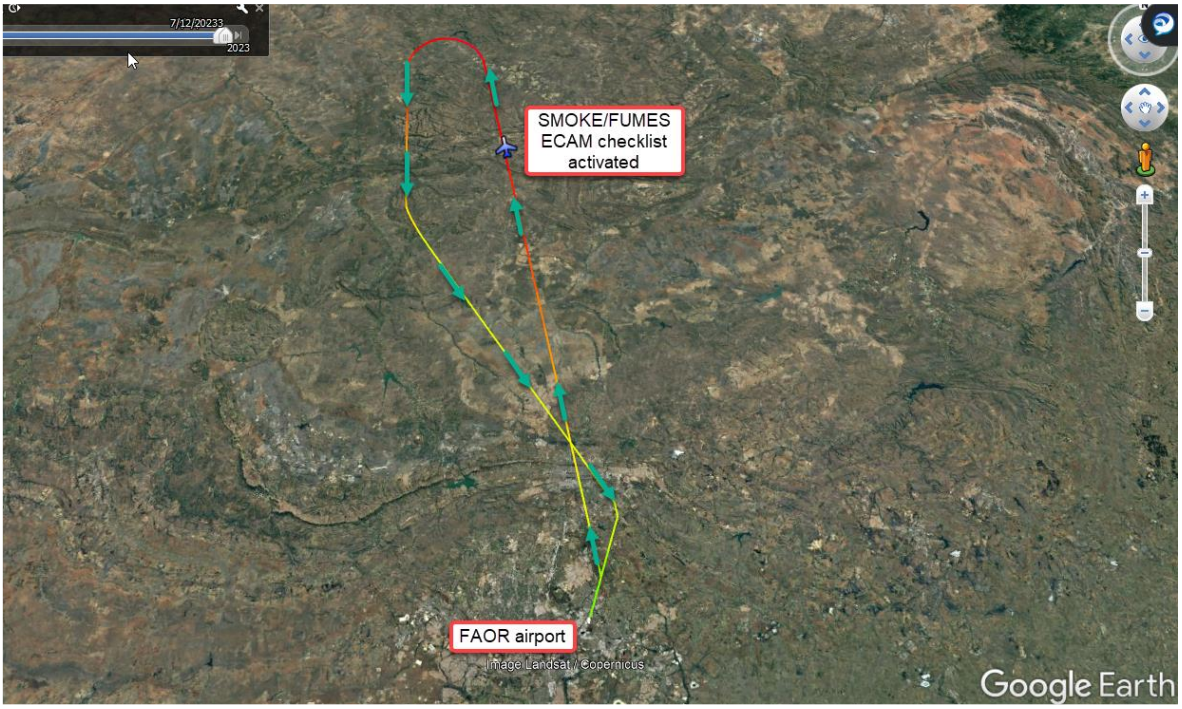


Figure 1: The radar track of the aircraft G-XLEH. (Source: Air Traffic Navigation Services/Google Earth)

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Minor	-	-	-	-	-
None	3	21	429	453	-
Total	**3**	**21**	**429**	**453**	**-**

Note: Other means people on the ground.

1.3 Damage to Aircraft

1.3.1 The aircraft was inspected by an aircraft maintenance organisation team after it landed at FAOR as this was an overweight landing. No damage was found. Subsequent troubleshooting by the operator's maintenance organisation identified that one of the air cycle machines had failed.

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

1.5.1 Pilot-in-command (PIC)

Nationality	British	Gender	Male	Age	53
Licence Type	Airline Transport Pilot Licence (ATPL)				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument				
Revalidation of Rating Airbus A380/1R	26 September 2022, valid until 30 September 2023				
Medical Expiry Date	17 August 2023 (Class 1)				
Restrictions	VDL – Valid only with correction for defective distance vision				
*CRM Training	4 September 2022				

*CRM stands for Cockpit Resource Management

Flying Experience:

Total Hours	20 000.0
Total Past 90 Days	190.0
Total on Type Past 90 Days	190.0
Total on Type	4 300.0

1.5.2 Senior First Officer (SFO) [Pilot Flying]

Nationality	British	Gender	Male	Age	41
Licence Type	Airline Transport Pilot Licence (ATPL)				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument				
Revalidation of Rating Airbus A380/1R	8 September 2022, valid until 8 September 2023				
Medical Expiry Date	17 December 2023				
Restrictions	None				
CRM Training	18 January 2022				

Flying Experience:

Total Hours	8 517.5
Total Past 90 Days	162.6
Total on Type Past 90 Days	162.6
Total on Type	740.3

1.5.3 Relief Pilot (SFO)

Nationality	British	Gender	Male	Age	41
Licence Type	Airline Transport Pilot Licence (ATPL)				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument				
Revalidation of Rating Airbus A380/1R	8 September 2022, valid until 30 September 2023				
Medical Expiry Date	17 December 2023 (Class 1)				
Restrictions	VDL – Valid only with correction for defective distance vision				
CRM Training	29 January 2023				

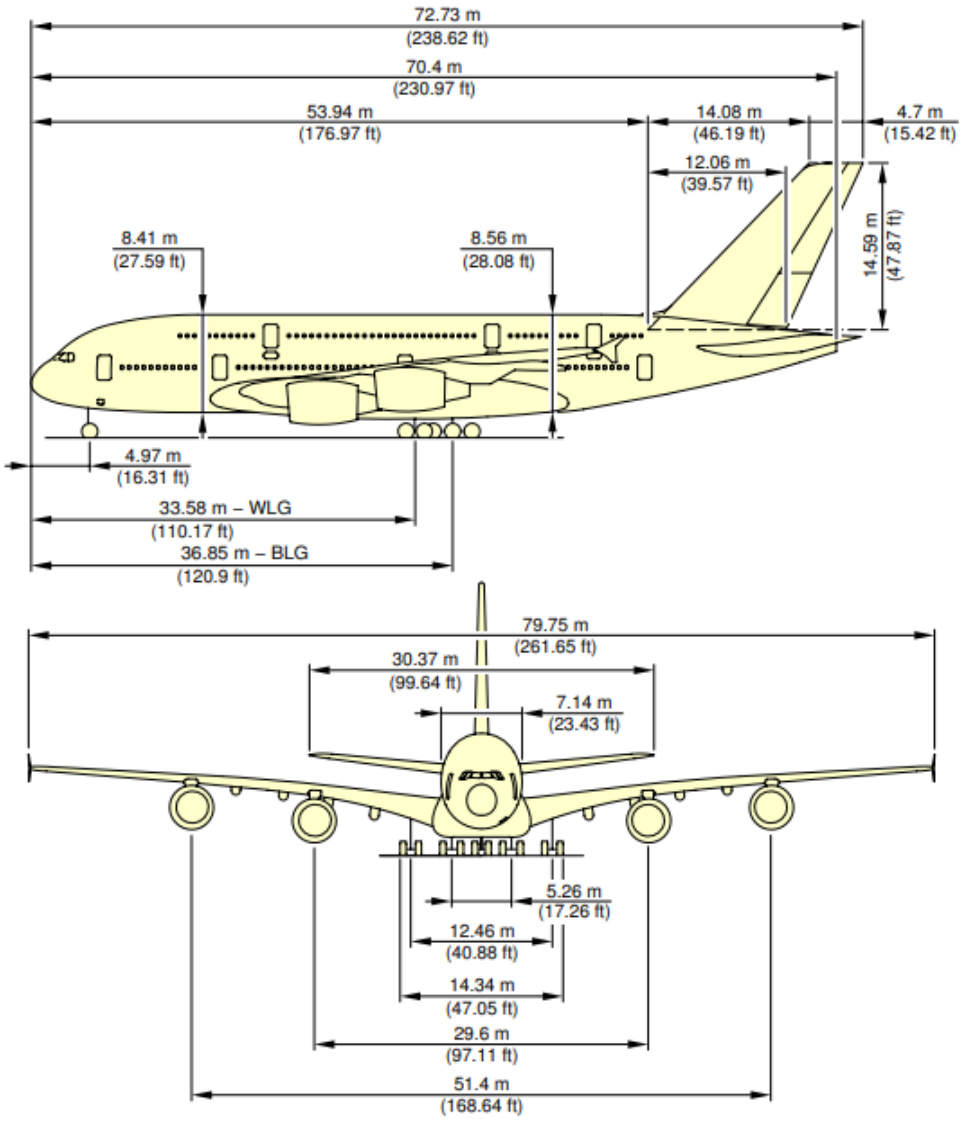
Flying Experience:

Total Hours	5 000.0
Total Past 90 Days	37.0
Total on Type Past 90 Days	37.0
Total on Type	290.0

1.6 Aircraft Information

1.6.1 Aircraft Description (Source: Airbus)

The Airbus A380 is a very long range (VLR) subsonic, civil transport aircraft. The design combines the in-service experience gained from the A330 and A340 aircraft operated all around the world with new technology developed specifically for the A380 program. The general arrangement is a four-engine configuration with a rearward swept low wing and a conventional tail.



General Aircraft Dimensions
(Sheet 1 of 2)
FIGURE-2-2-0-991-001-A01

Airframe:

Manufacturer/Model	Airbus 380-841	
Serial Number	163	
Year of Manufacture	2014	
Total Airframe Hours (at time of serious incident)	29 040.0	
Last Inspection (hours & date)	28 544.0	23 May 2023
Airframe Hours Since Last Inspection	496.0	
C of A (issue date)	16 October 2014	
Airworthiness Review Certificate (issue date)	25 July 2022	
Airworthiness Review Certificate (expiry date)	6 August 2023	
Maximum Take-off Weight (MTOW)	560 000kg	
Type of Fuel Used	Jet A1	
Operating Category	Air Transport Operations (Part 121)	

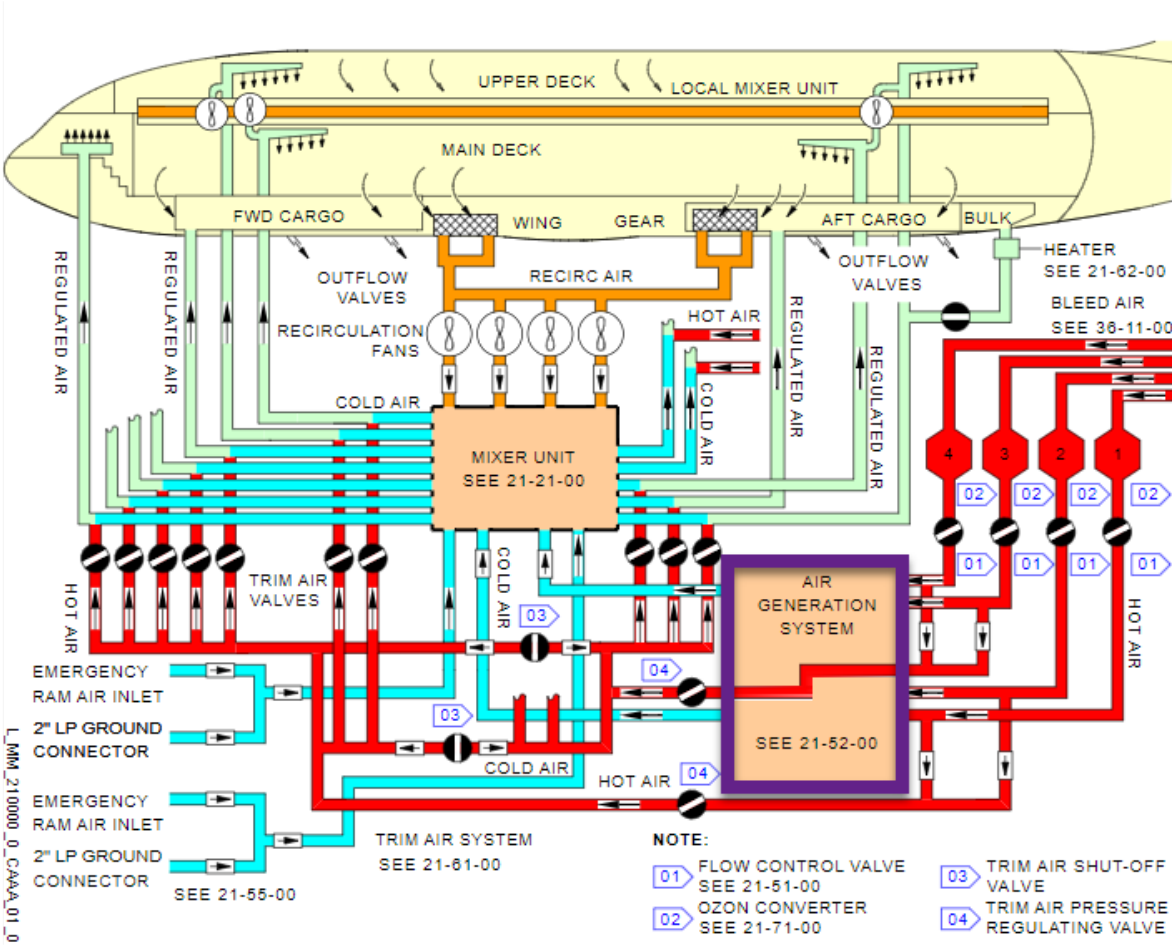
Engines:

Manufacturer and Model	Rolls Royce Trent 9708B-84			
Position	No. 1	No. 2	No. 3	No. 4
Serial number	91360	91478	91322	91328

1.6.2 Airbus A380 Airconditioning System Layout
(Source: Airbus)

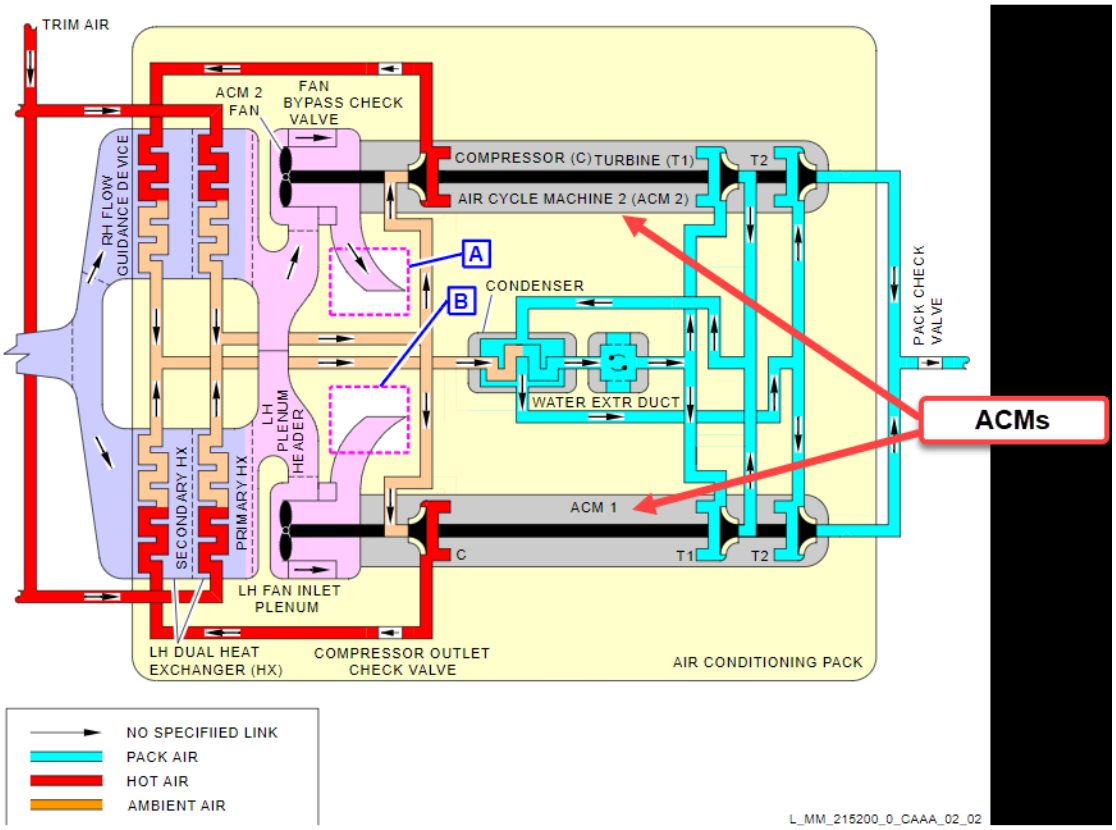
System Description – Air Generating System (AGS)

Within the A380 air conditioning system, the Air Generation System (AGS) provides conditioned air to the pressurised fuselage for ventilation, temperature control, and pressurisation. This includes both the cockpit and cabin.



Schematic 1: Airbus A380 air-conditioning system layout.

The AGS indicated in purple consists of two Air Generation Units (AGU). These units are supplied by the aircraft bleed air system, which is then cooled in each AGU in the primary section of a dual heat exchanger using ram air as a heat sink.



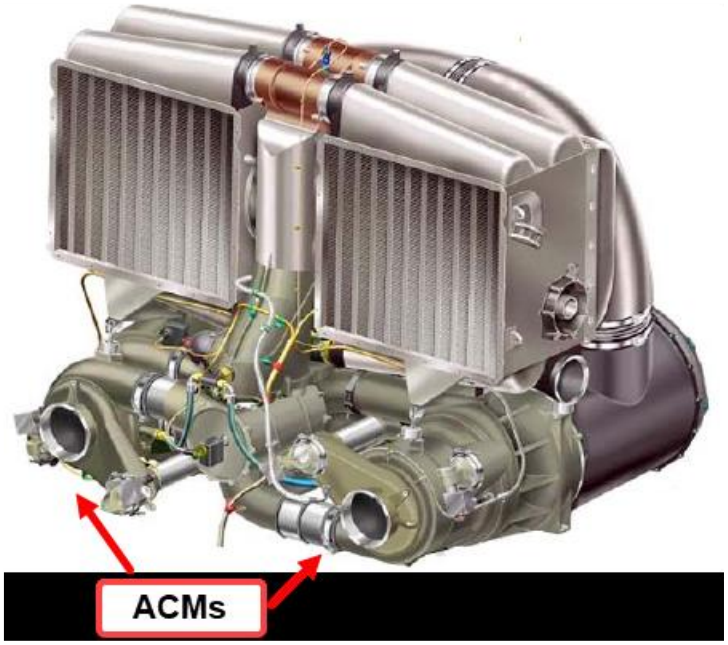
Schematic 2: Air generation unit (AGU) layout.

The bleed air is then compressed by the compressor portions of two dual-turbine Air Cycle Machines (ACMs), and subsequently, ducted to the secondary portion of the dual heat exchanger. This cooled air is then fed to the mixer unit, where it is mixed with recycled cabin air. The air is then regulated to the set temperature using hot bleed air before it is ducted to the cockpit and cabin. The rotor spins at around 20,000 revolutions per minute (RPM) under normal operating conditions and contact between the rotor and the housing will generate heat, smoke, and fumes. Any smoke or fumes generated are then passed to the cockpit and cabin through the air conditioning system.

The housing of the ACM consists of these parts:

- *A fan housing*
- *An integral compressor*
- *A first-stage turbine housing*
- *A second-stage turbine housing*

The ACM has two turbine wheels, a compressor wheel and a fan rotor. All four wheels are installed on the same shaft. The rotation of the two turbine wheels drives the compressor wheel and the fan rotor.



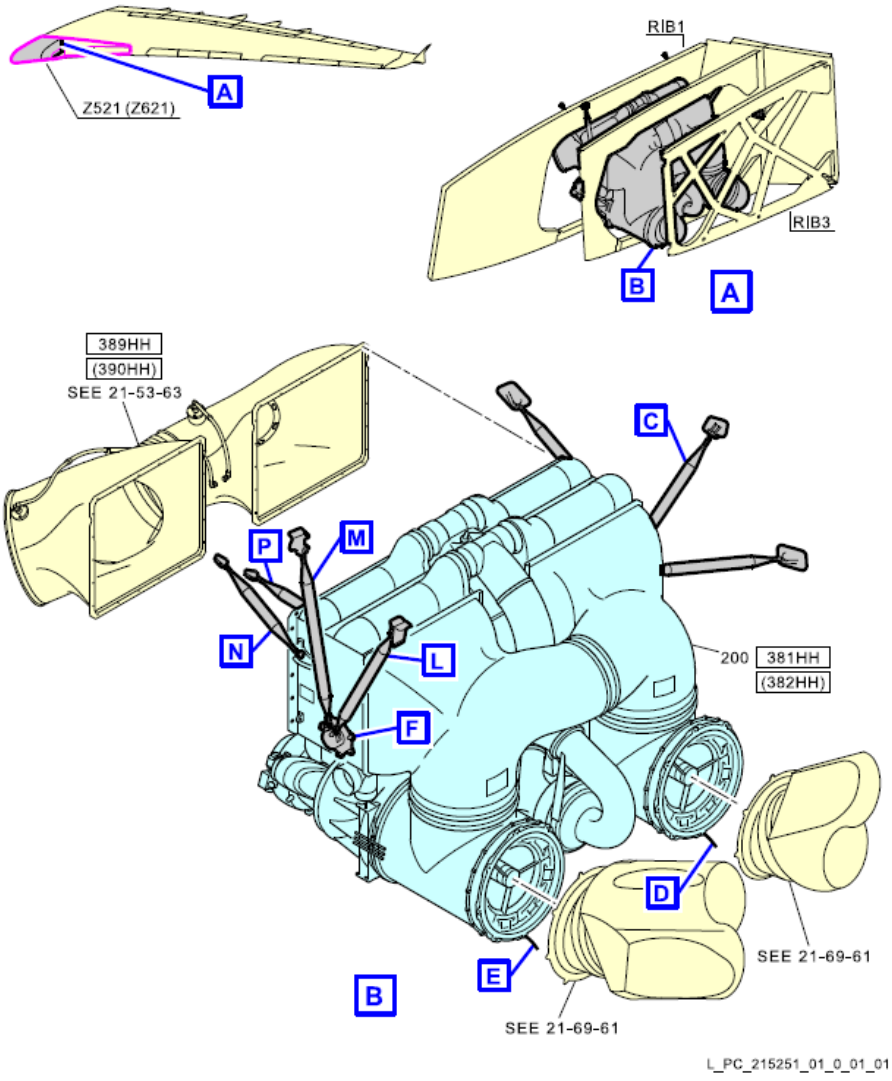


Figure 2: The illustration shows the AGU (light blue) with two ACMs coupled and lined abreast. AGU 1 is fitted to the left side of the aircraft where the fuselage and wing structure meet.

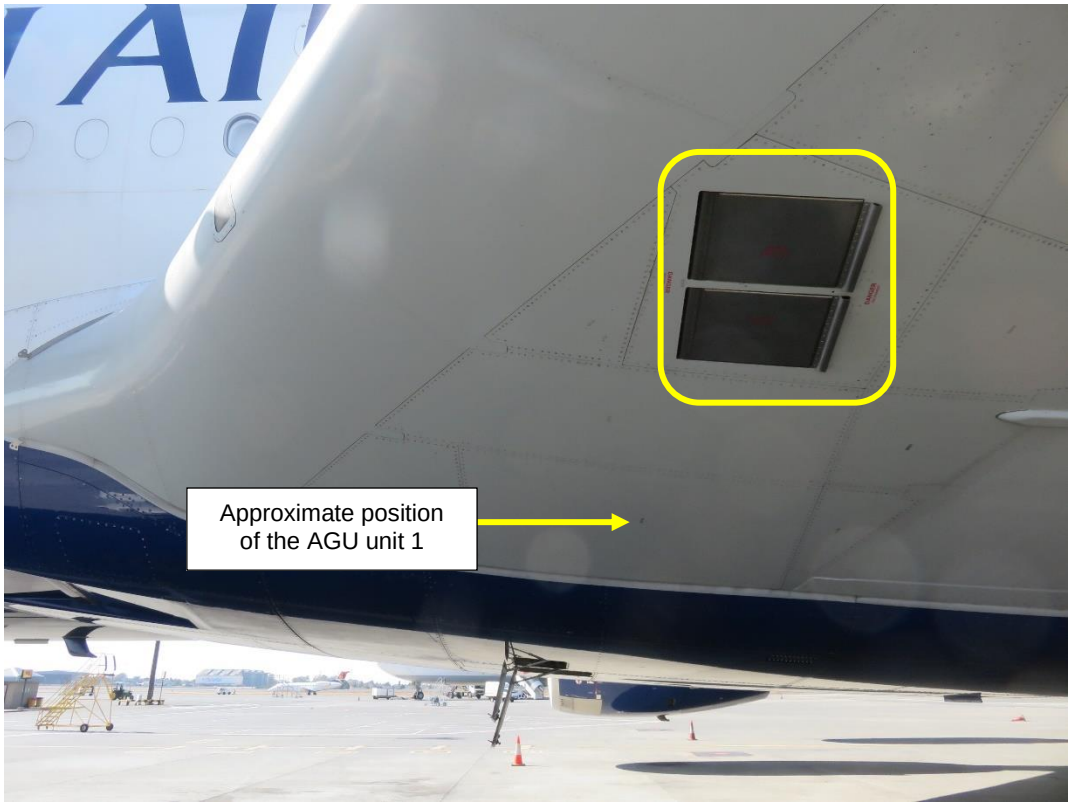


Figure 3: The yellow window indicates the ram air (hot air) doors for AGU 1 (left side). The yellow arrow points to the approximate position of the AGU.

1.6.3 The Air Cycle Machine (ACM)
(Source: Component Maintenance Manual [CMM 21-52-21] EC380 Air Cycle Machine Part Number 1380209-2/-3/-4)

The ACM comprises a fan and compressor housing, turbine housing and bypass housing. The rotating system operates on air bearings in tandem with an air-cooling system. The ACM has no oil system or on-wing servicing requirements relating to any liquid lubrication systems. The CMM has no recommended routine for ACM maintenance checks (ref CMM p/b 5001 – CHECK). All workshop maintenance is based on incoming fault/defect reports from in-service operations only.

Consequently, the A380 ACMs (BA Part Number 1380209-4) are aircraft monitored for continuous satisfactory operation 'on-condition' the units remain fault and/or defect-free. On-wing maintenance is only required when a fault message or defect condition occurs. This will cause the operator to investigate using the Airbus Trouble Shooting Manual (TSM) that would ultimately recommend ACM replacement, or in the case of the investigation event where the unit has suffered total failure due to the rotating system seizing and thus requires ACM replacement.

According to available information, no maintenance was required on the ACM unit that failed in-flight.

1.6.4 Air Cycle Machine (ACM) Lubrication System

Both the thrust and journal bearings in the Air Cycle Machine (ACM) are foil-type hydrodynamic bearings that self-generate an air film as a result of shaft rotation. The shaft essentially floats on a cushion of pressurised air when the ACM is operating. There is no alternative lubrication used for the bearings. The air film forms between the smooth shaft surfaces and the smooth static bearing surfaces which are coated with a lubricious material to minimise start-up friction. When the ACM shaft starts spinning, air is drawn into the space between the shaft and the bearings where a thin film of high pressure is developed. As the rate of rotation of the ACM shaft increases, the air film pressure and stiffness increase to provide the required load bearing capability to withstand the radial and axial shaft loads. As air passes through the bearing foils, it also provides cooling for the bearings.

1.7 Meteorological Information

1.7.1 The meteorological aerodrome report (METAR) that was issued by the South African Weather Service (SAWS) on 12 July 2023 at 1800Z for FAOR contained the following weather information:

FAOR 121800Z 03006KT 360V080 9999 BKN049 11/03 Q1035 NOSIG=

Wind direction	: 030° (north-easterly)
Wind speed	: 06 KT
Visibility	: 10km or more
Clouds	: No significant cloud
Weather	: No weather of significance to aviation
Temperature	: 11°C
Dew point temperature	: 3°C
Pressure reduced to mean sea level	: 1035hPa

1.8 Aids to Navigation

1.8.1 The aircraft was equipped with standard navigational equipment as per the requirements of the Regulator (United Kingdom Civil Aviation Authority [UKCAA]). No defects were reported with the navigational equipment at the time of the serious incident.

1.9 Communication

1.9.1 The aircraft was equipped with standard communication equipment as per the Regulator (UKCAA).

1.9.2 The crew was in constant communication with ATC at FAOR during the flight; this included radar, tower and ground control personnel.

1.9.3 There was no communication breakdown between ATC and the crew that could have increased the crew's workload.

1.9.4 At 18:04:30Z, the crew (flying under the callsign Speed Bird 56) declared a *Mayday* with the crew requesting an immediate return to FAOR, whereupon ATC instructed the PIC to turn left on a heading of 190°. A transcript of the communication between the crew, ATC and ground control is attached to this report as Appendix A.

1.9.5 The crew advised ATC that they required the longest available runway in line with their standard operating procedures (SOPs) laid out by the operator. ATC agreed to the request but allowed a Boeing 747 to depart off Runway 03L when G-XLEH was 17nm from the threshold of the runway. This meant that no Instrument Landing System (ILS) (JBI 110.9) was radiating towards the crew and no ident was received by the aircraft systems. Ident was finally received when the aircraft was 1.5nm offset from the inbound localiser. This resulted in an increased workload for the crew at a critical time of the approach phase. *It should be noted that the ILS can only radiate for one runway at a time*. With Runway 03L being the active departing runway, the ILS was set for that runway. The ILS was switched over to Runway 21R too late, which implied that the crew had to fly the visual approach with only the precision approach path indicators (PAPI's) for glide path monitoring; they had no assistance from the ILS glideslope or localiser.

1.9.6 The ATC service provider indicated that: *"There is no specific procedure that limits/stipulates how the emergency should be handled and I would not expect that to be in place as every situation is unique and should be treated as such."*

1.10 Aerodrome Information

1.10.1 The aircraft took off from FAOR on Runway 03L and returned to the same aerodrome after the crew declared an emergency; the aircraft landed on Runway 21R.

Aerodrome ICAO Designation	O.R. Tambo International Aerodrome (FAOR)	
Aerodrome Status	Gauteng Province, South Africa	
Aerodrome Status	Licensed	
Aerodrome GPS co-ordinates	26°08'01.30" South 028°14'32.38" East	
Aerodrome Elevation	5 558 feet	
Runway Headings	03L/21R	03R/21L
Dimensions of Runways	4 436 x 60m	3 410 x 60m

Heading of Runway Used	21R
Surface of Runway Used	Asphalt
Approach Facilities	DVOR/DME, ILS LOC, ILS GP, Runway lights, PAPI's
Radio Frequencies	ATIS: 126.20, 115.20 Apron: 122.65 Tower East: 118.60 Tower West: 118.10 Approach South: 124.50 Approach East: 124.50 Approach West: 123.70 Surface Movement Control (Ground): 121.90

1.10.2 The aerodrome layout chart for FAOR is attached as Appendix A.

1.11 Flight Recorders

1.11.1 The aircraft was equipped with a flight data recorder (FDR) and a cockpit voice recorder (CVR) as required by the Regulator (UKCAA).

1.11.2 The FDR is a L3 Harris FA2100 FDR, P/N 2100-4045-00, S/N 000849133. This is a Solid-State recorder with 25 hours of data. The FDR was successfully downloaded in France with the assistance of the AAIB (UK) and the BEA (France).

1.11.3 The CVR is a L3 Harris FA2100 CVR, P/N 2100-1026-02, S/N 000848683. This is a Solid-State recorder. The CVR had a recording time of 2 hours 4 minutes and 10 seconds.

1.11.4 The CVR was downloaded successfully. The recorder had four channels of audio; all channels were audible. The CVR circuit breaker was deactivated on time after the aircraft landed, and the serious incident flight recording was preserved. The IIC had listened to the audio (in France) with the assistance of the AAIB (UK) and the BEA (France).

1.12 Wreckage and Impact Information

1.12.1 The aircraft performed an air turn back and landed safely at FAOR Runway 21R. After landing, the aircraft was brought to a stop on the runway where all four engines were shut down. The aircraft was inspected by ARFF personnel. No external damage was reported, and the aircraft was towed back to the apron.

1.13 Medical and Pathological Information

1.13.1 Not applicable.

1.14 Fire

1.14.1 The flight crew reported an acrid smell in the cockpit. According to the Airbus Abnormal and Emergency Procedure for Fire, the suspected cause for an acrid smell could be attributed to: (i) electrical equipment, (ii) engine oil leak, (iii) galley equipment, and (iv) bird ingestion.

1.15 Survival Aspects

1.15.1 No person was injured during the serious incident.

1.16 Tests and Research

1.16.1 The damaged Air Cycle Machine (ACM) is one of two ACM units in the Air Generation Unit (AGU). There are two AGUs in the aircraft, therefore, there is a total of four ACMs per aircraft. ACM unit 2, which was installed in AGU 1, located on the left side of the aircraft (viewed from the aft) failed; it was removed from the aircraft by an approved aircraft maintenance organisation (AMO) in the United Kingdom. The unit was sent to the original equipment manufacturer (OEM) in Windsor Locks, Connecticut, in the United States of America for examination. The AIID requested oversight during the examination from the National Transportation Safety Board (NTSB) which, in turn, requested the regional Federal Aviation Administration (FAA) office to provide oversight supervision. The examination was performed on Tuesday, 14 November 2023. A brief description of the air-conditioning system on the aircraft is presented in paragraph 1.6.2 of this report.

ACM Information

Part Number	1380209-4
Serial Number	2014020010
Removal Date	1 August 2023
Time Since New/Installed	29 243 Flight Hours
Cycles since new/Installed	2 956 Flight Cycles
Time Between Overhaul	On-condition Item

ACM Condition Evaluation Summary
(Source: Extract from the official report received from Collins Aerospace)

The condition of the hardware showed a primary failure mode of turbine end journal bearing overload. The thrust bearings and the fan end journal bearing were damaged as a result of the shaft motion that occurred and are considered to be associated with damage. The condition of the ACM parts is shown in the following figures. These images were taken during the disassembly of the unit.

The degree of damage incurred at the turbine end journal bearing location was proportionately more severe than at any of the other bearing locations. The turbine journal bearing failure resulted in material degradation of the shaft journal surface to the point where a hole formed at the contact point, refer to Figure 12. This area was sufficiently deformed that it interfered with the inner geometry of the turbine journal bearing sleeve to the point where removal of the shaft was not possible in a normal manner.

The fan journal bearing was damaged to the point where the foils moved out of normal position and were rubbing on the back of the fan rotor. The fan end shaft showed a local area of contact with the bearing foils, refer Figure 8.

The thrust bearings were heavily damaged and the thrust disc on the turbine end shaft had a generally scored surface and local contact discolouration, refer to Figure 11.

The fan rotor had a light rub with the fan shroud which was uniform on the shroud and local on the rotor, refer to Figure 9.

The compressor rotor had a moderate, predominately radial, rub which was uniform on the shroud and local on the rotor, refer to Figure 8.

The Turbine 1 (T1) and Turbine 2 (T2) rotors were both heavily rubbed with their respective shrouds in both the axial and radial directions. The rub patterns on the shrouds were predominately uniform and had a material transfer from the rotors. The rub patterns on both the T1 and T2 rotors were locally heavy, refer to Figures 9 and 10.

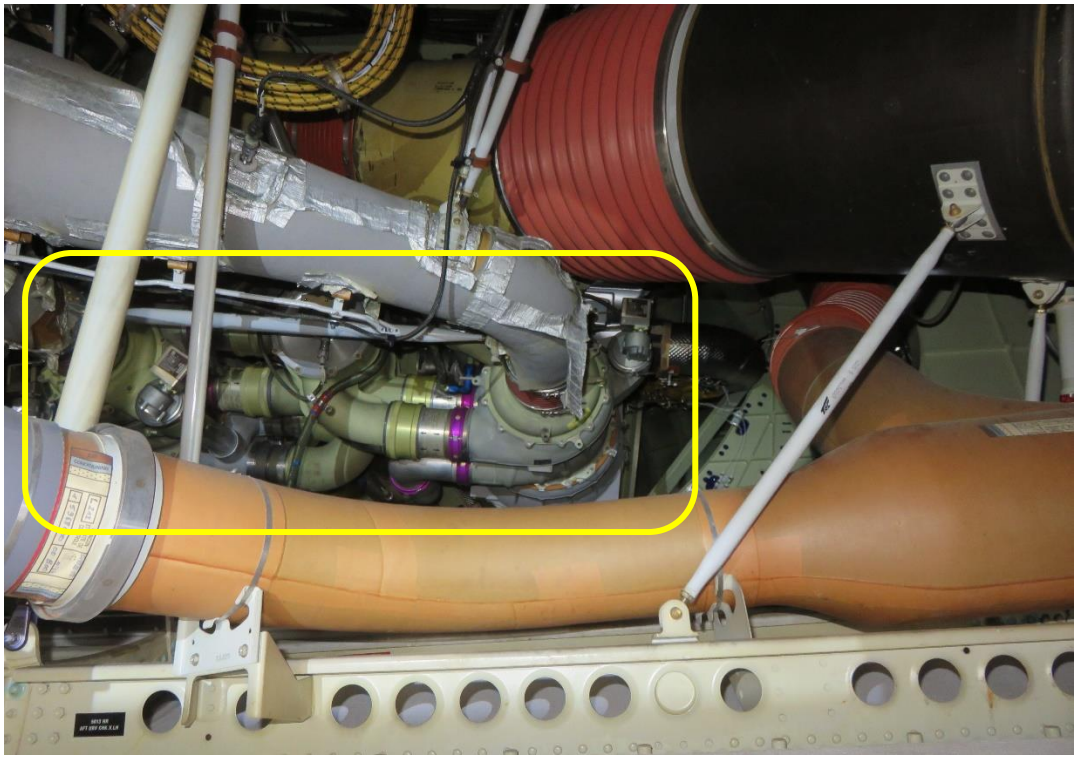


Figure 4: AGU 1 which consists of two ACMs before their removal from the aircraft.

Figure 5: A close-up view of the ACM before removal from the aircraft.

Figure 6: The ACM unit before disassembly.

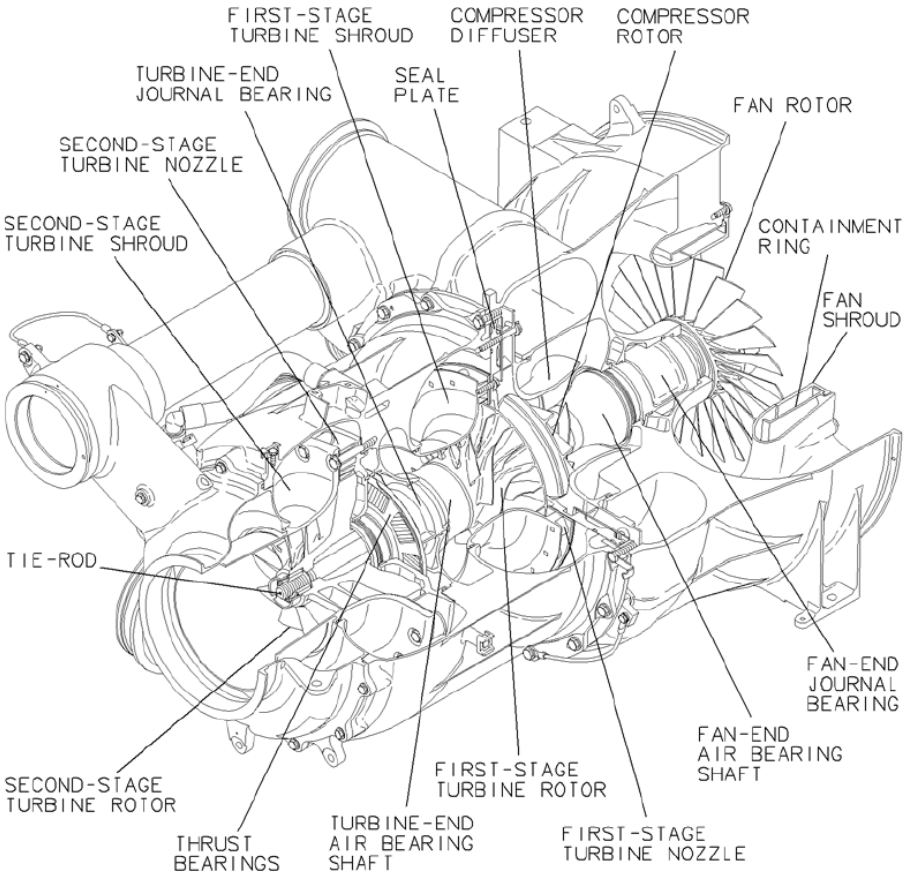


Figure 7: The ACM component identification.

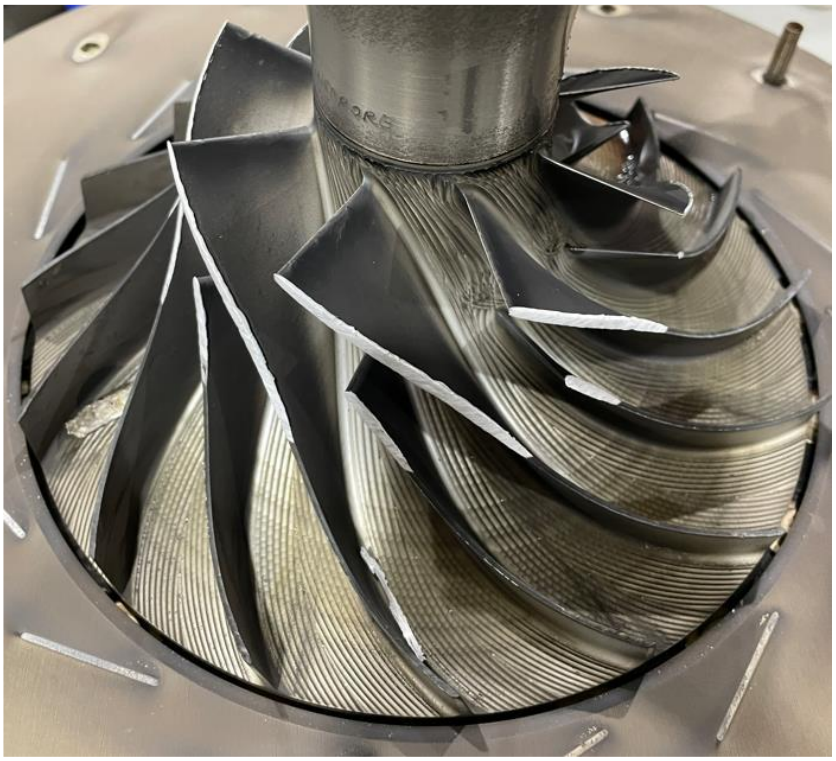


Figure 8: Compressor rotor with damage on the blades.

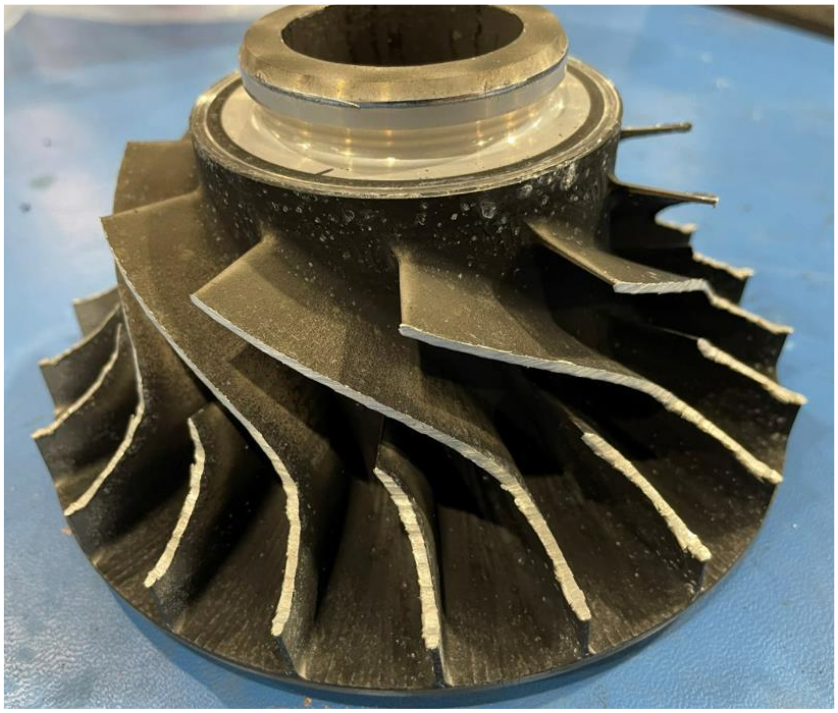


Figure 9: First-stage turbine rotor with damaged blades.

Figure 10: The second stage turbine rotor with radial damage.

Figure 11: Second stage turbine rotor with damaged blades.

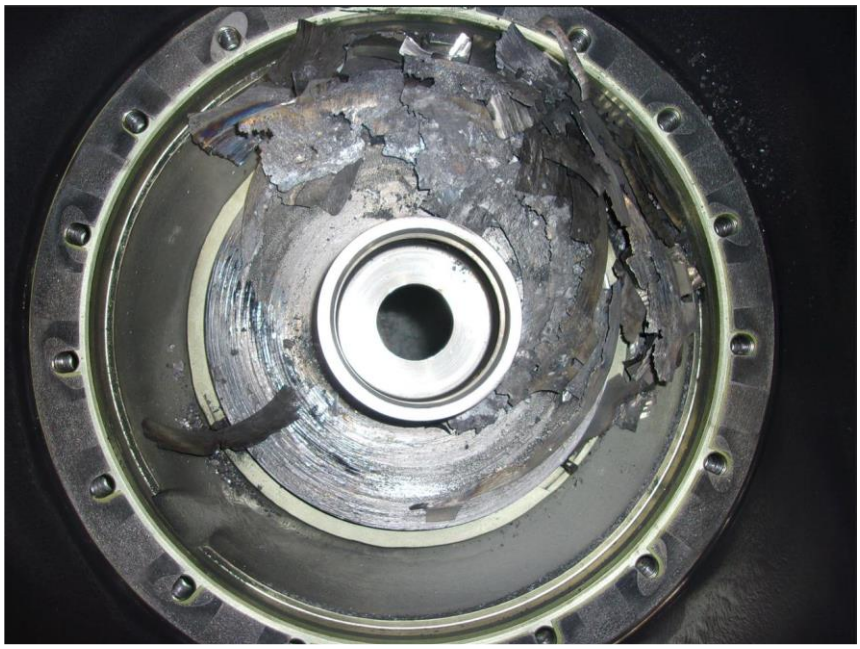


Figure 12: The turbine side thrust bearing was severely damaged during failure. The compressor side thrust bearing was similarly damaged, but as the turbine end shaft could not be removed, an image of that thrust bearing is not available.

Figure 13: The inside of the turbine end shaft with a hole that had developed at the point of failure of the turbine end journal bearing. The hole had formed at the tip of the bulge due to the heat generated by contact between the rotating shaft and the stationary parts.

1.17 Organisational and Management Information

1.17.1 This was a commercial passenger air transport flight that was conducted under the provisions of Part 121.

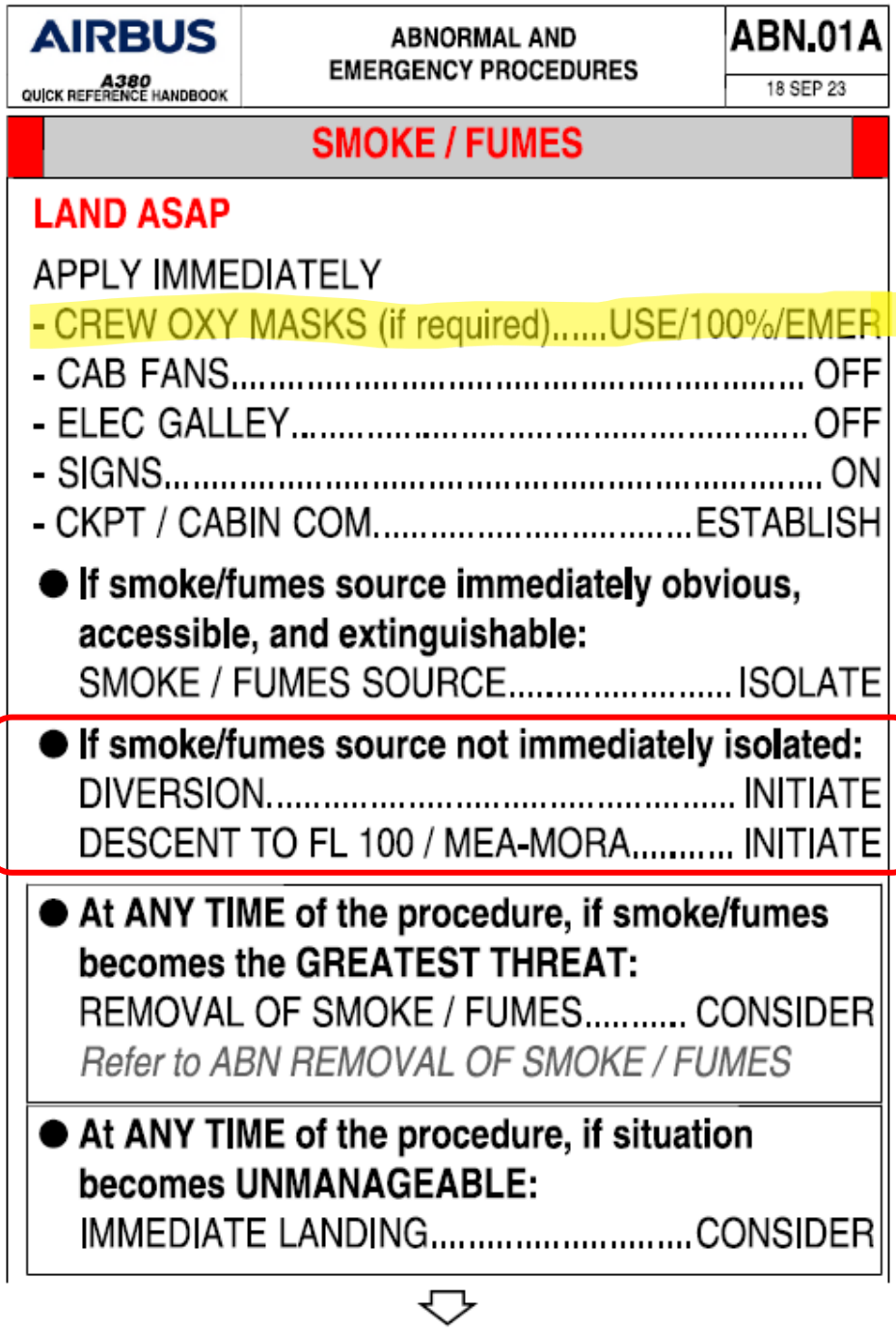
1.17.2 The airline had a valid Air Operating Certificate (AOC) that was issued by the Regulator (UKCAA) on 9 November 2022.

1.17.3 The last maintenance inspection that was conducted on the aircraft (Minor check 4A) before the serious incident flight was certified on 23 May 2023 at 28 544.0 airframe hours by the approved aircraft maintenance organisation (AMO). The aircraft accrued 496.0 hours since the last inspection.

1.18 Additional Information

1.18.1 Quick Reference Handbook (QRH)
(Source: Airbus)

Abnormal and Emergency Procedures, Smoke / Fumes, Pages. 1 and 2 of 8



AIRBUS
A380
QUICK REFERENCE HANDBOOK

ABNORMAL AND
EMERGENCY PROCEDURES

ABN.01A
18 SEP 23

SMOKE / FUMES

LAND ASAP

APPLY IMMEDIATELY

- CREW OXY MASKS (if required).....USE/100%/EMER
- CAB FANS..... OFF
- ELEC GALLEY..... OFF
- SIGNS..... ON
- CKPT / CABIN COM.....ESTABLISH

● **If smoke/fumes source immediately obvious, accessible, and extinguishable:**
SMOKE / FUMES SOURCE.....ISOLATE

● **If smoke/fumes source not immediately isolated:**
DIVERSION..... INITIATE
DESCENT TO FL 100 / MEA-MORA..... INITIATE

● **At ANY TIME of the procedure, if smoke/fumes becomes the GREATEST THREAT:**
REMOVAL OF SMOKE / FUMES..... CONSIDER
Refer to ABN REMOVAL OF SMOKE / FUMES

● **At ANY TIME of the procedure, if situation becomes UNMANAGEABLE:**
IMMEDIATE LANDING.....CONSIDER

***QRH:** Page 1.*

SMOKE / FUMES (Cont'd)

MENU ISOLATION OF SMOKE / FUMES SOURCE	
Smoke/fumes suspected from AIR COND or CABIN	To isolate AIR COND: *Refer to 03 - AIR COND / CABIN EQPT ISOL*
	To isolate CABIN EQPT: *Refer to 03 - AIR COND / CABIN EQPT ISOL*
Smoke detected from AVNCS with ECAM alert	SMOKE R MAIN AVNCS SMOKE: *Refer to 04 - ELEC ISOL SIDE R THEN SIDE L*
	SMOKE L MAIN or L UPPER AVNCS SMOKE: *Refer to 05 - ELEC ISOL SIDE L THEN SIDE R*
	Any other AVNCS SMOKE ECAM alert: *No QRH action, apply ECAM*
Source of smoke/fumes not determined	To isolate ELEC SIDE R then SIDE L: *Refer to 04 - ELEC ISOL SIDE R THEN SIDE L*

QRH: *Page 2.*

1.18.2 Airbus A380 Flight Crew Techniques Manual
Abnormal and Emergency Procedures – Fire, page 4 (See Appendix B)

- The crew may also perceive fumes with odors: to help the identification of the possible source and to enhance the communication coordination with the cabin crew, the table below gathers some of the fumes with odors that may occur on board, with the suspected causes.

Description of Odors	Suspected Cause (Most Reported Listed First)
Acrid	Electrical Equipment / IFE Engine Oil Leak
Burning	Electrical Equipment Galley Equipment Bird Ingestion
Chemical	Contaminated Bleed Ducts APU Ingestion
Chlorine	PBE Blocked Door Area Drain
Electrical	Electrical Equipment
Dirty Socks	APU or Engine Oil Leaks
Foul	Lavatories
Fuel	APU FCU/Fuel Line
Oil	Engine or APU Oil Leak
Skydrol	Engine Hydraulic
Sulphur	Wiring Avionics Filter Water Contamination Light Bulb

1.18.3 Electronic Centralised Aircraft Monitor (ECAM)

The report references ECAM several times. See Figure 14 for illustration purposes; the ECAM is captured in the yellow window. The cockpit photograph was taken from the G-XLEH aircraft after the serious incident.

Figure 14: ECAM displayed in the yellow window in the cockpit of the Airbus A380, G-XLEH.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 General

From the available evidence, the following analysis was made regarding this serious incident. This shall not be read as apportioning blame or liability to any organisation or individual.

2.2 Analysis

2.2.1 Crew

The crew was appropriately rated and qualified to perform the flight. The first officer (FO) was the pilot flying (PF), and the PIC was the pilot monitoring. After the crew experienced the acrid smell in the cockpit, the PIC declared an in-flight emergency *(Mayday)* and made a request to the ATC to return to the departure aerodrome (FAOR). This action was taken promptly by the crew with the time lapsed from detecting the acrid smell to declaring an emergency being 2 minutes and 41 seconds. It was determined from the CVR voice communication that the crew attempted to identify the origin of the acrid smell. The SCC reported hearing a loud 'mechanical grinding' sound coming from the floor level of the main deck. The crew initially thought this could be from the No. 2 engine, which had experienced an oil leak on a recent previous sector. However, it is now known that the noise was likely coming from the ACM unit that had failed; the ACM is located in the belly of the aircraft on the left side when viewed from the aft in the area of seats 11 A and B in business class on the main deck. The PIC requested the relief pilot to check if he could see anything. With the time of flight being at night, the relief pilot could not see any anomaly. In this case, there were no visually detectable symptoms (i.e., sparks/flames that emanated from the engine). By the time the relief pilot went into the cabin, the grinding noise had stopped. At this point the crew had performed the AIR COND / CABIN EQPT ISOL aspects of the QRH SMOKE/FUMES procedure, resulting in Pack 1 being turned off. This would have removed the source of the acrid smell/fumes and the reported grinding noise.

When the initial actions of the QRH SMOKE/FUMES procedure were conducted, the relief pilot asked the PIC if the crew was to don oxygen masks. The PIC remarked: *"I think we are okay, please keep an eye on us".* None of the pilots donned their oxygen masks at this point. The PIC subsequently stated to the investigation: *"At no point did I feel any ill effects, so I decided the risk of not going onto oxygen (O2) was worth the extra SA [situational awareness]. We briefed the relief FO to make us get on oxygen if he thought we needed to."*

The relief pilot stated that he later donned his oxygen mask when the aircraft was on final approach following a suggestion from the cabin that the smell was returning. He removed his mask shortly after landing when it became apparent that the smell/fumes had not returned.

While the PIC and PF did not deem it necessary to don their masks when the smell was first detected, they could have donned their oxygen masks at any time during the descent and return to FAOR if the situation in the cockpit had deteriorated. The operator's training emphasises that the initial actions on the QRH procedure are reversible (i.e. crew can don masks at any time, even if they did not immediately do so; or they can remove masks, if they had them on.)

No smoke or fire ECAM warning was triggered in the cockpit by any of the systems during the flight. The PIC executed the required checklist procedure after referencing the QRH (hardcopy) when there was acrid smell in the cockpit. The very first item on the QRH for Smoke/Fumes states *"APPLY OXYGEN MASKS (if required) – USE 100% EMER (see QRH procedure on page 22)",* which leaves this item to the discretion of the crew, depending on the conditions in the cockpit at the time. It is generally accepted that the use of flight crew oxygen masks can make communication in and from the cockpit difficult. This may have influenced the primary crew's decision not to don their respective oxygen masks. When the acrid smell was detected in the cockpit, the PF stated that it was a *"strong smell"* but did not elaborate further. Smoke was mentioned by the crew in their communication with ATC. From the CVR recording, the amount of smoke/haze in the cockpit and cabin areas was not discussed at any stage during the flight, however, subsequent crew reports described only fumes/an acrid burning smell in the cockpit, but no smoke. There was no photographic or video evidence of the condition, or any requirement for such evidence to be captured by the operator. The relative absence of smoke in the cockpit may have influenced the decision by the primary crew not to don their oxygen masks.

In the Airbus A380 Flight Crew Techniques Manual *(Appendix B, page 4)* under the heading *Abnormal and Emergency Procedures for Fire*, eleven (11) different odours and the suspected causes of each are described. This list acts as guidance to help the crew identify the origin of the odours they might encounter in-flight. An acrid smell is first on the list with the suspected causes being listed as: (i) electrical equipment or (ii) an engine oil leak. The smell from the ACM was caused by different components in the unit that rubbed against the casing whilst it was rotating at a speed of approximately 20 000 revolutions per minute (RPM) as presented under sub-heading 1.16.1. It was noted that there is no reference to the ACM units or the failure thereof (of which there are four on the aircraft) in this document, and it was not included under the heading *Suspected Causes* as a likely cause.

As the aircraft was not at cruise altitude when the acrid smell entered the cockpit/cabin, this might probably have been the reason why the primary crew did not opt to don their oxygen masks. Approximately 2 minutes and 20 seconds after the FO first mentioned the acrid smell,

the PIC declared a Mayday and requested to return to FAOR from ATC as well as descend to FL100 (ATC cleared the aircraft to descend to FL105), which was one of the QRH requirements on page 1 of the Smoke/Fumes checklist if smoke/fumes source was not immediately isolated.

At 1 000 ft above ground level (AGL), the PIC took control of the aircraft and performed a normal landing. Once the aircraft was brought to a stop on the runway, the engines were shut down as discussed during the pre-landing briefing. The aircraft was inspected by ARFF personnel before it was towed from the runway to the apron where a normal deplaning procedure was followed; there was no need for an emergency evacuation after landing.

2.2.2 Aircraft

The aircraft was maintained according to the approved maintenance schedule. The ACM unit that failed was installed on the aircraft during manufacture and had not been removed since. The ACMs are on-condition items and are overhauled when needed. A total of four ACMs were installed in the aircraft, two on each AGU. The failure of the ACM is a rare occurrence as it is not listed in the Airbus A380 Flight Crew Techniques Manual *(Appendix B, page 4)* under the heading *Abnormal and Emergency Procedures for Fire, Suspected Cause*. The ACM unit that had failed was not subjected to any maintenance intervention according to the information the AMO supplied to the investigating team.

2.2.3 Air Traffic Control

The crew was in constant communication with the ATC officer at FAOR who accommodated the crew's request for an immediate descent to FL100 (FL105 was granted). The crew first requested Runway 03L for landing but after ATC had mentioned that Runway 21 was also available, the crew changed their request to Runway 21R, which was the shortest possible route back to the aerodrome and which was in line with their SOPs.

At 18:06:26 the crew requested Runway 03L for landing, which was granted by ATC.
At 18:10:50 ATC informed the crew that Runway 21 was available.
At 18:12:32 the crew requested Runway 21R for landing, which was granted by ATC. At this stage, the aircraft was 80nm from FAOR. The crew continued with approach for Runway 21R.
At 18:34:39 the aircraft landed on Runway 21R.

The ARFF personnel were notified in advance by ATC whilst they awaited the return of the aircraft. After the aircraft landed and the engines and radar were switched off, the ARFF commander communicated with the crew of the SCM on frequency 121.90MHz to advise them that they would inspect the aircraft for damage, of which none was found.

2.2.4 Aerodrome

The FAOR is a licensed aerodrome with two parallel runways. The aircraft used Runway 03L for take-off, which is 4 436 metres (m) long and 60m wide. On their return to the aerodrome, the aircraft landed on the reciprocal Runway 21R, which was the shortest route back to the aerodrome.

The aerodrome could accommodate the Airbus A380 type aircraft. The required ARFF services were activated by the ATC, and they took up their respective positions next to Runway 21R. Once the aircraft had landed, and the engines and radar were shut down, the ARFF co-ordinator was in radio communication with the PIC and assured him that the aircraft was inspected and there was no structural damage or any other damage (i.e., engines) visible from the ground. The aircraft was then pulled by tug from the runway to the apron where the passengers deplaned the aircraft.

2.2.5 Environment

There were no environmental conditions that might have contributed to this serious incident. Fine weather conditions prevailed at the time of the flight with the wind reported as light and variable at FAOR during the return leg of the flight. The favourable weather conditions allowed the crew the opportunity to perform a straight-in approach for Runway 21R, which was the shortest possible route back to FAOR.

2.2.6 Conclusion

The sequence of events is per the data obtained from the CVR and FDR.

- *17:45:44: Aircraft takes-off from Runway 03L at FAOR.*
- *18:01:49: The PF asks the PIC; do you smell that?*
- *18:04:30: The PIC transmits a Mayday, requesting ATC to return to their departure aerodrome and descent to 10 000 ft (FL100). No smoke or fire warning was triggered automatically on the ECAM. The PIC referred to the QRH for SMOKE / FUMES. The aircraft was cleared to FL105.*
- *18:04:45: The aircraft changes heading from 357° to 192°.*
- *18:05:52: The PIC informs the passengers that they are returning to FAOR.*
- *18:06:45: Relief pilot asks the PIC if they are going to protect themselves by making use of their respective oxygen masks. The primary flight crew opts not to use their oxygen masks.*
- *18:07:31: PIC asks the relief pilot to go to the back of the aircraft and see if he could see what was causing the grinding noise that was reported to be from near the number 2 engine by the cabin crew.* It is not clear as to what the relief pilot had to look for as it was

dark at the time. There is no voice communication (CVR data) available where the relief pilot provides feedback to the PIC as to what he had observed.

- *18:08:02: Fuel jettison is activated.*
- *18:09:22: Air-conditioning Pack 1 is switched off by the PIC after the crew has followed the QRH procedure.*
- *18:25:53: PIC mentions that smoke was entering the cockpit "again some smoke back again".*
- *18:28:16: ATC informs the crew that the emergency services are activated and are awaiting the aircraft.*
- *18:32:19: Fuel jettison is de-activated.*
- *18:33:53: Air-conditioning pack 2 is switched off by the PIC as per the overweight landing checklist.*
- *18:34:39: Aircraft lands on Runway 21R at FAOR.*
- *18:35:39: The aircraft comes to a stop on the runway and the park brake is activated.*
- *18:36:02: All four engines are shut down.*

ACM unit 2 in the AGU pack 1 was found to have failed (the unit failure detection criteria is when the RPM stays consistently below 2 000 rpm during normal operations). This caused the acrid smell and smoke to enter the cockpit and cabin areas of the aircraft.

3. CONCLUSION

3.1 General

From the available evidence, the following findings, causes and contributing factors were made concerning this incident. These shall not be read as apportioning blame or liability to any organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusion heading:

- **Findings —** are statements of all significant conditions, events, or circumstances in this incident. The findings are significant steps in this incident sequence, but they are not always causal or indicate deficiencies.
- **Causes —** are actions, omissions, events, conditions, or a combination thereof, that led to this incident.
- **Contributing factors —** are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided, or absent, would have reduced the probability of the incident occurring, or would have mitigated the severity of the consequences of the incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil, or criminal liability.

3.2 Findings

The pilots

3.2.1 The crew was properly licensed and had valid medical certificates.

3.2.2 The crew (PIC) declared an in-flight emergency approximately 18 minutes after take-off and made a request to ATC to return to the departure aerodrome.

3.2.3 Neither the PIC nor the PF felt any ill effects and, thus, decided not to don oxygen masks after they detected the acrid smell in the cockpit.

3.2.4 The relief pilot who was also in the cockpit opted to protect himself by donning his oxygen mask; he was the only person on-board the aircraft to do so.

The aircraft

3.2.5 The last maintenance inspection that was conducted on the aircraft before the serious incident flight was certified on 23 May 2023 at 28 544.0 airframe hours. The aircraft accrued 496.0 airframe hours since the said inspection.

3.2.6 The aircraft was issued a Certificate of Airworthiness (C of A) on 16 October 2014.

3.2.7 The aircraft was issued an Airworthiness Review Certificate on 25 July 2022 with an expiry date of 6 August 2023.

3.2.8 The crew performed an overweight landing which exceeded the maximum landing weight (MLW) of the aircraft (391 000kg); the aircraft's weight upon landing was 441 360kg, which was more than 50 000kg overweight.

3.2.9 The ACM that failed was in operation for 29 243 hours since new, it formed part of the AGU 1 which was installed on the left side of the aircraft.

3.2.10 The ACM is an on-condition item and is overhauled as needed. The unit had been installed on the aircraft during manufacture.

3.2.11 The aircraft was equipped with two AGUs, the second unit remained operational throughout the flight and was shut down during the final approach as per the Airbus overweight landing procedure.

3.2.12 Approximately 53 240 litres of fuel was dumped before landing back at FAOR.

3.2.13 It was discovered that the failure of the Air Cycle Machine (ACM) unit 2 which forms part of the Air Generation Unit 1 had failed, and the fretting observed on the turbine end journal bearing was likely the source of the acrid smell.

Environment

3.2.14 Fine weather conditions prevailed at the time of the flight; the weather had no bearing to this serious incident.

Air Traffic Control

3.2.15 Following the emergency that was declared by the crew, ATC accommodated the aircraft for the emergency landing.

3.2.16 The ATC informed the ARFF of the emergency and requested them to take up their positions in preparation for the aircraft's arrival.

3.2.17 A Boeing 747 was cleared for take-off by ATC Runway 03L with the aircraft G-XLEH 17nm from the landing threshold (Runway 21R). The ILS was switched over late by ATC for the approaching aircraft to intercept the localiser for Runway 21R whilst on final approach. Ident was received when the aircraft was 1.5nm offset from the inbound localiser.

Aerodrome

3.2.18 The FAOR is a licensed aerodrome with two parallel runways. The aircraft used Runway 03L for take-off, which is 4 436m long and 60m wide. On their return to the aerodrome, the aircraft landed on the reciprocal Runway 21R which was the shortest route back to the aerodrome.

3.2.19 The aerodrome emergency services took position next to Runway 21R. After the aircraft came to a stop and the engines were shut down, it was inspected, and no external damage was observed.

3.2.20 There was no damage to the runway, taxiway or apron after the overweight landing and the repositioning of the aircraft to the apron.

3.3 Probable Cause

3.3.1 The acrid smell that entered the cockpit and cabin areas prompted the crew to declare a Mayday as well as request an air turnback due to the failure of the Air Cycle Machine (ACM) unit 2 that forms part of Air Generation Unit 1. The fretting observed on the turbine end journal bearing was likely the source of the acrid smell. Failure of the other components (fan end

journal bearing, thrust bearings, compressor rotor, and both turbine rotors) was associated with damage which led to the stoppage of the rotating system.

3.4 Contributory Factors

3.4.1 None.

4. SAFETY RECOMMENDATIONS

4.1 General

The safety recommendations listed in this report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report. The AIID expects that all safety issues identified by the investigation are addressed by the receiving States and organisations.

4.2 Safety Recommendation

4.2.1 It is recommended that Airbus consider changing its cockpit procedure regarding the use of oxygen masks during in-flight events such as the one in question. It is recommended that should a similar occurrence be experienced, at least one of the two active flying cockpit crew members don his/her oxygen mask. It is known that the use of the mask leads to distorted communication, but the primary function of the crew remains to fly the aircraft.

5. APPENDICES

5.1 Appendix A: Transcript of communication between G-XLEH crew and ATC.
5.2 Appendix B: FAOR Aerodrome Chart.
5.3 Appendix C: Airbus A380 Flight Crew Techniques Manual, Abnormal and Emergency Procedures for Fire, pages 1 to 4.

This report is issued by:
Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa

Appendix A

This is a transcript of the communication between FAOR ATC and the PIC of the aircraft G-XLEH (flying under the callsign Speed bird 56). NOTE: This transcript only contains essential information specific to the Mayday and the subsequent communication that followed during the aircraft's return flight to FAOR and landing.

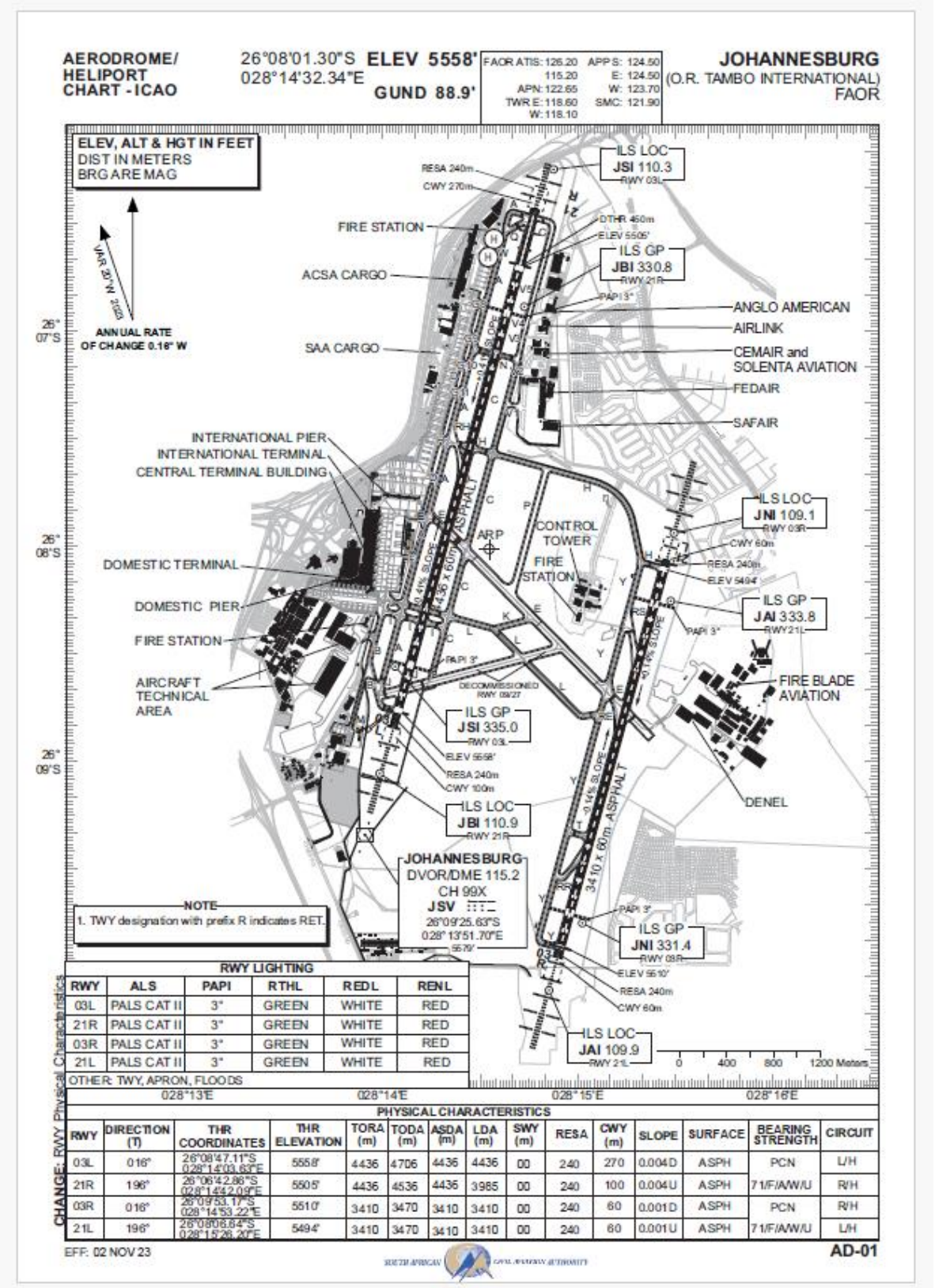
Time	From	To	Message
			---- Intentionally left blank ----
18:04:30	G-XLEH	ATC	Mayday, Mayday, Mayday, requesting an immediate return to FAOR.
18:04:35	ATC	G-XLEH	Speed bird 56, turn left on a heading of 190°.
18:05:00	G-XLEH	ATC	We have fumes in the aircraft, and we need to descend to flight level 100 (FL100) immediately.
18:05:05	ATC	G-XLEH	You are clear to descent to FL105 (10 500ft), the QNH setting is 1034.
18:06:26	G-XLEH	ATC	Can we have runway 03L for landing?
18:06:29	ATC	G-XLEH	Approved.
18:10:36	G-XLEH	ATC	*This time the first officer, which was the pilot flying spoke to ATC.* We request landing on Runway 03L (left) and to have the emergency services to meet the aircraft on arrival.
18:10:44	ATC	G-XLEH	Copied that, emergency services will be available. Runway 21R (right) is available if you prefer that.
18:10:50	G-XLEH	ATC	*This time the first officer, which was the pilot flying spoke to ATC.* Okay, that is copied, the current plan is Runway 03L but thank you for the availability for 21.
18:12:32	G-XLEH	ATC	Request runway 21R for landing. *At this stage of the flight, the aircraft was 80nm from FAOR.*
18:12:36	ATC	G-XLEH	Speed bird 56 copied, route for the 10-mile final for runway 21R.
18:15:55	G-XLEH	ATC	Would it be possible to use the Auto Land for landing on runway 21R?
18:15:58	ATC	G-XLEH	Speed bird 56, standby.
18:16:25	ATC	G-XLEH	Speed bird 56, could you just kindly advise again on the nature of your emergency, it was not very clear earlier.
18:16:31	G-XLEH	ATC	Okay my apologies, we have smoke in the flight deck and the cabin, it has since slightly dissipated after we had done the checklist, but we are *inaudible words,* so we are still on the mayday.
18:16:48	ATC	G-XLEH	Speed bird 56, that is noted, copied that, do you need to evacuate?
18:16:51	G-XLEH	ATC	At this time, we do not plan to evacuate we will stop on the runway to be inspected, we will probably down the far end of the runway as we are quite heavy.
18:17:00	ATC	G-XLEH	Speed bird 56, noted.
18:17:54	ATC	G-XLEH	Speed bird 56 will you be able to take runway 21L?

18:17:59	G-XLEH	ATC	We would like to take runway 21R as we are quite heavy.
18:18:04	ATC	G-XLEH	Speed bird 56, noted.
18:18:13	ATC	G-XLEH	Speed bird 56, you can continue for runway 21R.
18:18:15	G-XLEH	ATC	Noted.
18:20:40	ATC	G-XLEH	Speed bird 56, I have just been advised by the tower that vacating runway 21R would be difficult as there is some taxiways are closed. Landing runway 03L would be an easier option.
18:21:04	G-XLEH	ATC	We need 21R, we need to get on the ground as soon as possible. If you can get a tug out to pull us off that would help.
18:21:12	ATC	G-XLEH	Speed bird 56, Wilco, thank you.
18:21:20	ATC	G-XLEH	Speed bird 56, continue Sir, no worries continue runway 21.
18:21:46	ATC	G-XLEH	Speed bird 56, please contact Johannesburg radar on 124 decimal 5, all the best to you, bye-bye.
18:21:51	G-XLEH	ATC	1245 Bye-bye.
18:23:51	ATC	G-XLEH	Speed bird 56, contact Johannesburg radar on 124 decimal 5 please, bye-bye.
18:24:02	G-XLEH	ATC	My apologies, Speed bird 56.
			---- Intentionally left blank ----
18:25:05	ATC	G-XLEH	Speed bird 56, are you on frequency?
18:25:08	G-XLEH	ATC	Speed bird 56, go ahead, we are now on a heading of 160° for runway 21R.
18:25:17	ATC	G-XLEH	Speed bird 56, good evening to you, descent when ready to flight level 90, standby the localiser, just two more departures departing runway 03L.
18:25:25	G-XLEH	ATC	Good evening, descend to flight level 90.
18:28:00	ATC	G-XLEH	Speed bird 56, when ready to descend altitude eight *double transmission, inaudible words.*
18:28:06	G-XLEH	ATC	Mayday, Speed bird 56, is there any chance for the ILS?
18:28:11	ATC	G-XLEH	Speed bird 56, you are cleared for the ILS approach runway 21R, QNH 1035, and emergency on standby.
18:28:18	G-XLEH	ATC	1035, cleared for the ILS runway 21R, Speed bird 56, thank you for that.
18:30:08	ATC	G-XLEH	Speed bird 56, contact tower frequency 121 decimal 9, good evening.
18:30:14	G-XLEH	ATC	1219, Speed bird 56.
			---- Intentionally left blank ----
18:30:17	G-XLEH	ATC	Tower, Mayday Speed bird 56 Super at 12 miles for 21R.
18:30:23	ATC	G-XLEH	Speed bird 56, Good evening again, clear to land runway 21R, surface wind is light and variable.
18:30:31	G-XLEH	ATC	21R Copied that, Speed bird 56, we are going to stop at Juliet.
18:30:36	ATC	G-XLEH	Copied Sir, emergency services are on standby.
18:30:39	G-XLEH	ATC	Excellent, thank you.
18:30:58	ATC	G-XLEH	Speed bird 56, please be advised that all emergency services

			are on standby, and you can just advise us when on the ground your situation.
18:31:05	G-XLEH	ATC	Wilco
18:33:25	ATC	G-XLEH	Speed bird 56, wind is light and variable.
18:33:29	G-XLEH	ATC	Speed bird 56.
18:36:04	G-XLEH	ATC	Speed bird 56 we have stopped on the runway and shut down the engines, so we will need a tow-off.
18:36:12	ATC	G-XLEH	Speed bird 56, copied.
			---- Intentionally left blank ----
18:37:21	Ground controller	G-XLEH	Speed bird 56, just confirm you need a tug to tow you, are you going to organise that, or shall we organise the tug?
18:37:26	G-XLEH	Ground controller	Would you organise the tug please?
18:37:28	Ground controller	G-XLEH	Okay, we are going to speak with apron now.
18:37:31	G-XLEH	Ground controller	Okay, we need the engines off as we believe they were the source of the smoke and fumes.
18:37:35	Ground controller	G-XLEH	Confirm you are shutting down now.
18:37:38	G-XLEH	Ground controller	We are already shut down we think the engines were the source of the smoke and fumes do they are staying shut down.
18:37:52	G-XLEH	Ground controller	Did you copy?
18:37:53	Ground controller	G-XLEH	Affirm Sir, you shut down, we are organising you a tow and the vehicles are thereby you if you need their assistance.
18:38:02	G-XLEH	Ground controller	Okay, do we have a frequency for them?
18:38:06	Ground controller	G-XLEH	You can speak to them on this frequency.
18:38:09	G-XLEH	Echo 1 (Fire)	Hello fire, can you see us?
18:38:12	Echo 1	G-XLEH	Affirm, you are speaking to fire.
18:38:15	G-XLEH	Echo 1 (Fire)	Okay, would you have a look around the airplane and see how it looks, please?
18:38:19	Echo 1	G-XLEH	We'll do I will give you feedback, standby.
18:38:32	Echo 1	G-XLEH	Just confirm your engines are shut down.
18:38:35	G-XLEH	Echo 1 (Fire)	Affirm, the engines are shut down and the radar is off.
18:38:42	Echo 1	G-XLEH	Copied.

There was no further communication between ATC and Ground controller and the aircraft.

Appendix B


AERODROME/ HELIPORT CHART - ICAO
26°08'01.30"S 028°14'32.34"E
ELEV 5558'
GUND 88.9'
FAOR ATIS: 126.20 115.20 APN: 122.65 TWR E: 118.60 W: 118.10
APP S: 124.50 E: 124.50 W: 123.70 SMC: 121.90
JOHANNESBURG (O.R. TAMBO INTERNATIONAL) FAOR
ELEV, ALT & HGT IN FEET
DIST IN METERS
BRG ARE MAG
VAR 25°W 2023
ANNUAL RATE OF CHANGE 0.16° W
ILS LOC JSI 110.3 RWY 03L
ILS GP JBI 330.8 RWY 21R
ILS LOC JNI 109.1 RWY 03R
ILS GP JAI 333.8 RWY 21L
ILS GP JSI 335.0 RWY 03L
ILS LOC JBI 110.9 RWY 21R
ILS GP JNI 331.4 RWY 03R
ILS LOC JAI 109.9 RWY 21L
JOHANNESBURG DVOR/DME 115.2 CH 99X JSV 26°09'25.63"S 028°13'51.70"E
FIRE STATION
ACSA CARGO
SAA CARGO
ANGLO AMERICAN
AIRLINK
CEMAIR and SOLENTA AVIATION
FEDAIR
SAFAIR
INTERNATIONAL PIER
INTERNATIONAL TERMINAL
CENTRAL TERMINAL BUILDING
DOMESTIC TERMINAL
DOMESTIC PIER
FIRE STATION
AIRCRAFT TECHNICAL AREA
CONTROL TOWER
ARP
FIRE STATION
FIRE BLADE AVIATION
DENEL
DECOMMISSIONED RWY 09/27
3436 x 60m ASPHALT
3410 x 60m ASPHALT
RESA 240m
CWY 270m
DTHR 450m
ELEV 5505'
PAPI 3°
CWY 60m
ELEV 5494'
CWY 100m
ELEV 5558'
ELEV 5510'
26° 07'S
26° 08'S
26° 09'S
NOTE
1. TWY designation with prefix R indicates RET.
RWY LIGHTING
RWY | ALS | PAPI | RTHL | REDL | RENL
03L | PALS CAT II | 3° | GREEN | WHITE | RED
21R | PALS CAT II | 3° | GREEN | WHITE | RED
03R | PALS CAT II | 3° | GREEN | WHITE | RED
21L | PALS CAT II | 3° | GREEN | WHITE | RED
OTHER: TWY, APRON, FLOODS
028°13'E 028°14'E 028°15'E 028°16'E
0 400 800 1200 Meters
PHYSICAL CHARACTERISTICS
RWY | DIRECTION (T) | THR COORDINATES | THR ELEVATION | TORA (m) | TODA (m) | ASDA (m) | LDA (m) | SWY (m) | RESA | CWY (m) | SLOPE | SURFACE | BEARING STRENGTH | CIRCUIT
03L | 016° | 26°08'47.11"S 028°14'03.63"E | 5558' | 4436 | 4706 | 4436 | 4436 | 00 | 240 | 270 | 0.004D | ASPH | PCN | L/H
21R | 196° | 26°06'42.86"S 028°14'42.09"E | 5505' | 4436 | 4536 | 4436 | 3985 | 00 | 240 | 100 | 0.004U | ASPH | 71/F/A/W/U | R/H
03R | 016° | 26°09'53.17"S 028°14'53.22"E | 5510' | 3410 | 3470 | 3410 | 3410 | 00 | 240 | 60 | 0.001D | ASPH | PCN | R/H
21L | 196° | 26°08'06.64"S 028°15'26.20"E | 5494' | 3410 | 3470 | 3410 | 3410 | 00 | 240 | 60 | 0.001U | ASPH | 71/F/A/W/U | L/H
CHANGE: RWY Physical Characteristics
EFF: 02 NOV 23
AD-01

Appendix C

INTRODUCTION

Ident.: PR-AEP-FIRE-00027212.0001001 / 30 SEP 21
Applicable to: ALL

Fire, smoke or fumes in the fuselage may lead to potential hazardous situations. The flight crew will have to deal not only with the emergency itself, but also with the passengers who may possibly panic should they become aware of the situation. it is essential therefore, that action to control the source of combustion is not delayed.
An immediate diversion should be considered as soon as the smoke/fumes is detected. If the source is not immediate obvious, accessible and extinguishable, it should be initiated without delay.

FIRE SMOKE / FUMES

Applicable to: ALL

Ident.: PR-AEP-FIRE-10-00027478.0001001 / 30 SEP 21

GENERAL

The FIRE SMOKE / FUMES procedure is covered by:
- A not-sensed ECAM procedure (*Refer to FCOM/PRO-ABN-FIRE [ABN] FIRE SMOKE/FUMES*)
  The ECAM displays the actions that the flight crew must apply immediately (i.e immediate actions), and a reference to apply the associated Quick Reference Handbook QRH procedure
- A QRH procedure (*Refer to FCOM/PRO-ABN-FIRE [QRH] FIRE SMOKE / FUMES*).

The philosophy of these procedures includes the following main steps:
- Immediate actions to protect the flight crew and the passengers, to avoid further contamination of the cockpit or cabin, and to isolate potential smoke/fumes sources
- Actions to anticipate diversion or to isolate the smoke/fumes source, if the source is immediately obvious, accessible and extinguishable
- Actions to identify and isolate the smoke/fumes source, if the source is not immediately accessible and extinguishable (identification and isolation part of the procedure).

When the flight crew applies the FIRE SMOKE / FUMES procedure, some action steps may trigger ECAM alerts. In this case, the flight crew must acknowledge these ECAM alerts, and delay the ECAM actions until the end of the QRH procedure.
In addition, at any time during the application of the procedure, if smoke/fumes become the greatest threat, or if the situation becomes unmanageable, perform the boxed items.

Ident.: PR-AEP-FIRE-10-00027479.0001001 / 30 SEP 21

DETECTION AND PROCEDURE APPLICATION

The smoke/fumes is identified either by an ECAM alert, or by a crewmember (i.e. flight crew or cabin crew) without any ECAM alert.

SMOKE IDENTIFIED BY AN ECAM ALERT

- If the ECAM triggers an AVNCS SMOKE alert, the flight crew must apply the ECAM actions
  After the immediate actions, the ECAM requests to apply the [QRH] SMOKE / FUMES procedure
- If the ECAM triggers another SMOKE alert (e.g. LAVATORY SMOKE), the flight crew must apply the ECAM procedure.

If any doubt exists about the origin of the smoke, the flight crew must refer to the [QRH] SMOKE / FUMES procedure.

SMOKE/FUMES IDENTIFIED BY A CREWMEMBER

If a crewmember detects smoke or fumes, without any ECAM alert, the flight crew must apply the FIRE SMOKE / FUMES procedure, which covers all the events related to fire, smoke or fumes, with or without odors: it is the reference for the flight crews for addressing all of these events.

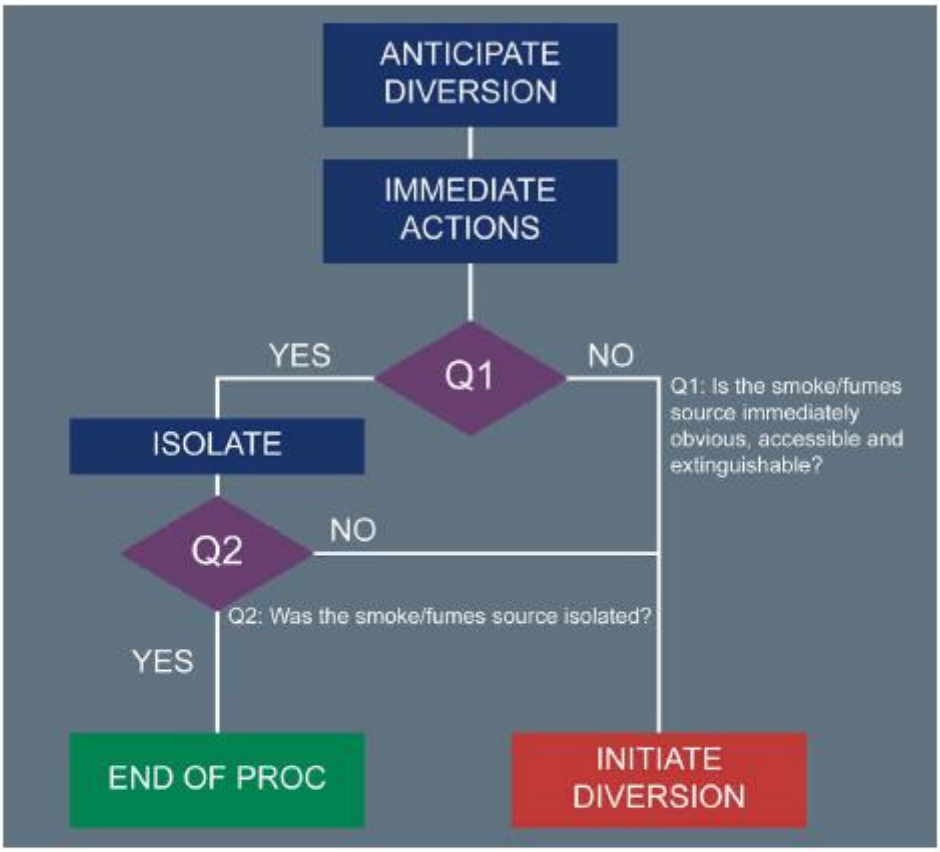
- If the visibility is sufficient to read the ECAM, the flight crew activates and applies the FIRE SMOKE / FUMES not-sensed procedure
  The activation of the not-sensed procedure enables to display LAND ASAP limitation
  After the immediate actions, the ECAM requests to apply the [QRH] SMOKE / FUMES procedure
- If the visibility is not sufficient to read the ECAM, the flight crew directly refers to the [QRH] SMOKES / FUMES procedure.

Ident.: PR-AEP-FIRE-10-00027480.0001001 / 30 SEP 21

QRH SMOKE / FUMES PROCEDURE

CONSIDERATION ABOUT DIVERSION

Time is critical.
Therefore, the flight crew must immediately anticipate a diversion, as indicated by LAND ASAP in the procedure.
Then, after the immediate actions, if the smoke/fumes source is not immediately identified and isolated, the flight crew must initiate the diversion before entering the SMOKE/FUMES ORIGIN IDENTIFICATION AND FIGHTING part of the procedure.



IMMEDIATE ACTIONS

The immediate actions are common to all cases of smoke and fumes, regardless of the source.

The objectives of the immediate actions are:
- Avoid any further contamination of the cockpit/cabin
- Communicate with the cabin crew
- Protect the flight crew.

SMOKE/FUMES ORIGIN IDENTIFICATION AND FIGHTING

The flight crew tries to identify the smoke/fumes source by isolating systems. Some guidelines may help to identify the origin of the smoke/fumes:

- If smoke/fumes initially comes out of the cockpit ventilation outlets, or if smoke/fumes is detected in the cabin, the flight crew may suspect an air conditioning smoke/fumes.
  In addition, the ECAM may immediately trigger SMOKE alerts (e.g. cargo, lavatory, avionics).
  The flight crew must apply the associated ECAM procedures
- Following an identified ENG or APU failure, smoke/fumes may come from the faulty equipment through the bleed system and be perceptible in the cockpit or the cabin.
  In that case, smoke/fumes is re-circulated throughout the aircraft, until it completely disappears from the air conditioning system
- If the ECAM only triggers the AVNCS SMOKE alert, the flight crew may suspect an avionics smoke
- If smoke/fumes is detected, while an equipment is failed, the flight crew may suspect that smoke/fumes is coming from this equipment
- The crew may also perceive fumes with odors: to help the identification of the possible source and to enhance the communication coordination with the cabin crew, the table below gathers some of the fumes with odors that may occur on board, with the suspected causes.

Description of Odors	Suspected Cause (Most Reported Listed First)
Acrid	Electrical Equipment / IFE Engine Oil Leak
Burning	Electrical Equipment Galley Equipment Bird Ingestion
Chemical	Contaminated Bleed Ducts APU Ingestion
Chlorine	PBE Blocked Door Area Drain
Electrical	Electrical Equipment
Dirty Socks	APU or Engine Oil Leaks
Foul	Lavatories
Fuel	APU FCU/Fuel Line
Oil	Engine or APU Oil Leak
Skydrol	Engine Hydraulic
Sulphur	Wiring Avionics Filter Water Contamination Light Bulb