



Summary Report

A summary investigation, in accordance with article 45 of the Ordinance on the Safety Investigation of Transport Incidents (OSITI), was carried out with regards to the following serious incident. This report was prepared to ensure that lessons can be learned from the incident in question.

Aircraft	Boeing B777-300ER	A7-BAO
Operator	Qatar Airways Q.C.S.C., Doha, State of Qatar	
Owner	Qatar Airways Tower, Airport Road or P.O. Box 22550, Doha, State of Qatar	

Crew A:

Pilot	Spanish citizen, born 1978			
Licence	Airline transport pilot licence aeroplane (ATPL(A)) according to the International Civil Aviation Organisation (ICAO), issued by the Civil Aviation Authority (CAA) of Qatar			
Flying hours	Total	8023 h	During the last 90 days	223 h
	On the incident type	3121 h	During the last 90 days	223 h
Copilot	Italian citizen, born 1979			
Licence	ATPL(A) according to ICAO, issued by the CAA of Qatar			
Flying hours	Total	4152 h	During the last 90 days	195 h
	On the incident type	1617 h	During the last 90 days	195 h

Crew B:

Pilot	American citizen, born 1972			
Licence	ATPL(A) according to ICAO, issued by the CAA of Qatar			
Flying hours	Total	11 900 h	During the last 90 days	207 h
	On the incident type	4800 h	During the last 90 days	207 h
Copilot	Spanish citizen, born 1978			
Licence	ATPL(A) according to ICAO, issued by the CAA of Qatar			
Flying hours	Total	6421 h	During the last 90 days	211 h
	On the incident type	3068 h	During the last 90 days	211 h

Location	16 NM north-north-west of Basel		
Coordinates	---	Altitude	Flight level (FL) 350
Date and time	19 November 2016, 09:10 UTC		
Type of operation	Scheduled flight		
Flight rules	Instrument flight rules (IFR)		
Flight phase	Cruise flight		
Incident type	Electrical smell in the cockpit, use of oxygen masks		
Point of departure	Miami (KMIA)		
Destination	Doha (OTHH)		

Injuries to persons	Crew	Passengers	Third parties	
	Minor	0	0	0
	None	20	359	-
Damage	Aircraft not damaged			
Third-party damage	None			

General

In accordance with the aviation company's operation manual (OM) A, the flight from Doha (DOH) to Miami (MIA) and back is defined as an ultra-long-range (ULR)¹ flight. Two flight crews, each consisting of a commander and a copilot, are used on such flights. The two crews are referred to as crew A and crew B. The commander of crew A is responsible for the out-bound flight and the crew from Doha until after landing at the destination airport. From that point onwards the commander of crew B is responsible for the crew as well as the return flight to Doha².

The division of working hours and rest periods between the two flight crews is laid out in detail in section 7.7.12.4 of OM A, which is entitled 'ULR OPERATIONS: DOH – MIA – DOH'. At the time of the serious incident, crew A (commander A and copilot A) was in the cockpit and crew B (commander B and copilot B) – the commander responsible for the flight and his copilot – had a rest period. Copilot A was the pilot flying (PF) and commander A was the pilot monitoring (PM). In accordance with the aviation company's guidelines for emergencies, commander A took over the function of PF for the final approach and copilot A that of PM.

Course of events

The Boeing B777-300ER aircraft, registered as A7-BAO, took off from Miami (KMIA) with the radio call sign QTR 778 (Qatari Seven Seven Eight) at 01:16 UTC on 19th November 2016 for the scheduled flight to Doha (OTHH). The aircraft was fuelled with 124.3 tonnes of fuel and its take-off weight was 346.9 tonnes. There were 4 pilots, 16 cabin crew members and 359 passengers on board.

QTR 778 was at a cruising altitude of FL 350 approximately 35 NM north-west of Basel and flying towards the Trasadengen omnidirectional radio beacon when crew A, which was in the cockpit, established contact with the Skyguide M4 (upper sector) air traffic service at 09:06:31 UTC. Moments later, a strong odour developed in the cockpit. After the flight, both flight crews concurred in their statements that it was an electrical smell. As commander A subsequently felt somewhat unwell ("dizzy"), he donned his oxygen mask. According to the cockpit voice recorder (CVR), this occurred at 09:10:44 UTC.

The flight crew summoned a member of the cabin crew to the cockpit in order to ask if they noticed anything. Those present had the impression that the development of the odour initially abated, but then reoccurred. From 09:13:41 UTC, both pilots used their oxygen masks. Crew B was subsequently informed. According to the CVR, a cockpit display pertaining to a cooling system was mentioned in the process. Copilot A later stated that this concerned the status message EQUIP COOLING FAN R. The decision to make a diversion landing in Zurich (LSZH) was taken.

At 09:15:04 UTC, the flight crew issued the 'Mayday' distress message over Schaffhausen. At the same time, they informed the air traffic controller about the presence of smoke in the cockpit and requested a diversion landing in Zurich. Following that, the air traffic controller immediately gave the flight crew of QTR 778 instructions for their descent towards Zurich.

At 09:17:11 UTC, commander B, who was by now in the cockpit, informed the cabin services director of the diversion landing in Zurich, which was to take place in ten minutes. At the same time, the air traffic controller told the crew to expect an approach to runway 16 using the instrument landing system (ILS) and mentioned that for the time being only a category I approach was possible, and not a category II approach.

At 09:18:16 UTC, the flight crew of QTR 778 informed the air traffic controller of their intention to dump fuel and asked whether they could do so along the flight path for the final approach. Authorisation to do so was subsequently granted. Assisted by commander B, the flight crew

¹ OM A: Section 7.7 FTL SUPPLEMENT – ULTRA-LONG-RANGE (ULR) OPERATIONS

² OM A: Section 7.7.3.3 Travelling time – Crew responsibilities

then worked through the fuel jettison checklist (see short description of the fuel jettison system). According to the recordings of the digital flight data recorder (DFDR), the fuel jettison arm switch was actuated at 09:18:41 UTC, followed by the two fuel jettison nozzle valve switches at 09:19:05 UTC. According to the DFDR, both nozzle valves opened.

At 09:19:21 UTC, the air traffic controller asked whether a frequency change was acceptable, to which the flight crew responded in the affirmative. The flight crew subsequently contacted air traffic controller E (sector east). During this conversation, the fuel jettison arm switch was actuated once more at 09:19:36 UTC according to the DFDR, whereupon both nozzle valves closed. At this point, the aircraft was at FL 250.

At 09:20:49 UTC, air traffic controller E informed the flight crew that a category III ILS 16 instrument landing approach was now possible. Thereafter, the flight crew enquired about the meteorological visibility. At 09:21:20 UTC, the fuel synoptic page (see figure 2) was selected. At almost the same time, a member of the flight crew noted that the fuel dumping was not working. Commander A later stated that the right nozzle valve had not opened and that he wanted to refrain from dumping fuel in order to prevent an imbalance. The DFDR recordings show that moments later, at 09:21:47 UTC, the fuel jettison arm switch was actuated once again, whereupon both nozzle valves reopened.

After the flight crew of QTR 778 had received clearance to descend to FL 130, a discussion ensued in the cockpit concerning a malfunction of the fuel dumping system and whether the weather necessitated a category III instrument landing approach. At 09:22:37 UTC, a member of the flight crew discovered that fuel dumping was working again.

At 09:22:39 UTC, the flight crew requested the current weather report for Zurich. The air traffic controller reported wind from 270 degrees at 10 knots, 9 km of visibility, increasing cloud at between 1000 ft and 4000 ft above the airport altitude and a temperature of 8 °C. The flight crew confirmed the visibility of 9000 m and stated that they would execute a category I ILS approach and perform an overweight landing. In this context, a relatively long discussion was held regarding the rate of climb in the event of a go-around (see annex 2, landing climb limit weight).

At 09:23:47 UTC, air traffic controller E enquired as to whether fuel dumping was still in progress. The flight crew responded to this in the negative and added that fuel dumping was not possible at all due to technical problems. At 09:23:56 UTC, the flight crew was directed to establish contact with the 'final' air traffic controller. At this point, the flight crew confirmed that fuel dumping was going ahead after all. Subsequently, the crew was again asked to contact the 'final' air traffic controller.

At 09:24:29 UTC, the flight crew made contact with the 'final' air traffic controller. The controller continued radar vectoring for an ILS approach for runway 16 and informed the flight crew that the fire brigade was standing by. At the same time, commander B informed the aviation company of the diversion landing. At 09:27:26 UTC, the air traffic controller asked to be advised once fuel dumping had been concluded.

At 09:27:57 UTC, the flight crew of QTR 778 was directed to turn to a southerly heading and descend to 6000 ft QNH. After removing his oxygen mask, a member of the flight crew noted that smoke could no longer be detected and that there was no longer a need for hurry. At 09:28:46 UTC, the air traffic controller gave the instruction to follow the localiser for runway 16. At the suggestion of a member of the flight crew, fuel dumping was halted at 09:29:11 UTC. The DFDR recordings show that around 8 tonnes of fuel had been dumped.

At 09:30:05 UTC, the flight crew received clearance to make an ILS 16 approach. After enquiring of the cabin crew, the flight crew was also informed that the cabin was not yet ready for landing. They therefore requested a longer approach path and were subsequently instructed to turn left on a heading of 140 degrees and maintain an altitude of 5000 ft QNH. All members of the flight crew were now removing their oxygen masks.

At 09:31:26 UTC, the air traffic controller enquired once more as to whether fuel dumping was still in progress. The flight crew subsequently confirmed that fuel dumping had, by this time, been halted. The flight crew responded to a further enquiry from the air traffic controller by saying that a further two to three minutes would be needed until the cabin was ready for landing. At 09:32:39 UTC, commander B then informed the passengers himself about the imminent diversion landing.

At 09:33:05 UTC, the flight crew reported their readiness to make an approach, whereupon they were directed to turn to a heading of 290 degrees. At 09:34:00 UTC, control of the aircraft was handed over to the commander for the landing as stipulated by the operating procedures. At 09:35:18 UTC, commander A requested that the landing flaps be set to position 15. When subsequently asked which flap position would be used for the landing, the commander said: „Flaps 30“. After several course and altitude instructions, at 09:35:57 UTC the air traffic controller once again granted clearance to make an ILS 16 approach. At 09:37:22 UTC, QTR 778 reported that it was established on ILS 16.

At 09:37:33 UTC, the air traffic controller granted clearance to land on runway 16 and reported that the wind was 12 knots from 220°. At 09:38:10 UTC, the flight crew was directed to contact the tower. At 09:38:19 UTC, it was stated that the landing checklist had been completed. At 09:38:23 UTC, the flight crew contacted the ‘tower’ air traffic controller. At that time, the aircraft was 5 NM from runway 16. The air traffic controller repeated the landing clearance and reported that the wind was 11 knots from 220°.

At around 400 ft above ground, the autopilot was switched off. The aircraft touched down at 09:40:27 UTC. While the aircraft was still on landing roll, the air traffic controller enquired as to how the flight crew intended to proceed. The crew indicated that they would stop on the runway and requested that the aircraft then be checked for signs of smoke development from the outside. At 09:41:33 UTC, the ‘tower’ air traffic controller informed the flight crew that no development of smoke could be observed.

At 09:42:08 UTC, the flight crew requested instructions to taxi and leave the runway. At 09:42:33 UTC, a member of the flight crew noted that the status message EQUIP COOLING FAN R, which had previously been observed, had disappeared. In response to an enquiry from the air traffic controller, the flight crew stated that the situation on board was normal. At 09:44:11 UTC, the flight crew reported that they had the marshaller in sight, and taxied to stand C55. The passengers left the aircraft in the normal way.

Short description of the air conditioning and cooling system

The air conditioning system supplies conditioned bleed air and recirculated cabin air at a controlled temperature throughout the airplane. Two identical air conditioning packs cool the bleed air from the two engines; normally the left pack cools the bleed air from the left engine and the right pack cools that from the right engine.

The cockpit receives 100 % freshly conditioned air from the left pack. The cockpit is maintained at a slightly higher pressure than the passenger cabin to prevent smoke and objectionable odors from entering the cockpit.

The forward equipment cooling and ventilation provides cooling and ventilation for the electrical and electronic equipment on the flight deck and in the forward electrical and electronic (E&E) compartment equipment racks. The forward systems use internal fans and valves to direct air drawn from the cabin to the equipment and ventilates the warm exhaust air into the forward outflow valve or the forward cargo compartment, if the compartment requires additional heat. There are two cooling system supply fans, a primary and a backup. If the primary supply fan fails, the backup supply fan operates automatically.

The forward system reconfigures automatically to an override mode when either both supply fans fail or smoke is detected in the forward equipment cooling system or the forward equipment ventilation system. In the override mode the vent valve opens, both supply fans shut down and the forward cargo heat valve closes.

Short description of the fuel dump system

The B777-300ER aircraft is equipped with a system to dump fuel during flight. The maximum take-off weight (MTOW) of 351 534 kg is about 100 tonnes above the maximum landing weight (MLW) of 251 290 kg. In case of an unexpected or unplanned landing with a landing weight well above the MLW, the weight of the aircraft can be reduced rapidly by dumping fuel.

Fuel dumping is carried out by the flight crew in accordance with a checklist. The relevant actions are performed on the overhead panel (see figure 1) and are briefly described as follows:

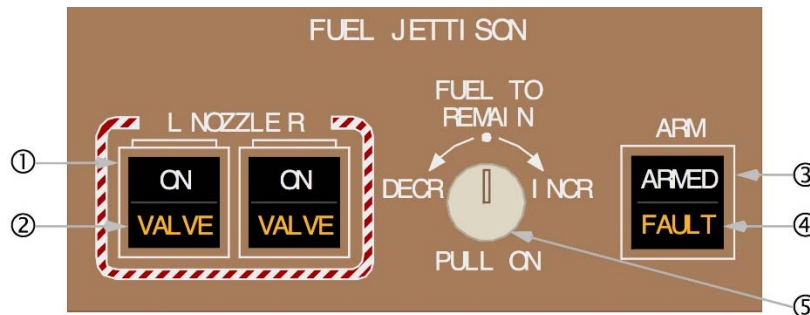


Figure 1: Fuel dump controls on the overhead panel (source: FCOM³ of the aircraft manufacturer)

In order to dump fuel, the system must be activated by pushing the ARM push button. The white ARMED indicator (3) lights up and, at the same time, the fuel-to-remain is automatically calculated so that fuel dumping is halted when the MLW is reached. If the flight crew is planning on a landing weight other than the MLW, the weight can be selected manually using the FUEL TO REMAIN (5) rotary knob.

If the system fails or a fault occurs in the system, this is indicated to the flight crew by the amber FAULT (4) indicator.

Fuel dumping begins when the two nozzle valves, left (L) and right (R), are opened by pushing the respective L NOZZLE R push buttons. The white ON (1) light confirms the opening of the valves. If the valves fail to open, the crew is notified by the amber VALVE (2) indicator which lights up.

When fuel dumping has finished, the two nozzle valves must first be closed using the respective push buttons and then the system must be deactivated by the ARM push button.

The flight crew can also track fuel dumping on the fuel synoptic page (see figure 2).

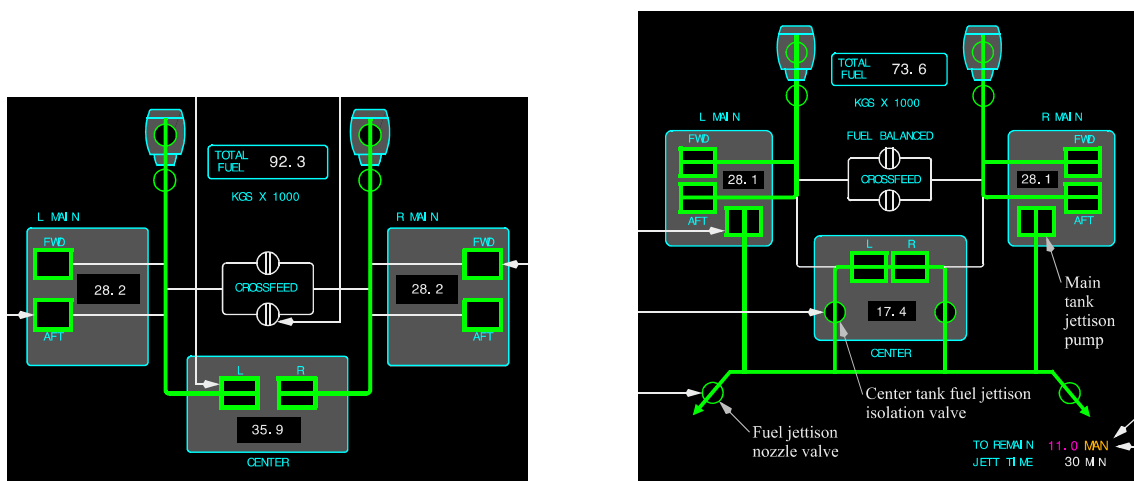


Figure 2: Left: fuel synoptic page. Right: fuel synoptic page during fuel dumping (source: FCOM)

³ FCOM: flight crew operations manual

Landing with a weight that exceeds the maximum landing weight

Landing with a landing weight that is greater than the maximum landing weight specified by the aircraft manufacturer, a so called 'overweight landing' is permitted under abnormal circumstances or in emergencies. Amongst other things, the section on the landing climb limit⁴ (FCOM, performance inflight PI.27.8) in the aviation company's operating procedures states the following: „*In the event an overweight landing is necessary [...], landing climb limits should be checked if a flaps 25 or 30 landing is planned.*”

The flight crew must work through a corresponding checklist for such a case. This also addresses the rate of climb in the event of a go-around and the consequent landing flap position for an approach (see annex 2). In the present case, the weight of the aircraft on landing was 257 495 kg and therefore exceeded the maximum landing weight of 251 290 kg by around 6 tonnes. The landing reference speed (VREF) with flaps 30 was 152 knots (PI-QRH⁵.20.6).

Findings

The flight crew stated that the status message EQUIP COOLING FAN R was displayed at the same time that the electrical smell occurred. The specialists at the maintenance company therefore removed this cooling fan, which is located on the left sidewall of the forward cargo compartment (see figure 3). It became apparent that the rotor of the fan was jammed and a slight electrical odour could still be detected.



Figure 3: Image on the left: cooling fan on the left sidewall of the forward cargo compartment. Image in the middle and on the right: removed cooling fan with jammed rotor (photos taken on 19 November 2016 at 12:29 UTC).

Analysis and conclusions

It can be assumed that the electrical coils in the right cooling fan were burnt and that the resulting electrical smell, accompanied by a slight development of smoke, found its way into the E&E compartment and from there entered the cockpit, where it was detected by the flight crew.

The flight crew immediately linked the status message EQUIP COOLING FAN R with the electrical smell detected, however they continued to look for possible sources of odour in the cockpit. These actions were logical and prudent. The use of oxygen masks and the rapid decision to make a diversion landing in Zurich in response to the uncertain situation were systematic and safety-conscious.

In the meantime, commander B, who was responsible for the flight, had entered the cockpit and assisted the active crew A. Copilot B also joined them. The input of commander B as a

⁴ Landing climb limit: the minimum gradient is defined as 3.2 % for a go-around in the landing configuration (Federal Aviation Regulations – FAR, part 25, section 119); the associated landing climb limit weight depends on the atmospheric conditions and exceeded the maximum take-off weight (MTOW) of 351 534 kg (PI-QRH.21.39) in the present case.

⁵ QRH: quick reference handbook, a checklist for emergencies and abnormal cases

communicator – with the cabin crew on the one hand and the aviation company on the other – was appropriate for the situation and created additional leeway for crew A.

However, the fact that commander B also assisted crew A in working through the checklist for fuel dumping must be questioned. The recordings show that there was not enough oversight in the cockpit with regard to fuel dumping. It seems that the active crew A was not sufficiently involved in working through the checklist for fuel dumping. As a result, there was a lack of clear information provided to air traffic control. However, such information is necessary, as air traffic control must take relevant guidelines for fuel dumping into account⁶.

The voice recordings show that the various statements made by air traffic control concerning the technical category status of the ILS unsettled the flight crew with regard to the runway selection and the landing and resulted in unnecessary discussions in the cockpit concerning the prevailing weather conditions. With clear visibility of 9 km below 1000 ft above airport altitude, flight crews are able to take over control of the aircraft at any time during the short final to perform the landing manually. The technical ILS status for an autoland was therefore of minor importance in this present case.

According to the CVR recordings, a relatively long time was spent during the approach discussing the landing climb limits for the landing or a go-around. The decision of commander A to perform an overweight landing using a normal flap position was appropriate for the situation given that the weight at the time was only 6 tonnes over the maximum permissible landing weight and was in compliance with the operating procedures (see annex 2).

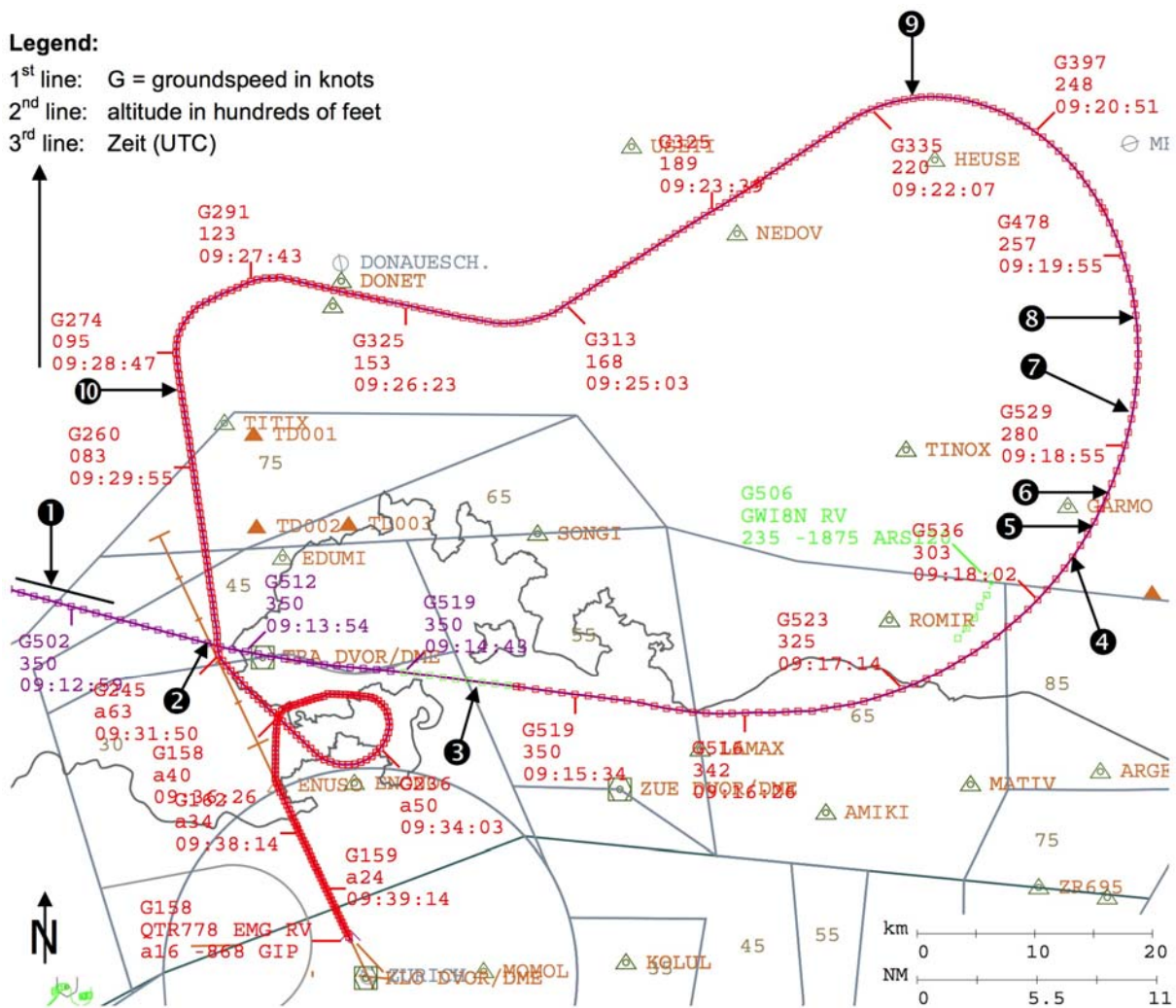
Thanks to the rapid decision-making and prudent actions of the flight crew, the passengers and crew were not in serious danger at any time.

Bern, 27 June 2017

Swiss Transportation Safety Investigation Board

⁶ As stipulated in ICAO doc 4444 on Air Traffic Management (ATM), fuel dumping should not be carried out below 6000 ft above ground. With regard to separation from other aircraft, the following distances are given in section 15.5.3.2: 10 NM horizontally, at least 1000 ft above the aircraft and at least 3000 ft below the aircraft that is dumping fuel.

Annex 1: Flight path of A7-BAO



Pos.	Time UTC	Event
①	from 09:10	The flight crew detects an electrical smell. Commander A donned his oxygen mask.
②	09:13:41	Copilot A also donned his oxygen mask.
③	09:15:04	The flight crew reports: "Zurich, Qatari 778, Mayday Mayday, requesting divert to Zurich due to smoke in the flight deck."
④	09:18:16	The flight crew reports, "Qatari 778, we need to dump fuel, can we do it on the way to final?"
⑤	09:18:28	The flight crew receives the following clearance: "Qatari 778, affirm, now fuel dumping is approved."
⑥	09:18:41	Fuel dumping is activated.
⑦	09:19:05	The two nozzle valves open.
⑧	09:19:36	Fuel dumping is deactivated and the nozzle valves close at the same time.
⑨	09:21:47	Fuel dumping is activated and the nozzle valves open at the same time.
⑩	09:29:11	Fuel dumping is deactivated; the nozzle valves close at 09:29:15 UTC.

Annex 2: Checklist for an overweight landing (Source: FCOM of the aircraft manufacturer)

Overweight Landing

Condition: A landing at greater than the maximum landing weight is needed.

- 1 Refer to the Landing Climb Limit Weight table in the Performance Inflight chapter.
- 2 Choose one:
 - ◆ Landing gross weight is **greater than** the Landing Climb Limit Weight, **or one engine is inoperative**:

GND PROX FLAP OVRD switch OVRD

Note: Use flaps 20 and VREF 20 for landing and flaps 5 for go-around. This gives greater climb capability.

▶▶ Go to step 5
 - ◆ Landing gross weight is **less than or equal to** the Landing Climb Limit Weight, **and both engines are running** normally:

▶▶ Go to step 3
- 3 Enter the landing gross weight on the APPROACH REF page.
- 4 Choose one:
 - ◆ VREF 30 + additives (wind and gusts, 5 knots minimum) is **at or below** 170 knots:

Note: Use flaps 30 and VREF 30 for landing and flaps 20 for go-around.

■ ■ ■ ■
 - ◆ VREF 30 + additives (wind and gusts, 5 knots minimum) is **above** 170 knots:

Note: Use flaps 25 and VREF 25 for landing and flaps 20 for go-around. This gives greater margin to the flap placard speed.

▶▶ Go to step 5
- 5 **Checklist Complete Except Deferred Items**

Deferred Items

Descent Checklist

Recall Checked

Notes Checked

Autobrake ___

Landing data **VREF 20 ___ or VREF 25 ___, Minimums ___**

Approach briefing Completed

Approach Checklist

Altimeters ___

Seat belts ON

Landing Checklist

Speedbrake ARMED

Landing gear DOWN

Flaps **20 or 25**

■ ■ ■ ■