NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

October 25, 2016

Operations Group Chairman's Factual Report

OPERATIONAL FACTORS

DCA15FA185

Contents

A. ACCIDENT

Operator:	British Airways (BA)
Location:	Las Vegas, Nevada
Date:	September 8, 2015
Time:	1613 Pacific Daylight Time (PDT)[1]
Airplane:	Boeing 777-236ER (British registration G-VIIO)

B. OPERATIONAL FACTORS GROUP

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C. SUMMARY

On September 8, 2015, at about 1613 Pacific daylight time (PDT), a British Airways flight 2276, a Boeing 777-236ER, registration number G-VIIO, powered by two General Electric GE90-85BG11 turbofan engines experienced a No. 1 engine (left) uncontained failure and subsequent fire during the takeoff ground roll on runway 07L at McCarran International Airport (LAS), Las

[1] All times in the report will be in pacific daylight time, also known as Local Time, except as noted.
[2] Roger Cox (NTSB) was Ops Group Chairman until his retirement in March 2016.
[3] On April 6, 2016, Mr. Simmons had separated from Boeing and Captain Lisa A. Clark was assigned to the operational factors group.

Vegas, Nevada. The flightcrew aborted the takeoff, stopped the aircraft on runway 07L, and evacuated the airplane. The No. 1 engine, the inboard left wing, and a portion of the left and right fuselage experienced fire damage. The fire was extinguished by airport rescue and firefighting (ARFF) after the evacuation started. The 157 passengers, including 1 lap child, and 13 crew members evacuated via emergency slides on the runway. There were 19 minor injuries and 1 serious injury reported. The airplane was substantially damaged. The flight was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 129 flight from LAS to London-Gatwick International Airport (LGW) Horley, England.

D. DETAILS OF THE INVESTIGATION

The Operations Group was formed on October 20, 2015. Interviews with the two accident first officers were conducted on October 28, 2015, and an interview with the accident captain was conducted on November 13, 2015 at the NTSB offices in Washington, D.C. Flight documents, company manuals, and pilot training information were obtained and reviewed from BA, and manufacturer guidance was obtained from the Boeing Company. Pilot certification information was received from the United Kingdom's Civil Aviation Authority (CAA).[4]

E. FACTUAL INFORMATION

1.0 History of the flight

The crew consisted of a Captain (CA), First Officer (FO), Relief First Officer (RFO) and 10 flight attendants. The crew reported for duty on the day of the accident at 1500 at KLAS. The captain stated he had downloaded and reviewed the flight documents on his IPad prior to leaving the hotel, and discussed the flight plan documents with the flight crew in the van on the way to the airport. The flight time from KLAS to EGKK was projected for 9 hours 12 minutes, and according to the captain there were no unusual flight plan items, NOTAMs,[5] or fuel figures. The captain also briefed the cabin crew while on the van, but did not discuss any emergency procedures with them. He stated he had flown with some of the cabin crew on previous flights and he knew they were a senior crew.[6]

Preflight and boarding activities were uneventful and the flight departed the gate at 1555, ten minutes prior to the scheduled 1605 departure. The flight taxied to runway 7L via taxiway B for a takeoff from intersection A8. The weather was VFR at the time and the reported ambient temperature was 100°F (38°C) and the FO noted that taxi was slow due to the uphill gradient and hot pavement.

About 1612, the captain lined up for takeoff and advanced the engines to takeoff flex power. The captain was the pilot flying (PF) and the FO was the pilot monitoring (PM). According to the FO

[4] The Civil Aviation Authority (CAA) was the United Kingdom's aviation regulatory authority.
[5] Notice to Airmen.
[6] For additional information, see Attachment 1 - Combined Interviews.

and RFO sitting in the cockpit jumpseat,[7] during the takeoff roll they heard a "bang" or "thud" sound just before the airplane reached 80 knots (kts), and the airplane veered to the left. The captain announced he was stopping, retarded the thrust levers to idle, and began applying wheel brakes. As they were braking, the FO noticed the thrust levers began moving forward, and he disconnected the autothrottle (AT).[8] According to the pilots' interviews, no reverse thrust was selected and ground spoilers were not deployed.

As the airplane came to a stop the captain noticed the left (No. 1) engine exhaust gas temperature (EGT) indication turned red and the left engine fire indication came on, accompanied by an audible fire bell. The captain set the parking brake and called for the FIRE ENG LEFT checklist, and the FO performed the checklist memory items. As part of the memory items, the FO moved the left fuel control switch to fuel cutoff, pulled the left engine fire switch, and rotated the left fire switch to the stop to discharge the first fire bottle. He then selected the electronic checklist (ECL) on the multifunction display (MFD) in the cockpit to use the automatic 30 second timer, which provided a means to determine when to discharge the second fire bottle. Recorded data showed that the second fire bottle was discharged 15 seconds after the first bottle was discharged.

The RFO, who was seated in the cockpit jumpseat just aft and between the other two pilots, asked the captain if he should make an announcement to the passengers, and the captain approved. The RFO used the public address (PA) system to announce that passengers and cabin crew should remain seated. The RFO then noticed the shadow of a large cloud rising above the shadow of the fuselage, and he asked the captain if he should go into the cabin to investigate. The captain again approved. The RFO left the flight deck and met a cabin crewmember at door 2L, who said she had been trying to call the flight deck. The RFO observed black smoke, an orange glow, and a cabin window glass becoming "crazed."[9] He told a cabin crewmember to get ready to evacuate and returned to the flight deck.

While the RFO was in the cabin assessing the situation, the FO started the Auxiliary Power Unit (APU) in accordance with the follow up reference items on the engine fire checklist. When the RFO returned to the flight deck he reported they needed to get off the airplane immediately. The captain commanded the FO to call the tower, then utilized the PA (public address) system to order an evacuation, and activated the evacuation alarm.

According to interviews, the captain did not call for the evacuation checklist or pick up the quick reference handbook (QRH) to read and do the captain's checklist reference items. The captain stated he attempted to run his portion of the evacuation checklist from memory and he missed the second step of ensuring both engines were turned off.

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[7] BA used the term "heavy" to refer to the relief first officer (RFO) position, and "P3" to refer to the pilot occupying the jumpseat.

[8] Prior to reaching 80 kts, the B777 autothrottles will attempt to set takeoff power if the thrust levers were retarded with the autothrottles still engaged. After reaching 80 knots, the B777 AT went into HOLD mode and the thrust levers would remain in the manually set position.

[9] Per FAA Advisory Circular AC25.775-1, 5b (4) dated January 17, 2003 "Crazing is a network of fine cracks that extend over the surface … induced by prolonged exposure to surface tensile stresses above a critical level or by exposure to organic fluids and vapors."

The FO, who was referring to his portion of the QRH evacuation checklist, stated he spent between 15 to 20 seconds attempting to open the outflow valves (OFV) to depressurize the airplane for the evacuation, utilizing their respective switches on the cockpit overhead panel. However, recorded information showed the OFV selection switches remained in the automatic position. According to cockpit voice recorder information, a sound similar to the engine fire switches were pulled about 1613:20, followed about 2 seconds later by a sound, similar to the fire switch handle, being rotated. The other engine fire bottle was discharged about 3 seconds later, as called for in the evacuation checklist.

The RFO noticed the right engine EICAS[10] showed that the right (No. 2) engine was still operating. He pointed this out to the FO, who then moved the right engine fuel control switch to the fuel cutoff position. The FO stated he then also pulled the right engine fire switch.[11] According to data obtained from the flight recorders, the right engine had remained operating for approximately 44 seconds after the captain gave the evacuation command.

About the same time as the right engine was shutdown, the forward cargo bay fire warning light illuminated and the fire bell sounded in the cockpit. The captain reported he was the one who noticed this warning. While the captain was thinking about the cargo fire warning, he saw the other two pilots had donned their fluorescent jackets and were getting ready to exit the cockpit. The captain armed the cargo fire switch but was not certain if he discharged the fire bottles. Three of the five cargo fire bottles were found discharged.

All of the occupants and crew evacuated the airplane through various exits and slides. During the evacuation at least 2 of the cabin crew received minor and serious injuries.

2.0 Flight Crew Information

2.1 The Captain

According to BA records, CAA records and interview statements, the following information pertained to the captain:

Age at the time of the accident:	63
Date of hire at British Airways:	August 1973
Prior aviation employment:	flight school

The captain had been continuously employed at British Airways since August 1973, and had been a captain on the B777 for 20 years. He had not held a check airman or management position and he had no other duties at BA. He estimated he had approximately 30,000 hours of total flight time, of which approximately 15,000 hours were on the B777. Documentation provided by BA revealed

[10] Engine indication and crew alerting system.

[11] Investigators found the right engine fire switch in the "down" (not activated) position. For further information, see Systems Group Chairman's Factual Report.

about 12,000 hours were on the B777 and that he had about 15,000 total hours as Pilot in Command. He had previously flown the Tri-Star (L-1011)[12], DC-10[13], and B747-400, at BA.

The captain held a CAA class I medical certificate[14] dated April 28, 2015, with the limitation that he must have available corrective spectacles and carry a spare pair of spectacles[15]. The captain stated in an interview he was not wearing his spectacles at the time of the accident because he could see the instruments and outside the airplane without them and that the spectacles were only for reading.

According to CAA records, the captain had no prior accidents, incidents, or violations and had no record of training failures. The captain stated he had not had an engine fire previously in his career, except during simulator training, and had only had a rejected takeoff (RTO) once, on a narrow body Trident[16] many years before due to an instrument failure. He had never had to conduct an evacuation on an actual flight before. He further stated that he found the terms P1 and P2 confusing; however, during the accident flight the P1 was also the PF so it was not confusing.

The captain stated that the accident trip was a regular bid trip. He had previously flown with the FO but not with the RFO. He thought he had flown with the FO twice within the preceding 2-3 years. The captain had flown with some of the cabin crew before, but not with the cabin manager.[17]

2.1.1 The Captain's Recent Activities

The captain stated he was off duty on September 5 and 6. On his days off he went to bed around 2230Z[18] and arose around 0630Z, and none of his activities during the day were strenuous or out of the ordinary. He reported for duty at EGKK at 0845Z on September 7, 2015 and flew from EGKK to KLAS as a passenger. After arriving in KLAS on September 7, 2015, he recalled taking a walk and joining the RFO around 1800 local for a beer and a burger. He went to bed around 2100 and arose around 0400. He ate breakfast and did not sleep again during the day. He rested in his room at the hotel until his van pickup time.

The captain stated he had experienced an 8-hour time change in the last 24 hours and did feel "out of phase" with his body clock, but he stated overall he felt alright and it was sunny out, which helped. He stated "he was okay, but not as good as he could have been."[19]

2.1.2 The Captain's Training, Flight Currency and Certification

2.1.2.1 Training

A summary of the captain's recent training events at BA was as follows:

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[12] Lockheed Aircraft Corporation L-1011.
[13] McDonnell Douglas Aircraft Corporation DC-10.
[14] According to the "UK CAA Medical Certificate Validity Table" dated September 2014, V5.0, a Class 1medical was valid for pilots under 60 years of age for up to 12 months, and for pilots 60 years and older for 6 months.
[15] Source: NTSB Pilot/Owner Aircraft Accident/Incident Report 6120.1.
[16] Hawker Siddeley HS121.
[17] According to BA OM A this was also known as the senior cabin crew member or SCCM
[18] Universal Time Coordinated – UTC (Z). At the time of the accident PDT was UTC (Z) -7 hours.
[19] See Attachment 1 - Crew Interview Summaries.

TRNG – Recurrent Simulator Training	March 23, 2015
LOE – Line Oriented Evaluation	March 22, 2015
DGDS – Dangerous Goods	March 24, 2015
SECT – Security Training	March 24, 2015
SEPC – Safety Equipment	March 24, 2015
DAD – Ditching & Decompression	March 24, 2015
FIR – Fire Drill	March 24, 2015
DOEX – Doors & Exits	March 5, 2014
OPC – Operators Proficiency Check	September 19, 2014
LPC – License Proficiency Check	September 19, 2014
AWOP – All Weather Operations	September 19, 2014
RTC – Line Check	July 9, 2014
LFS – Leading Flight Safety	March 17, 2011

According to the captain's training record, on his 2014 proficiency check he was asked to repeat the RTO due *to "no a/t disconnect and failure to appreciate that autobrake was inactive due to slow speed at rejection."* On his 2013 proficiency check he practiced turning while stopping on the RTO, and on his 2012 proficiency check the following comment was noted *"De-brief points were related to declaration of emergencies, and engine shutdown policy on RTO etc."*

2.1.2.1 Flight Currency

According to BA records and interview summaries the following information was provided on the Captain's flight currency:

Flight Time, previous 24 hours	0
Flight Time, previous 7 days	15 hours[20]
Flight Time, previous 30 days	80 hours
Flight Time, previous 90 days	220 hours

2.1.2.1 Certification

According to information provided by the CAA, the captain held an EASA ATPL(A)[21] issued on July 23, 2013. He had received his initial United Kingdom ATPL(A) License on July 8, 1997 and was type rated on the B777 on April 14, 1999. CAA records also indicated the following licenses and ratings for the captain:

Single-engine Piston (Land)
Multiengine Piston (Land)
Night – Airplane
Instrument- Airplane

[20] According to documentation provided by BA, the captain had been on a 4-day trip beginning September 1, 2015 through September 4, 2015 and was on days off from September 5, 2015 and September 6, 2015.
[21] European Aviation Safety Agency Airline Transport Pilot License - Airplane

Type ratings in the B747 100-300 series, B747-400, B777/787, DC10, L1011.

2.2 The First Officer

According to BA records, CAA records, and interview statements, the following information pertained to the FO:

Age at the time of the accident:	30
Date of hire at British Airways:	January 2006
Prior aviation employment	flight school

The FO had been a B777 FO for 6 years, and prior to that he had been an Airbus A320 FO for 3 years. In an interview, the FO estimated he had approximately 7,000 total hours of flight experience, of which approximately 2,600 hours were in the B777. Documentation provided by BA indicated that the FO had approximately 6,400 hours of total flight experience of which 3,100 hours were in the accident aircraft make and model. He stated he had no pilot-in-command (PIC) time while employed at BA.

According to CAA records and his interview statement, the FO had no prior accidents, incidents or violations and had no record of training failures.

2.2.1 The FO's Recent Activities

In an interview, the FO stated he was off duty for a three-day period beginning Sunday, September 4, 2015 at his home in Dublin, Ireland. On September 5, 2015, he went to bed at about 2300Z[22] and arose the next day at about 0900Z and travelled as a passenger from his home to EGKK, and stayed at a hotel there overnight. He reported for duty on September 7, 2015 about 0945Z and operated the flight to KLAS. The flight departed about 1100Z and arrived in KLAS around 1400. He went to his room and to the pool, and then went to bed at 1830. He arose at 0300 September 8, 2015, had breakfast, and slept again from 0900 to 1130. The scheduled crew pickup for the event flight was at 1430. He stated he had no issues with food or health and he was alert and awake when he reported for duty.

2.2.2 The First Officer's Training, Flight Currency and Certification

2.2.2.1 Training

A summary of the FO's recent training at British Airways was as follows:

OPC – Operators Proficiency Check	September 3, 2015
LPC – License Proficiency Check	September 3, 2015
AWOP – All Weather Operations	September 3, 2015
TRNG – Recurrent Simulator Training	September 2, 2015
LOE – Line Oriented Flight Evaluation	March 27, 2015
RTC – Line Check	December 8, 2014
SECT – Security Training	December 4, 2014

[22] Dublin reverted to Irish Standard Time on October 25, 2015

SEPC – Safety Equipment	December 4, 2014
DGDS – Dangerous Goods	December 4, 2014
DAD – Ditching & Decompression	December 4, 2014
DOEX – Doors & Exits	October 30, 2013
FIR – Fire Drill	October 26, 2012
LFS – Leading Flight Safety	November 24, 2010

Following the FO's most recent LPC/OPC check on September 3, 2015, the examiner graded the FO's overall score as "Exceed," and commented "a very good LPC with all items completed. Well managed P1 sector with good NOTECHS[23] in evidence throughout." Under the area of teamwork, the examiner noted "calm style with appropriate advocacy and intervention."

2.2.2.1 Flight Currency[24]

According to BA records and interview summaries the following information was provided on the FO's flight currency:

Flight Time, previous 24 hours	0 hours[25]
Flight Time, previous 7 days	19 hours
Flight Time, previous 30 days	80 hours
Flight Time, previous 90 days	220 hours

According to the FO's statement, he operated a flight into KLAS on September 7, 2015.

2.2.2.1 Certification

According to information provided by the CAA, the FO held an EASA ATPL(A) issued on August 6, 2010, and he was type rated on the B777 on January 11, 2011. CAA records also indicated the following licenses and ratings for the FO:

Multiengine Piston (Land)
Night – Airplane
Instrument- Airplane
Type ratings in the B777/787 and A320

According to the FO, he held a CAA class I medical certificate with no restrictions, dated March 11, 2015.

2.3 The Relief First Officer

According to BA records, CAA records, and interview statements, the following information pertained to the RFO:

Age at the time of the accident:	45

[23] Non-Technical Skills. Source: Skybrary website http://www.skybrary.aero/index.php/Assessment_and_Feedback_of_Non-Technical_Skills_(OGHFA_BN)
[24] Source: British Airways
[25] Source: NTSB 6120 form completed by a British Airways Representative

Date of hire at British Airways:	November 1997
Prior aviation employment	Royal Air Force (RAF)

The Relief FO stated in an interview he had been a B777 FO for 14 years, and had been a B747 classic FO for 4 years prior to that. His flight experience while in the RAF included the HS125[26] and 3 years on the L-1011. He stated he had approximately 14,000 hours of total flight experience and approximately 10,000 hours of flight experience in the B777. He had not flown as pilot in command while employed with BA. He also stated he had no accidents, incidents, or violations.

2.3.1 The Relief FO's Recent Activities

The Relief FO stated he was off duty for two days beginning Monday, September 5, 2015. He was a "positioning" crewmember (non-flying) on the flight from EGKK to KLAS on September 7, 2015. That flight departed about 1100Z and arrived in KLAS around 1600. After landing he met his crew, had a light meal with wine and then went to bed and read. He awoke early on September 8, 2015, took a walk, and had breakfast. He got about 3 hours of rest, including 1 hour of sleep in the afternoon. He stated he expected to be able to get the first rest break in flight and sleep about 3 hours on the flight back to London. The airplane was equipped with a business or first class seat for him to use.

On the day of the accident he stated the crew pickup at the hotel was at about 1430 and "he felt he remained on English time." He had eaten, exercised, and rested during the day, and he felt alert and rested at the time he reported for duty.

2.3.2 The Relief FO's Training, Flight Currency and Certification

2.3.2.1 Training

A summary of the Relief FO's recent training at British Airways was as follows:

OPC – Operators Proficiency Check	June 21, 2015
LPC – License Proficiency Check	June 21, 2015
AWOP – All Weather Operations	June 21, 2015
TRNG – Recurrent Simulator Training	June 20, 2015
LOE – Line Oriented Flight Evaluation	November 12, 2014
RTC – Line Check	January 18, 2014
SECT – Security Training	December 2, 2014
SEPC – Safety Equipment	December 2, 2014
DGDS – Dangerous Goods	December 2, 2014
DAD – Ditching & Decompression	December 2, 2014
DOEX – Doors & Exits	November 13, 2013
FIR – Fire Drill	December 14, 2012
LFS – Leading Flight Safety	April 13, 2012

[26] Hawker Siddeley Aviation, LTD 125

Following the RFO's most recent LPC/OPC check on June 21, 2015, the examiner graded the FO's overall score as "Exceed," and commented "a very good performance in all areas. Nicely paced P1 sector, excellent NOTECHS, and plenty of spare capacity at all times. Minimal debrief required. Well done!" The RFO was graded as "exceed" in leadership and management, situation awareness, and teamwork.

2.3.2.1 Flight Currency

Flight Time, previous 24 hours	0 hours
Flight Time, previous 7 days	0 hours[27]

2.3.2.1 Certification

According to information provided by the CAA the RFO had the following pilot certificates:

EASA ATPL(A) – UK Conversion (issued on July 23, 2013)
United Kingdom ATPL(A) License (issued on July 9, 2004)
Type ratings in the B747 100-300 series, B777/787, HS125, L1011

CAA records also indicated the following licenses and ratings for the RFO:

Commercial Pilot – Airplane
Private Pilot – Airplane Single-engine Piston (Land)
Multiengine Piston (Land), Instructor – Airplane
Night – Airplane
Instrument- Airplane
Self-Launching Motor Gliders

The RFO also held type ratings for the B747 100-300 series, B747-400, B777/787, DC10, L1011. The RFO was type rated on the B777 on December 29, 2001.

The RFO held a class I CAA medical certificate with a limitation to fly as, or with, a copilot.

[27] According to documentation provided by BA, the RFO had been on a day off September 1, LPC on September 2, 2015, simulator duty on September 3, 2015, and had days off from September 4 through September 6, 2015. See Attachment 20 – Flight Crew Rosters 1st to 9th September

3.0 Airplane Information

Figure 1: Courtesy of JetPhots.net website

The accident airplane was a Boeing B777-236ER, British Registration G-VIIO, serial number 29320.

4.0 Weight and Balance[28]

The following weight and balance information was taken from the flight release and load sheet. Limitations were taken from the British Airways B777 Flight Crew Operating Manual, dated December, 2014.

Basic Operating Weight	324,333 lb. (147,115 kg.)
Total Payload	35,668 lb. (16,179 kg.)
156 adult passengers and one infant plus, baggage	
Zero Fuel Weight	360,001 lb. (163,294 kg.)
Maximum Zero Fuel Weight	430,000 lb. (195,044 kg.)
Fuel	140,000 lb. (63,504 kg.)
Ramp weight	500,001 lb. (226,798 kg.)
Maximum Taxi Weight	608,270 lb. (275,907 kg.)
Taxi Fuel	2,200 lb. (1,000 kg.)

[28] For additional information, see Attachment 3 - Flight Documents.

Takeoff Weight	497,801 lb. (225,798 kg.)
Maximum Takeoff Weight	606,270 lb. (275,000 kg.)
Planned trip fuel	123,270 lb. (55,914 kg.)
Planned landing weight	374,531 lb. (169,884 kg.)
Maximum landing weight	460,000 lb. (208,652 kg.)
Takeoff center of gravity (CG)	33.53% MAC[29]

For the takeoff, the forward CG limit was approximately 18.64% MAC and the aft CG limit was approximately 41.05% MAC, based on the BA load sheet.

5.0 Takeoff Performance

According to the flight's performance data uplink message, the maximum allowable takeoff weight from runway 7L, intersection A8 was 513,456 lb. (232,900 kg.) at the ambient temperature of 41°C (101°F). The actual takeoff weight of 497,800 lb. (225,800 kg.) allowed a slightly reduced, or de-rated (FLEX) takeoff power setting. Using an assumed temperature of 42°C, the performance data showed the aircraft could lift 507,500 lb. (230,200 kg.). The V speeds were V1 of 149 kts., VR of 149 kts., and V2 of 153 kts.

6.0 Relevant Systems

The following information has been obtained from the British Airways Boeing 777 Flight Crew Operations Manual (FCOM).

6.1 Engines

The airplane was powered by two General Electric GE90–85B engines. The engines were rated at 85,000 pounds of takeoff thrust each. Thrust was set by positioning the thrust levers, either automatically, by the autothrottle system, or manually by the flight crew. Engine indications were displayed on the EICAS display and any selected MFD. N1[30] and EGT were the primary engine indications. Normally, the EICAS was on the upper center display unit. If that unit failed, the EICAS display automatically moved to the lower center display unit.

6.1.1 Electronic Engine Controls (EEC)

Each EEC had full authority over engine operation. The EEC used thrust lever inputs to automatically control forward thrust and reverse thrust. The EEC had two control modes: normal and alternate. In both normal and alternate modes, the EEC used N1 fan speed as the parameter for setting thrust.

6.1.2 Engine Failure Alert System

The engine failure alert system provided alerts when actual engine performance was less than commanded engine performance during a part of the takeoff and for other phases of flight. A red ENG FAIL was displayed on the primary flight display (PFD) if actual thrust was less than

[29] Mean Aerodynamic Chord is the average distance between the leading and trailing edge of the wing as measured parallel to the normal airflow over the wind on a swept wing aircraft.
[30] Low Pressure Compressor.

commanded thrust during takeoff with airspeed between 65 knots and 6 knots prior to V1. The PFD display was accompanied by the voice annunciation ENGINE FAIL and the Master WARNING lights illuminating.[31]

6.2 Fire Detection and Protection

There were fire detection and extinguishing systems for the following:

- APU
- cargo compartments
- engines
- lavatories.

6.2.1 Engine Fire Warning[32]

There were two detector loops in each engine nacelle. Each detector loop provided both fire and overheat detection. Normally, both loops must detect a fire or overheat condition to cause an engine fire warning or overheat caution.

The indications of an engine fire were:

- the fire bell sounded
- the master WARNING lights illuminated
- the EICAS warning message FIRE ENG (L or R) was displayed
- the engine fire switch LEFT or RIGHT fire warning light illuminated
- the engine fire switch unlocked
- the engine FUEL CONTROL (L or R) switch fire warning light illuminated.

6.2.2 Engine Fire Extinguishing

There were two engine fire extinguisher bottles. Either or both bottles could be discharged into either engine. When the engine fire switch was pulled out, rotating the fire switch in either direction discharged a single extinguisher bottle into the associated engine. Rotating the engine fire switch in the other direction discharged the remaining extinguisher bottle into the same engine.

If an extinguisher bottle was discharged or had low pressure:

- the ENG BTL (1 or 2) DISCH light illuminated
- the EICAS advisory message BOTTLE (1 or 2) DISCH ENG was displayed.

[31] Source: British Airways Flight Crew Operations Manual – B777 "Warning Systems - System Description" pg. 15.20.5 dated June 2015

[32] Source: British Airways Flight Crew Operations Manual – B777 "Fire Protection – System Description" pg. 8.20.2 dated June 2012

6.2.3 Cargo Compartment Fire Protection

The cargo compartments had smoke detection and fire extinguishing capability. The forward and aft cargo compartments each had smoke detectors. Each compartment was divided into three detection zones. If smoke was detected in any zone, a fire warning occurred. The indications of a cargo compartment fire were:

- the fire bell sounded
- the master WARNING lights illuminated
- the EICAS warning message FIRE CARGO (FWD or AFT) was displayed
- the CARGO FIRE (FWD or AFT) fire warning light illuminated

Five fire extinguisher bottles were installed for cargo compartment fire extinguishing. Pushing the FWD or AFT CARGO FIRE ARM switch (ARMED visible) armed the extinguishers. On the ground, if a CARGO FIRE DISCHARGE switch was pushed, two extinguisher bottles discharged into the selected compartment, but only one of the remaining extinguisher bottles discharged after the time delay. When cargo fire extinguisher bottle discharge was initiated:

- The CARGO FIRE DISCHARGE switch light illuminated when the first two extinguisher bottles began to discharge.
- The EICAS advisory message BOTTLE DISCH CARGO was displayed when the first two extinguisher bottles had completely discharged.

6.3 Audio control panels

The audio control panels were used to manage the radio and interphone communication systems. Navigation receiver audio could also be monitored. The Captain, First Officer, and First Observer audio control panels were installed on the aft aisle stand (Figure 3). Microphones were keyed by pushing the desired audio control panel transmitter select switch and using the MIC position on the control wheel or audio control panel microphone/interphone switch, a glareshield MIC switch, or a hand microphone push–to–talk switch.

Figure 2: B-777 Audio Control Panel.[33] **[Courtesy of Boeing)**

6.4 Interphone communication system

The interphone communication system included the flight interphone, the cabin interphone, the service interphone, and the passenger address (PA) system.

The flight interphone system provided communications between flight deck crew members. The cabin interphone system provided voice communications between the flight deck and the flight attendant stations. The PA system was used by the flight crew to make cabin announcements. The service interphone system provided voice communications between ground crew stations at various locations around the airplane.

6.5 Cabin interphone system

EICAS communications alert messages and chimes alerted the pilots to incoming cabin calls. Priority calls from the cabin display the CABIN ALERT EICAS message. Priority calls automatically disconnected lower priority cabin interphone calls. Priority calls placed while a priority call was in progress were automatically connected as a conference call. Calls could be answered by selecting an audio control panel CAB transmitter select switch or, if a CAB transmitter select switch was already pushed in, by pressing a mic/interphone switch to the MIC position. Calls could also be answered or placed using the flight deck handset. Desired call locations were entered using the numeric keys on the handset. The handset PA push–to–talk switch was not required to operate the handset except for PA announcements.

6.6 Communication crew alerting system

The communication crew alerting system provided aural and visual alerts for normal operations requiring crew awareness that may require crew action. Visual alerts were presented as EICAS messages preceded by a bullet symbol (•). The aural alert was a high–low chime.

[33] Source: Boeing.

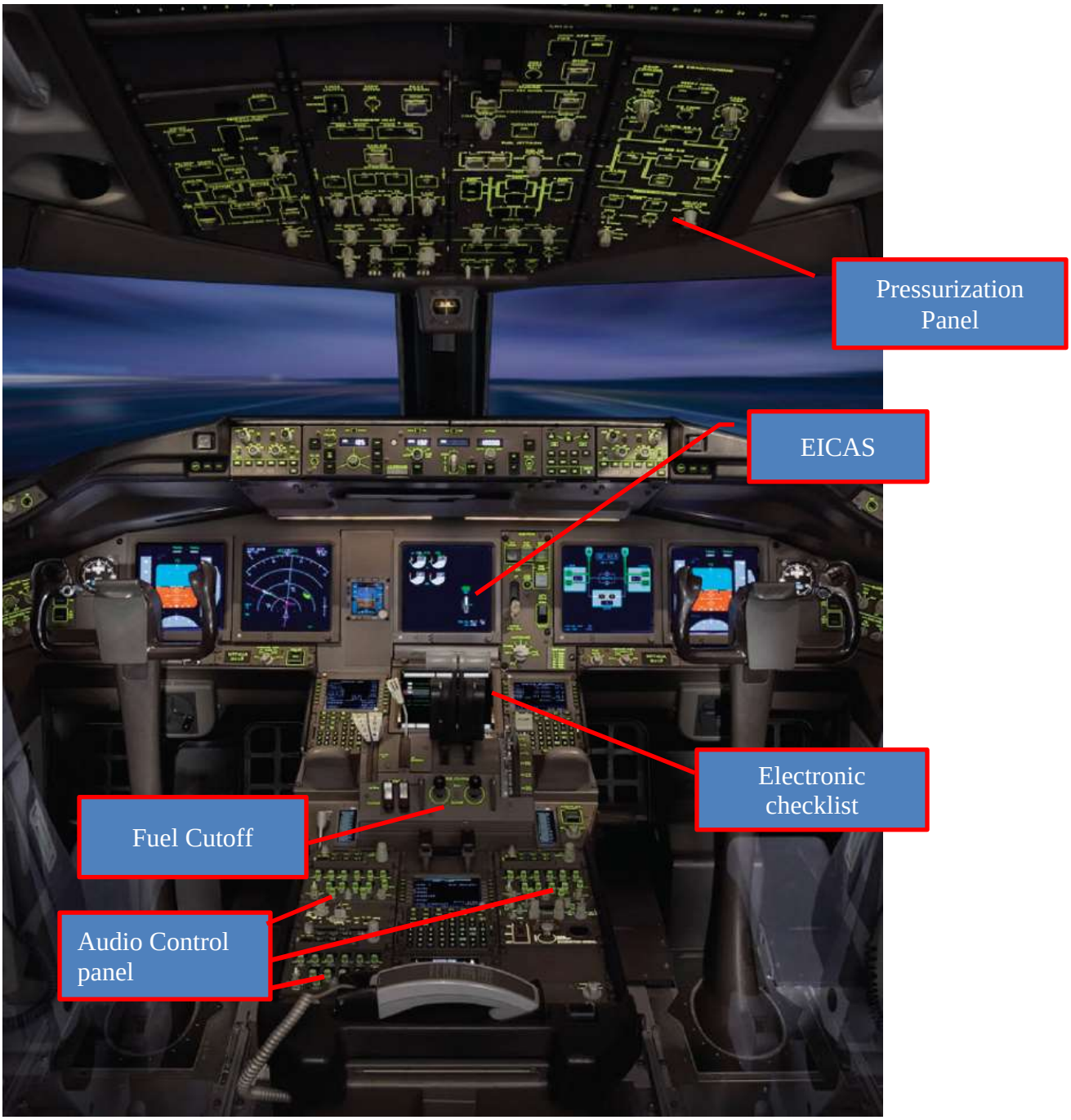

Figure 3: B777 Cockpit Layout - Courtesy of Boeing

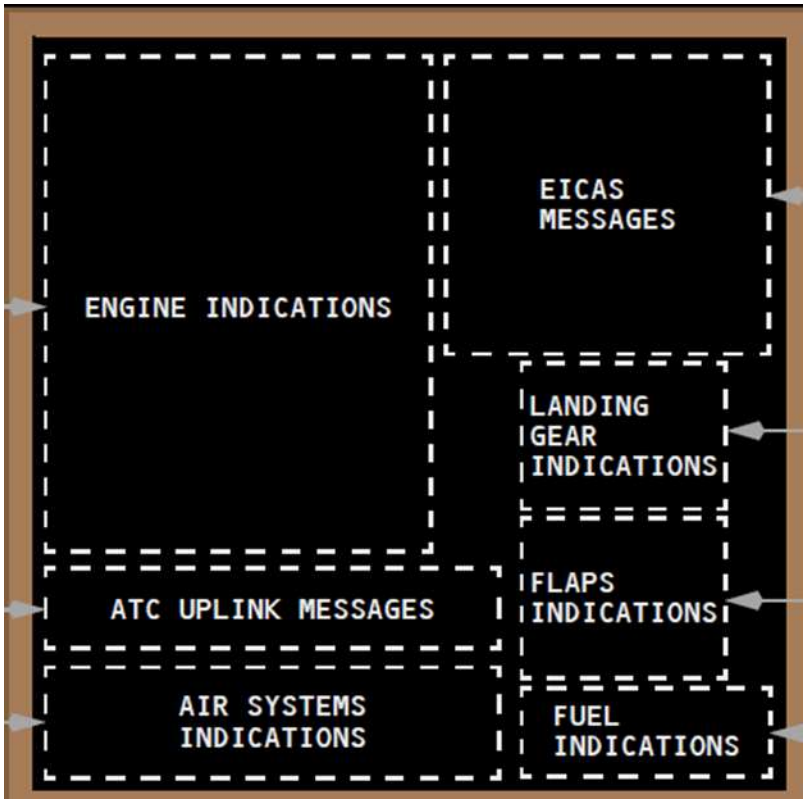

Figure 4: B-777 EICAS Display layout

6.7 Electronic Checklist

The electronic checklist (ECL) system showed normal and non-normal checklists on the MFD The electronic checklist system was not required for dispatch, and a paper checklist or other approved backup checklist must be available on the flight deck.

Three types of checklists could be shown on the MFD:

- normal
- non-normal for an EICAS message (annunciated)
- non-normal for a condition without an EICAS message (unannunciated)

Some checklist steps must be checked off by the flight crew to show as complete. Other checklist steps were automatically checked off from sensed flight deck control positions, airplane system status, or EICAS messages. The engine fire checklist was one of those checklist.

Closed loop action items continuously monitored the position of a flight deck switch, lever, or selector. In a few cases, actual system state, such as flap or landing gear position, was monitored. When the control was in the required position, the action item color changed to green and the complete indicator showed to the left of the action item. The current line item box then moved to the next incomplete line item. Open loop action items required the flight crew to manually confirm

completion with the cursor control device (CCD). Open loop action items did not monitor control position or system state.

Timers helped the flight crew keep track of time delays that were a part of checklists. The timer showed in the upper right hand corner of the checklist page. All timers were countdown timers. Timers were white when they are running. When the timer was finished, it showed ":00" and the color changed to amber. The current line item box did not move to the next incomplete line item until the line item with the timer was completed and the timer was finished.

6.8 Pressurization

Cabin pressurization was controlled by regulating the discharge of conditioned cabin air. Two outflow valves were installed: one forward and one aft. The pressurization system had automatic and manual operating modes. Other than accomplishing normal procedures for entering FMC data, no specific flight crew action was required for fully automatic operation.

For takeoff, the system supplied a small positive pressurization prior to rotation to cause a smooth cabin altitude transition to the cabin altitude climb schedule. At touchdown, the outflow valves opened to depressurize the cabin.

If both OUTFLOW VALVE switches were in MAN, all automatic cabin altitude control functions were bypassed. To operate either outflow valve manually, the respective outflow valve switch must be pressed to place it in MAN, and the open/close switch must be moved. (See Figure 5) The position of the respective outflow valve could be observed on the EICAS display (See Figure 3).

Boeing Environmental Control System (ECS) engineering provided the following explanation of ground operation of the pressurization system:

> *"The 777 pressurization system Ground Mode maintains both outflow valves in the full open position which results the cabin being fully equalized with ambient conditions. This mode is entered when the airplane is below 15,000 feet and weight on wheels is true or when weight on wheels is true and the airplane ground speed is less than 140kts. The 777 pressurization system uses a Takeoff Mode to pre-pressurize the airplane during the takeoff roll to 0.1 psid[34] to reduce the "pressure bump" experienced at rotation. This level of differential pressure is less than the Cabin Door Emergency Egress pressure. The Takeoff mode is entered when thrust is advanced such that N1 exceeds 60% on either engine and the airplane ground speed is at least 25kts and increasing."*

[34] Pounds per square inch differential.

Figure 5: B-777 Pressurization Panel.[35]

6.9 Emergency Evacuation Signal System

The emergency evacuation signal system alerted the flight attendants to evacuate the passenger cabin. Placing the flight deck evacuation signal COMMAND switch to ON activated the evacuation signal on the flight deck and on the flight attendant panels. With the flight deck evacuation signal COMMAND switch in the OFF (guard down) position, pressing an EVAC COMMAND switch on a flight attendant panel would activate the evacuation signals on the flight deck and on the flight attendant panels.

Figure 6: Emergency Evacuation Command Panel[36]

6.10 Airport Information

McCarran International Airport (KLAS) was the main commercial airport for the city of Las Vegas, Nevada, and was located about 5 miles south of downtown Las Vegas. It covered about

[35] Source: Boeing Aircraft
[36] Source: Boeing Aircraft

2,800 acres with four runways and two terminals. According to McCarran Airport records, the airport had 522,399 takeoffs and landings in 2014, of which 340,174 were air carrier flights. In 2014 there were a total of 3,344,648 international passengers arriving or departing KLAS, and 292,837 of those passengers flew on BA.

6.11 Airport Diagram and Notes

According to the FAA Airport Facility Directory[37], runway 7L was 14,512 ft. in length and 150 ft. in width, and had a gradient of 1.1% down. The surface was asphalt/porous friction course, in good condition. The runway was equipped with high intensity runway lights, non-precision runway markings, and a 4 light precision approach path indicator installed on the left side of the runway.[38] The runway length available from A8 intersection was 11,850 ft. At the time of the accident BA was utilizing LIDO[39] charts (figure 8). A review of the BA provided LIDO chart revealed that the runway length was in meters instead of feet as done in the NOS chart.

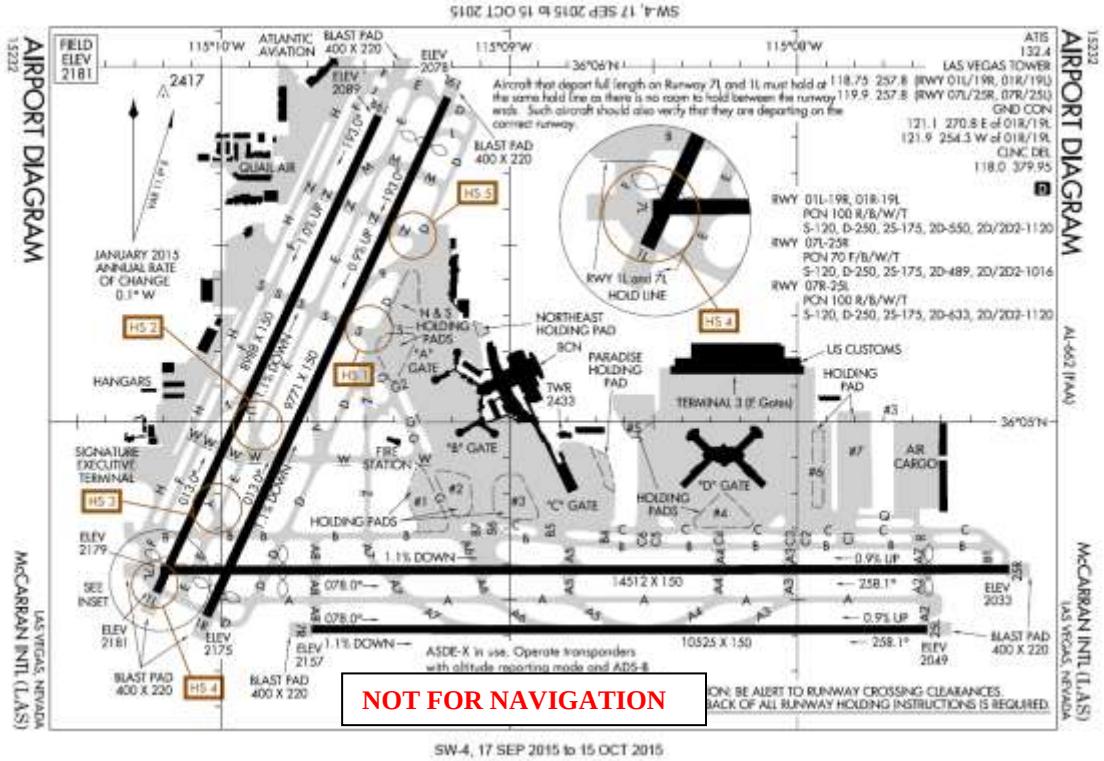

Figure 7: LAS Airport Diagram Chart[40]

[37] On March 31, 2016 the Airport Facility Directory became known as the Chart Supplement within the United States Source: FAA

[38] See attachment 19 – Airport Facility Directory

[39] LIDO charts provided navigational information and was produced by German based information technology company, Lufthansa Systems

[40] Source: FAA.

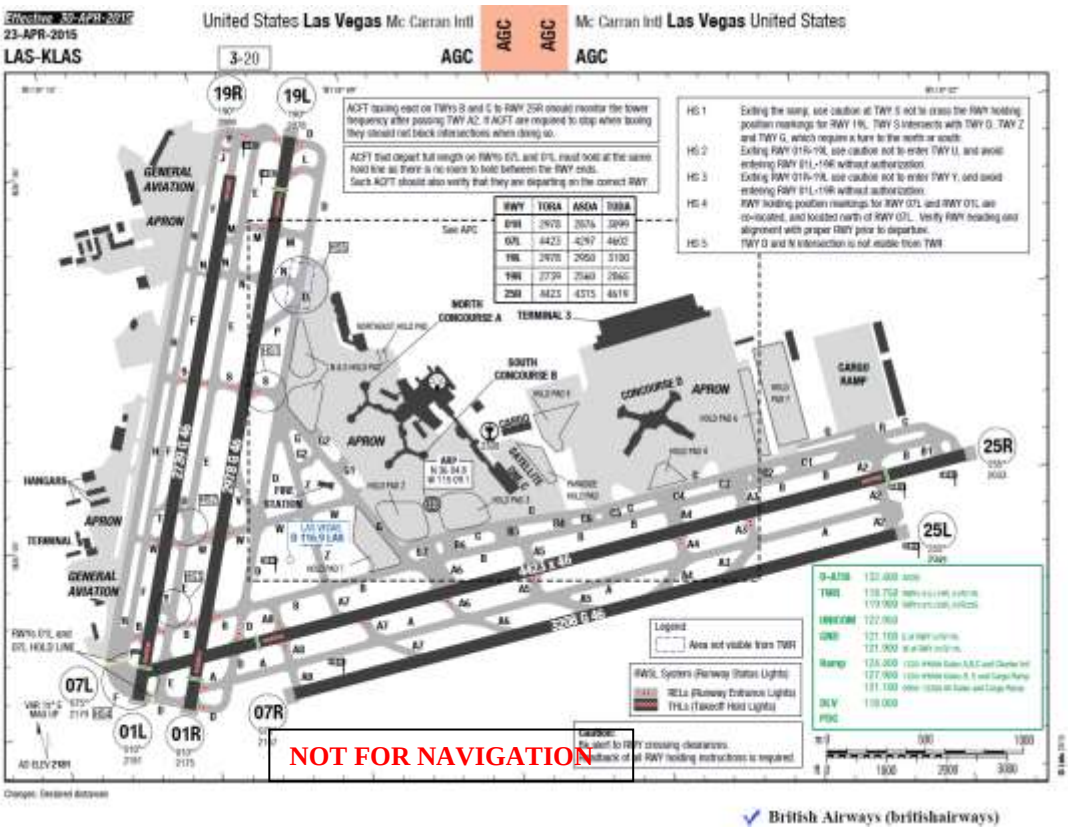

Figure 8 LIDO LAS Airport Chart[41]

7.0 British Airways Procedures

7.1 Company Procedural Guidance

BA procedural guidance to flight crews was located in several manuals. The BA OM A provided operational information of a general nature pertaining to all aircraft. The BA OM B contained specific aircraft information. The BA OM B was divided into BA B777 FCOM volumes I and II, a BA B777 FCOM QRH, and a BA B777 FCOM performance manual.

7.2 Cabin and Flight Crew Takeoff Briefing

The BA OM A, Section 1.4.4.c, "Cabin Service," dated October 2014, stated the following:

> *"Whilst British Airways delegates the responsibility for cabin service standards to the senior cabin crew member, the Commander is ultimately responsible that the service is delivered in a safe and secure manner and must brief the SCCM*[42] *on any relevant operational, safety or security requirements accordingly."*

41 Source: British Airways
42 Senior cabin crew member.

The BA OM A, Section 1.4.4.d, "Flight Crew Takeoff Briefing," dated October 2014, stated the following:

> *"Before every take-off the Commander must ensure that his/ her First Officer(s) is (are) familiar with the standard take-off briefing for the aircraft concerned. The 'heavy' crew member(s), who will be in the flight crew compartment for take-off, should listen to the departure briefing and contribute as required with any salient points in the briefing. A monologue style brief should be avoided and all crew members should participate in the briefing*
>
> *The Standard Take-off Briefing listed in the Checklists is intended as an aide-memoire of important items to be discussed during Briefing. Other items may be relevant to that departure and hence should be added as required. Because of their importance, procedures involving the shutting down of an engine should be regularly discussed during the pre-take-off briefing. It is accepted that when the same crew are on a multi-sector duty, the engine shut-down procedures need not be rehearsed in detail before every take-off. Commanders should, however, ensure that such a briefing is given on a regular basis. When time permits other checklists, particularly those involving memory items, should be regularly discussed and rehearsed"*

7.3 Allocation of Duties

The BA OM A, Section 8.3.2, "Allocation of Duties," dated May 2015, provided definitions for flight crew roles and responsibilities.[43] In addition to captain, first officer, pilot flying (PF) and pilot monitoring (PM), BA added the role of P1 as "duties allocated to the commander, which may be assigned to the other pilot at his/her discretion," and P2 as "duties allocated to the first officer." P2 was further defined as "In role reversal or PICUS[44], at the Commander's discretion, P1 and P2 duties may be exchanged wholly or in part."

The section further stated the commander must assess any exceptional workload associated with non-normal conditions and assign revised duties as necessary. It also stated that each flight started out with PF duties undertaken by P1 and PM duties undertaken by P2.

The definition of P3 was not provided, but the accident pilots used that term to describe the RFO. Another term used by BA to refer to the RFO was "heavy" crewmember.

7.4 Emergencies on the Runway

The BA OM A, Section 8.28.11.d, "Emergencies on the Runway, dated May 2015, stated the following:

> *"After a rejected take-off or an emergency landing the aircraft should normally be brought to a halt on the runway and the emergency evaluated quickly before taxying clear. Stopping*

[43] See attachment 7, - British Airways Allocation of Duties.
[44] Pilot in command under supervision.

the aircraft expeditiously is of prime importance. If required, an evacuation must be initiated promptly. If not required, the Commander will make the announcement:

'Passengers and Crew remain seated and await further instructions.'

Alternatively, the Commander may delegate this responsibility, after suitable briefing, to the SCCM. ATC should be informed and the Fire Services normally requested to stand down. However, in the event of any fire on the ground, even in light winds, consideration should be given to turning the aircraft so that any wind will blow the fire/smoke away from the fuselage. This consideration will also take account of the relevant factors, runway width, and supporting indications from both inside and outside of the aircraft. Generally, in headwind conditions any turn towards the fire will be beneficial. Similarly, in tailwind conditions, any turn away from the fire will be beneficial."

7.5 Fire on the Ground – Discharge of Cargo Hold Fire Bottles

The BA OM A, Section 8.28.11.h.i, "Fire on the Ground – Discharge of Cargo Hold Fire Bottles," dated May 2015, stated the following:

"Fire bottles will not be discharged in the under floor cargo holds while the aircraft is on the ground with the cargo doors open, unless the crew are independently advised of actual fire and all personnel are clear."

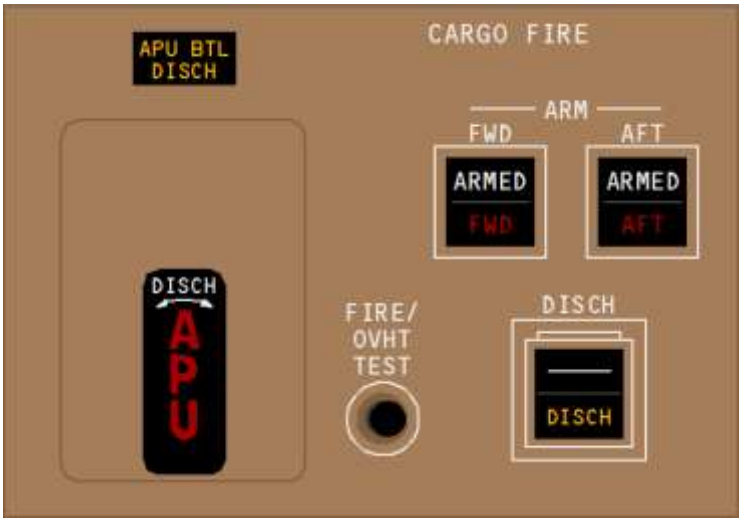

Figure 9: B-777 Cargo Fire Control Panel.[45]

7.6 BA B777 FCOM Quick Reference Handbook (QRH)

The BA B777 QRH was a laminated ring-bound booklet containing normal and non-normal ground and flight procedures. Two copies of the QRH were provided on the flight deck, one for the captain and one for the FO. The QRH's were normally stowed in storage inserts in the forward instrument panel when not in use.

[45] Source: Boeing Aircraft Corporation

7.7 Non-Normal Checklist Operation

The BA B777 QRH provided guidance on non-normal checklist operation on pages CI.2.1 through CI.2.6.[46] Following are excerpts from this section:

"Most checklists correspond to an EICAS alert message. The EICAS alert message indicates a non-normal condition and is the cue to select and do the associated checklist."

"A rectangle icon [] precedes all EICAS alert messages that have procedural steps, notes, or other information of which the flight crew should be aware. The rectangle icon is removed from the EICAS message when the checklist has been completed. In the printed non–normal checklists, the titles also have the rectangle icon to agree with the EICAS alert message"

"Checklists can have both memory and reference items. Memory items are critical steps that must be done before reading the checklist. In the printed non-normal checklists, the last memory item is followed by a dashed horizontal line. In the electronic checklists, memory items are not identified. Reference items are actions to be done while reading the checklist"

"*In some multiple failure situations, the flight crew may need to combine the elements of more than one checklist. In all situations, the captain must assess the situation and use good judgment to determine the safest course of action"*

"It must be stressed that for smoke that continues or a fire that cannot be positively confirmed to be completely extinguished, the earliest possible descent, landing, and evacuation must be done."

"When a non–normal situation occurs, at the direction of the pilot flying, both crewmembers do all memory items without delay"

"The pilot flying calls for the checklist when:

- *the flight path is under control*
- *the airplane is not in a critical phase of flight (such as takeoff or landing)*
- *all memory items are complete.*

The pilot monitoring reads aloud:

- *the checklist title*
- *as much of the objective statement (if applicable) as needed to understand the expected result of doing the checklist*

[46] See attachment 5 – Non-Normal Checklist Instructions – British Airways

The pilot flying does not need to repeat this information but must acknowledge that the information was heard and understood"

"The word "Confirm" is added to checklist items when both crewmembers must verbally agree before action is taken. During an inflight non-normal situation, verbal confirmation is required for:

- *an autothrottle arm switch*
- *an engine thrust lever*
- *a fuel control switch*
- *an engine or APU fire switch, or a cargo fire arm switch*
- *a generator drive disconnect switch.*

The pilot monitoring places his hand on the lever or switch to be identified and states the checklist challenge for that control, e.g. "LEFT THRUST LEVER". Pilot Flying observes the identified lever or switch and states "CONFIRMED".

"With the airplane stationary on the ground:

- *the PF calls for any non-normal checklist and the PM takes action. PF is not required to monitor PM's actions.*

When the aeroplane becomes stationary after a rejected takeoff (RTO):

- *the Captain becomes P1, calls for any non-normal checklist and the P2 takes action.*

With the airplane in flight or in motion on the ground:

- *the PF calls for any Non-Normal Checklist and the PM takes action. PF confirms critical actions in accordance with the Non-Normal Checklist.*

After moving the control, the PM also states the checklist response."

"Closed loop (sensed) checklist items change from white to green when the action is taken. The pilot monitoring must "check off" any open loop (not sensed) items and verify that all closed loop items are green."

"In the printed non-normal checklists, each checklist has a checklist complete symbol at the end. The symbol consists of four bold squares centered on the page.

7.8 Electronic Checklist Operation

The BA B777 QRH, page CI.1.2, Electronic Checklist Operation, dated May 2014, stated the following:

"Operation with the electronic normal checklist is the same as the printed normal checklist except that, there is no need to read aloud or visually confirm items that are complete (green). For all checklists, the PM announces "___ CHECKLIST COMPLETE," the PF visually confirms that the CHECKLIST COMPLETE indication is shown, and announces "CHECKLIST COMPLETE."

Closed loop (sensed) checklist items change from white to green when the action is taken. The PM is responsible to check off any open loop (not sensed) item and to verify that all closed loop items are green. See Chapter 10, Flight Instruments, Displays, for a complete description of the electronic checklist system.

A checklist should not be opened/started until the procedure is complete and all items can be checked off."

7.9 Rejected Takeoff Procedure

The RTO procedure, dated December 2014, was located within the Maneuvers section beginning at page MAN.1.3 of the QRH and was considered a "Non-Normal Maneuver." Flight crews were expected to do non-normal maneuvers from memory. The procedure was divided into two distinct responsibilities: Pilot Flying and Pilot Monitoring. The guidance provided by the QRH included the following:

The decision to reject the takeoff must be made in time to start the maneuver by V1. The Captain shall call "STOP" if the takeoff is to be rejected, or "CONTINUE" if the takeoff is to be continued. If "STOP" is called, PF shall immediately start the rejected takeoff maneuver. The First Officer is authorized to call "STOP" for items marked with an asterisk.

Prior to 80 knots, the Captain (or First Officer where permitted) should call "STOP" for any of the following:

- *activation of the master caution system*
- *system failure(s)*
- *unusual noise or vibration*
- *tire failure*
- *abnormally slow acceleration*
- *takeoff configuration warning*
- *fire or fire warning**
- *engine failure**
- *predictive windshear warning**
- *RAAS runway alert**
- *if the airplane is unsafe or unable to fly*

Above 80 knots and prior to V1, the Captain or First Officer shall call "STOP" for any of the following:

- *fire or fire warning**
- *engine failure**

*• predictive windshear warning**
• if the airplane is unsafe or unable to fly

At all times when the First Officer is PF he may, in addition call "STOP" for a significant handling difficulty or a blocked runway.
During the takeoff, the crew member observing the non-normal situation will immediately call it out as clearly as possible.

Pilot Flying	Pilot Monitoring
Without delay: Simultaneously close thrust levers, disengage autothrottles, and apply maximum manual wheel brakes or verify operation of RTO autobrakes. If RTO autobrakes is selected, monitor system performance and apply manual wheel brakes if the AUTOBRAKE message is displayed or deceleration is not adequate. Verify speedbrake lever UP. Continue maximum braking until certain the airplane will stop on the runway.	Verify actions as follows: Thrust levers closed. Autothrottles disengaged. Maximum brakes applied. Apply reverse thrust up to the maximum amount consistent with conditions. Verify the speedbrakes are extended, if not manually select speedbrake lever UP, and call "SPEEDBRAKES UP." If speedbrake lever cannot be selected UP call "SPEEDBRAKES NOT UP." When both REV indication(s) are green, call "REVERSERS NORMAL". If there is no REV indication(s) or the indication(s) stay amber, call "NO REVERSER LEFT ENGINE", or "NO REVERSER RIGHT ENGINE" or "NO REVERSERS". Call out any omitted action items.
When speed is decreasing below 60 knots and Field Length permitting, call "REVERSE IDLE." Safe stop assured and taxi speed reached call "FORWARD IDLE." Stop on the runway. Set Parking Brake.	Call out 60 knots. Initiate movement of the reverse thrust levers to be at the reverse idle detent before taxi speed. **Note:** If stopping from below 60 knots only reverse IDLE is required.

Figure 10: BA B-777 rejected takeoff procedures.[47]

The BA QRH RTO procedure goes on to provide the following:

[47] Source: BA QRH

When the Parking Brake is set, the Captain shall take control and assume the role of P1 by calling "I HAVE CONTROL".

When the airplane is stopped, perform procedures as required. The Captain's primary responsibility is to co-ordinate all subsequent activity to ensure a safe outcome; the First Officer may therefore conduct Non Normal checklists unmonitored at the Captain's command. The Captain should communicate the reject decision to the control tower as soon as practical.

7.10 Engine Fire Procedure

The B777 engine fire procedure was provided in the BA QRH and displayed electronically on the multifunction display (MFD). The title of the procedure was **[ ]** FIRE ENG L, R.[48] The first five items of the checklist pertained to the affected engine and were to be performed from memory, items 6 through 9 were to be performed by reference to the checklist:

1 A/T ARM switch……. confirm……. OFF
2 Thrust lever……. confirm…….Idle
3 FUEL CONTROL switch...confirm……..CUTOFF
4 Engine fire switch…….confirm……. Pull
5 If the FIRE ENG message stays shown:

Engine fire switch……. Rotate to the stop and hold for 1 second

If after 30 seconds, the FIRE ENG message stays shown:

Engine fire switch……Rotate to the other stop and hold for 1 second

6 APU selector……..START, then ON
7 Transponder mode selector……TA ONLY
8 Plan to land at the nearest suitable airport
*9 Do **not** accomplish the following checklist: AUTOTHROTTLE*

The remaining items of the engine fire checklist pertained to actions to be taken in flight in preparation for landing.

7.11 Forward Cargo Fire Procedure

The B777 forward cargo fire procedure was provided in the BA QRH and displayed electronically on the multifunction display (MFD). The title of the procedure was [ ] FIRE CARGO FWD[49]. There were no memory items. There were three steps to be accomplished by reference if the airplane was on the ground:

1 FWD CARGO FIRE ARM switch…..confirm.....ARMED

[48] See attachment 10 - Engine Fire Procedure.
[49] See attachment 13 - Forward Cargo Fire Procedure.

2 CARGO FIRE DISCH switch……..Push and hold for 1 second
3 Warning! Inform ground personnel NOT to open any cargo door until all passengers and crew have exited the airplane and firefighting equipment is nearby.

7.12 Emergency Evacuation Checklist Handling

The BA B777 FCOM QRH, page CI 2.7, dated June 2012, stated the following:

> *"The Captain will decide if an evacuation is necessary.*
>
> *Whenever an evacuation is required, the Evacuation Checklist must be used. The aircraft will be brought to a halt and the parking brake will be set. The checklist is a reference procedure like other non-normal checklists but it is split into areas of responsibility.*
>
> *All other checklists will be stopped. The Evacuation Checklist is independent of other non-normal checklists.*
>
> *If the aircraft has left the paved surface, the engine fire handles should be discharged."*

7.13 Evacuation Checklist

The BA B777 Evacuation procedure, dated June 2013, provided on the back cover of the BA QRH. The checklist was to be read and performed by each pilot for their respective positions. The evacuation checklist was as follows[50]:

CAPTAIN

1. *PARKING BRAKE……Set*
2. *FUEL CONTROL switches (both)……CUTOFF*
3. *PA…….. "This is an Emergency. Evacuate, Evacuate (Hazard at__)"*
4. *EVAC COMMAND Switch……ON*
5. *Notify ATC/Ground Crew of evacuation.*

FIRST OFFICER

1. *OUTFLOW VALVE switches (both)……MAN*
2. *OUTFLOW VALVE MANUAL switches (both)…. Hold in OPEN*
   Until the outflow valve indications show
   Fully open to depressurize the airplane
3. *Engine fire switches (both)…… PULL*

The evacuation procedure included the following warning:

[50] See attachment 12 - BA Evacuation Procedure.

Warning! Do not pull the ENGINE FIRE switches before the FUEL CONTROL switches are in the CUTOFF position.

4. *APU fire switch…… Override and Pull*
5. *If an engine or APU fire warning occurs:*
   Related fire switch……..Rotate to the stop and hold for 1 second

7.14 Unplanned Emergencies

The BA OM B manual, Section 3 *"Emergency Aircraft Procedures"* stated the following:

> *Unplanned Emergencies are those that take place with little or no warning. These might occur immediately after takeoff or immediately prior to or after landing. This type of emergency is typically the most critical case and success will depend upon the competence and initiative of the crew.*
>
> *The following are examples of unplanned emergencies:*
> - *An emergency on landing;*
> - *A Rejected Take-off (RTO);*
> - *An emergency with landing imminent*
>
> *The commander will endeavor to give as much information as possible in the time available.*

The section goes on to provide the following guidance to the cabin crew:

> *Once the aircraft has stopped the Commander will assess the situation. If an immediate evacuation is not required, the Commander will make the announcement:*
> *"PASSENGERS AND CREW REMAIN SEATED AND AWAIT FURTHER INSTRUCTIONS."*
>
> *This call is intended to signal to the cabin that the situation has been/is being assessed and that the commander believes that there is no immediate threat to the aircraft.*
>
> *This should not inhibit cabin crew from initiating an evacuation if the situation is clearly catastrophic. Also, if on hearing this call, a cabin crew member at any location in the aircraft believes that there is a threat to the aircraft of which flight crew should be made aware, the call will prompt them to feed this information back up the chain of command to the Commander.*

Section 3 of BA's OM B provided further guidance on the initiation of the evacuation:

> *In the event of a passenger evacuation being initiated by the Commander, and before activating the evacuation alarm, the Commander will announce on the PA:*

"This is an emergency, evacuate, evacuate."

He/she should give guidance concerning hazards at doors using the phrase:

"Hazard at _____"

Unless there are other compelling reasons, internal or external visual information should be taken into account before initiating and evacuation. A Flight Deck warning may be due to a faulty warning system rather than representing a compelling reason to evacuate."

The next subsection of Section 3 included the following warning:

WARNING: Only open exits not affected by fire or other hazard.

7.15 BA Pilot Training

7.15.1 Rejected Takeoff Maneuver (RTO)

According to the BA 777/787 Flight Crew Training Manual, Chapter 3 *"Takeoff and Initial Climb"* page 3.26 *"Rejected Takeoff Maneuver"*

The RTO maneuver is initiated during the takeoff roll to expeditiously stop the airplane on the runway. The PM should closely monitor essential instruments during the takeoff roll and immediately announce abnormalities, such as "ENGINE FIRE", "ENGINE FAILURE", or any adverse condition significantly affecting safety of flight. The decision to reject the takeoff must be made before V1 speed.

Note: If the decision is made to reject the takeoff, the flight crew should accomplish the rejected takeoff non-normal maneuver as described in the Maneuvers Chapter of the QRH.

If the takeoff is rejected before the HOLD annunciation, the autothrottle should be disconnected as the thrust levers are moved to idle. If the autothrottle is not disconnected, the thrust levers advance to the selected takeoff thrust position when released. After HOLD is annunciated, the thrust levers, when retarded, remain in idle. For procedural consistency, disconnect the autothrottles for all rejected takeoffs.

The 2015 "Check A – Day 2" training scenario given to all BA flight crews, during their respective simulator training, included a tire failure at 30 kts followed by a TIRE PRESSURE EICAS message at 60 kts. The training also included an APU FIRE which was preset for 80 kts.

The 2014 "Check G – Day 1" training scenario, given to all BA flight crews, during their respective simulator training, included an ENG R COMPRESSOR STALL, which was preset for 80 kts and was designated as the FO's RTO. The Captains RTO was an ENG L FAIL which was preset for 100 kts.

7.15.2 Evacuation

According to the BA 777/787 Flight Crew Training Manual Chapter 8 *"Non-Normal Operations"* page 8.10: *"Evacuation"*

If an evacuation is planned and time permits, a thorough briefing and preparation of the crew and passengers improves the chances of a successful evacuation. Flight deck preparations should include a review of pertinent checklists and any other actions to be accomplished. Appropriate use of autobrakes should be discussed. If evacuating due to fire in windy conditions, consider positioning the airplane so the fire is on the downwind side.

Notify cabin crew of possible adverse conditions at the affected exits. The availability of various exits may differ for each situation. Crewmembers must make the decision as to which exits are usable for the circumstances.

For unplanned evacuations, the captain needs to analyze the situation carefully before initiating an evacuation order. Quick actions in a calm and methodical manner improve the chances of a successful evacuation.

8.0 Boeing Guidance

Boeing utilizes the terms captain, first officer, pilot flying (PF) and pilot monitoring (PM).

8.1 Rejected Takeoff Maneuver

According to the Boeing 777 Flight Crew Training Manual, page 3.22, dated June 30, 2013, the following guidance was provided:

> *The RTO maneuver is initiated during the takeoff roll to expeditiously stop the airplane on the runway. The PM should closely monitor essential instruments during the takeoff roll and immediately announce abnormalities, such as "ENGINE FIRE", "ENGINE FAILURE", or any adverse condition significantly affecting safety of flight. The decision to reject the takeoff is the responsibility of the captain, and must be made before V1 speed. If the captain is the PM, he should initiate the RTO and announce the abnormality simultaneously.*
>
> ***Note:*** *If the decision is made to reject the takeoff, the flight crew should accomplish the rejected takeoff non-normal maneuver as described in the Maneuvers Chapter of the QRH.*
>
> *If the takeoff is rejected before the HOLD annunciation, the autothrottle should be disconnected as the thrust levers are moved to idle. If the autothrottle is not disconnected, the thrust levers advance to the selected takeoff thrust position when released. After HOLD is annunciated, the thrust levers, when retarded, remain in idle. For procedural consistency, disconnect the autothrottles for all rejected takeoffs.*
>
> *If an engine failure occurs above TAC activation speed, TAC provides rudder input, as needed, to help maintain directional control. TAC rudder input is available during forward*

thrust operations only, until speed is reduced below TAC activation speed. With TAC inoperative, the PF must make rudder inputs.

If rejecting due to fire, in windy conditions, consider positioning the airplane so the fire is on the downwind side. After an RTO, comply with brake cooling requirements before attempting a subsequent takeoff.

8.2 Rejected Takeoff Procedure

The RTO procedure was located within the Maneuvers section beginning at page MAN.1.3 of the Boeing QRH, was considered a "Non-Normal Maneuver,", and was dated June 15, 2015. Flight crews were expected to do non-normal maneuvers from memory. The procedure was divided into two distinct responsibilities, Captain and First Officer. According to the guidance provided by the QRH:

The Captain has the sole responsibility for the decision to reject the takeoff. The decision must be made in time to start the rejected takeoff, the Captain must clearly announce "REJECT," immediately start the rejected takeoff maneuver, and assume control of the airplane. If the First Officer is making the takeoff, the First Officer must maintain control of the airplane until the captain makes a positive input to the controls.

Prior to 80 knots, the takeoff should be rejected for any of the following:

- *activation of the master caution system*
- *system failure(s)*
- *unusual noise or vibration*
- *tire failure*
- *abnormally slow acceleration*
- *takeoff configuration warning*
- *fire or fire warning*
- *engine failure*
- *predictive windshear warning*
- *if a side window opens*
- *if the airplane is unsafe or unable to fly*

Above 80 knots and prior to V1, the takeoff should be rejected for any of the following:

- *fire or fire warning*
- *engine failure*
- *predictive windshear warning*
- *if the airplane is unsafe or unable to fly*

During the takeoff, the crew member observing the non-normal situation will immediately call it out as clearly as possible.

Captain	First Officer
Without delay:	Verify actions as follows:
Simultaneously close thrust levers, disconnect autothrottles, and apply maximum manual wheel brakes or verify operation of RTO autobrakes.	Thrust levers closed. Autothrottles disconnected. Maximum brakes applied.
If RTO autobrakes is selected, monitor system performance and apply manual wheel brakes if the AUTOBRAKE message is displayed or deceleration is not adequate.	Reverse thrust applied. Verify speedbrake lever UP and call "SPEEDBRAKES UP." If speedbrake lever not UP call "SPEEDBRAKES NOT UP."
Apply reverse thrust up to the maximum amount consistent with conditions. Verify the speedbrakes are extended. Continue maximum braking until certain the airplane will stop on the runway.	When both REV indication(s) are green, call "REVERSERS NORMAL" If there is no REV indication(s) or the indication(s) stay amber, call "NO REVERSER LEFT ENGINE", or "NO REVERSER RIGHT ENGINE" or "NO REVERSERS" Call out any omitted action items.
Field length permitting: Initiate movement of the reverse thrust levers to reach the reverse idle detent by taxi speed.	Call out 60 knots. Communicate the reject decision to the control tower and cabin as soon as practical.
When the airplane is stopped, perform procedures as required. Review Brake Cooling Schedule for brake cooling time and precautions (refer to the Performance Inflight chapter). Consider the following: • the possibility of wheel fuse plugs melting • the need to clear the runway • the requirement for remote parking • wind direction in case of fire • alerting fire equipment • not setting the parking brake unless passenger evacuation is necessary • advising the ground crew of the hot brake hazard • advising passengers of the need to remain seated or evacuate • completion of Non-Normal checklist (if appropriate) for conditions which caused the RTO	

Figure 10: Boeing Quick Reference Handbook Pg. MAN.1.3 dated June 15, 2015

8.3 Engine Fire

The B777 engine fire procedure was provided in the Boeing QRH in the "Non-Normal Checklists" Section 8 "Fire Protection" and was also able to be displayed electronically on the multifunction display (MFD). The title of the procedure was [ ] FIRE ENG L, R.[51] The first five items of the checklist pertained to the affected engine and were to be performed from memory, items 6 through 9 were to be performed by reference to the checklist:

1 A/T ARM switch…… confirm…… OFF

[51] See attachment 15, "Engine Fire Procedure - Boeing"

2 Thrust lever…… confirm……..Idle
3 FUEL CONTROL switch...confirm……..CUTOFF
4 Engine fire switch…….confirm…… Pull
5 If the FIRE ENG message stays shown:

Engine fire switch…… Rotate to the stop and hold for 1 second

If after 30 seconds, the FIRE ENG message stays shown:

Engine fire switch……Rotate to the other stop and hold for 1 second

6 APU selector……..START, then ON
7 Transponder mode selector……TA ONLY
8 Plan to land at the nearest suitable airport
*9 Do **not** accomplish the following checklist…… AUTOTHROTTLE*

8.4 Evacuation Checklist

The Boeing B777 Evacuation procedure designated which crew member was to perform each sequential action (C for captain, F/O for FO). The checklist, provided on the back cover of the QRH, dated December 12, 2011, was as follows[52]:

1. *Parking Brake…….. Set* *C*
2. *OUTFLOW VALVE switches (both)……MAN* *F/O*
3. *OUFLOW VALVE MANUAL switches (both)…. Hold in OPEN until the outflow valve indications show fully open to depressurize the airplane* *F/O*
4. *FUEL CONTROL switches (both)…….CUTOFF* *C*
5. *Advise the cabin to evacuate* *C*
6. *Advise the tower* *F/O*
7. *Engine fire switches (both)……PULL* *F/O*
8. *APU fire switch…… Override and pull* *F/O*
9. ***If** an engine or APU fire warning occurs:*

   Related fire switch……..Rotate to the stop and hold for 1 second *F/O*

9.0 Previous Recommendations and Guidance

9.1 United Kingdom Safety Recommendation 2015-005

On July 14, 2015 the UK AAIB issued the following safety recommendation after a May 24, 2013 accident at London Heathrow Airport involving a British Airways Airbus A310-131in which the engine cowls became detached from the engine and led to an engine fire and subsequent evacuation:[53]

[52] See attachment 14, Boeing Evacuation Checklist
[53] See https://www.gov.uk/aaib-reports/aircraft-accident-report-1-2015-airbus-a319-131-g-euoe-24-may-2013

It is recommended that British Airways Plc reviews its evacuation procedures and training to take account of the potential risks of leaving engines running during on-ground emergencies.

The latest response from BA dated November 27, 2015 was:

The Recommendation 2015-005, to review the evacuation procedures has been completed; however, the action remains open as a result of a recommendation in the British Airways investigation into the evacuation of the 777-200 in Las Vegas in September 2015. British Airways feels it appropriate to conclude the work of the 777-200 recommendation and apply the learnings from both events as a single action.

AAIB Assessment – Partially Adequate – Open

F. ATTACHMENTS

Attachment 1 - Interview Summaries
Attachment 2 – CAA Medical Certificate Validity Table
Attachment 3 – Flight Documents
Attachment 4 – Electronic Checklist Operation – British Airways
Attachment 5 – Non Normal Checklist Instructions – British Airways
Attachment 6 – Commanders Preflight Checklist – British Airways
Attachment 7 – Allocation of Duties – British Airways
Attachment 8 – Normal Checklist Operation – British Airways
Attachment 9 – Rejected Takeoff Non Normal Procedures – British Airways
Attachment 10 – Engine Fire Checklist - British Airways
Attachment 11 – Emergency Evacuation Checklist Handling – British Airways
Attachment 12 – Evacuation Checklist – British Airways
Attachment 13 – Fire Forward Cargo Checklist – British Airways
Attachment 14 – Non-Normal Checklist Instructions – Boeing
Attachment 15 - Engine Fire Checklist – Boeing
Attachment 16 – Aircraft Evacuation Checklist – Boeing
Attachment 17 – Rejected Takeoff Procedures – Boeing
Attachment 18 – Abbreviations – Boeing
Attachment 19 – Airport Facility Directory
Attachment 20 – Flight Crew Rosters 1st to 9th September

Submitted by

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Air Safety Investigator