DATA SUMMARY

LOCATION

Date and time	**Sunday, 2 August 2009; 09:39 local time**
Site	**On approach to Barcelona Airport**

AIRCRAFT

Registration	**G-CPEM**
Type and model	**BOEING 757-236**
Operator	**British Airways**

Engines

Type and model	**ROLLS ROYCE RB211535E4-B**
Number	**2**

CREW

	Pilot in command	Copilot
Age	**41 years old**	**33 years old**
Licence	**ATPL**	**ATPL**
Total flight hours	**N/A**	**5,100 h**
Flight hours on the type	**N/A**	**2,300 h**

INJURIES

	Fatal	Serious	Minor/None
Crew			**7**
Passengers			**176**
Third persons			

DAMAGE

Aircraft	**None**
Third parties	**None**

FLIGHT DATA

Operation	**Commercial passenger transport – Scheduled – International**
Phase of flight	**Approach**

REPORT

Date of approval	**17 October 2011**

1. FACTUAL INFORMATION

1.1. History of the flight

The Boeing 757-236 aircraft, registration C-GPEM and callsign BAW478, operated by the airline British Airways, had taken off from London's Heathrow Airport (England) on Sunday, 2 August 2009, bound for Barcelona.

Shortly before initiating the descent to Barcelona, a status message "STANDBY INVERTER" appeared on EICAS. The crew checked the breaker panel, verified that everything was normal and contacted its technical personnel in Barcelona to request an inspection of the aircraft and avoid any problems on the return flight. Although the crew did not detect any anomaly when the message was received, shortly afterwards a slightly odd smell was noticed in the passenger cabin and cockpit that grew in intensity. The crew continued with the approach as they monitored the situation. At 09:36 h, ATC cleared them for the ILS approach to runway 25R, and the localizer was armed. From that moment on, the situation started to develop rapidly. The acrid odor became stronger, the cabin crew reported the presence of smoke in the passenger cabin, and smoke could also be seen in the cockpit, appearing to emerge from the left of the captain's seat.

At 09:39 h, the crew declared an emergency due to smoke in the cockpit after deploying the oxygen masks. The aircraft was at 4,500 ft and descending, 15 NM northeast of the Barcelona Airport, heading south toward reporting point TEBLA. The pilot flying was the copilot, while the captain handled the communications, the emergency and changing the aircraft's configuration.

As stated by the flight crew, once they captured the path, four or five EICAS messages appeared, including YAW DAMPER and SPOILERS, of which only the SPOILERS message did not clear. The LAND 2 message appeared. The captain maintained the autopilot engaged as long as possible until he decided to perform a manual landing, aware that the smoke had been caused by an electrical problem and that the aircraft's ability to perform an automatic landing was not guaranteed.

The landing took place on runway 25R at 09:44 h. The captain ordered the evacuation of the aircraft after receiving a report that there was still smoke in the passenger cabin. The firefighting services were standing by and aided in evacuating the passengers, who were taken to the terminal and treated by airport medical personnel. The door 2R remained partially open and the slide did not deploy.

[1] All times in this report are local.

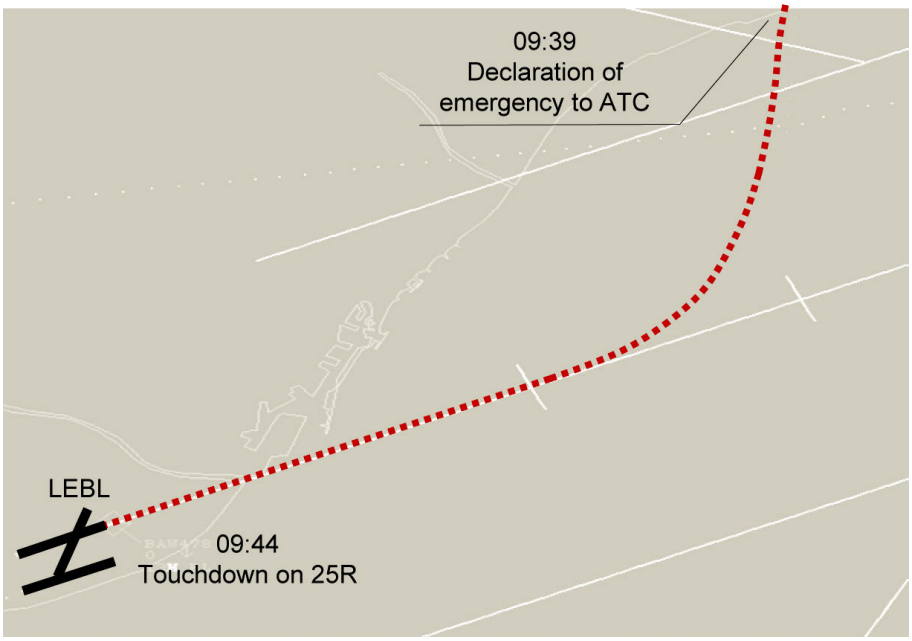

Figure 1. Radar trajectory following MAYDAY declaration

Once the passengers evacuated, firefighters and an airline technician entered the airplane and checked there was still smoke. The batteries were disconnected, a static inverter and the slides were removed and the airplane was towed to a parking stand.

1.2. Injuries to persons

The 183 persons onboard left the aircraft using seven of the eight slides. The passengers and the entire crew were taken to a boarding lounge in the terminal. Eight passengers received medical attention – three due to anxiety attacks, two for contusions, two for back pain and one for a twisted ankle, which was taken to a hospital in one of the two ambulances and discharged a few hours later.

1.3. Damage to aircraft

The only damage to the aircraft was limited to the static inverter that was taken from the forward avionics compartment, situated under the cockpit floor. The outer housing showed signs of discoloration by fire and emitted an acrid odor. Opening the inverter revealed obvious signs of fire in some of its components (Figure 2). The fire that originated in the static inverter did not spread to other equipment.

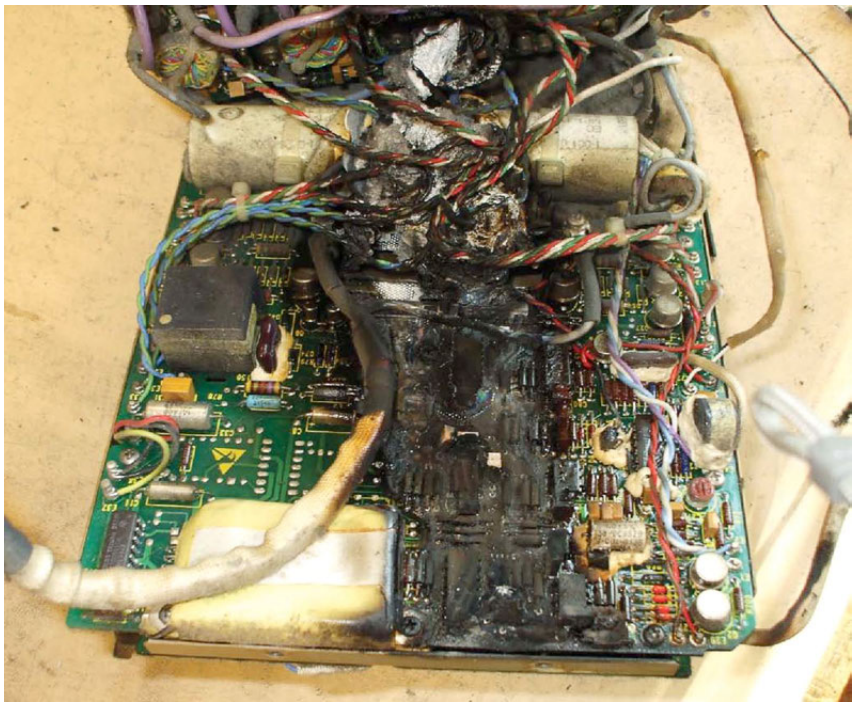

Figure 2. Static inverter after incident

1.4. Aircraft information

1.4.1. *General information*

Aircraft G-CPEM, a Boeing 757-236, S/N 28665, was delivered to British Airways in March 1997, at which time it started operations. The static inverter installed on G-CPEM, P/N 1-002-0102-1000 and S/N CJ000370, had been manufactured by Avionic Instruments Inc. and installed on the aircraft in March 1997. At the time of the incident it had 26012 total hours and 18596 cycles.

1.4.2. *Operation of the static inverter and EICAS messages*

The static inverter is a standby electrical component in the airplane whose function is to transform 28V DC from the main battery into 115V AC to supply the 115V AC STBY BUS. It is located in the forward equipment compartment, underneath the cockpit.

It operates under load in the following conditions:

- In the absence of electrical energy in the 115V AC left main bus.
- When performing category III autoland operations as the third independent energy source.

The static inverter's voltage and frequency values are displayed on the EICAS. If the static inverter voltage is below 106V DC or above 124V DC, a STBY INVERTER status message will appear on the EICAS.

1.4.3. *EICAS messages during landing*

The EICAS messages displayed on the EICAS on approach involve the power supplied from the standby busses to the autopilot computers and to the control modules for the spoilers and yaw dampers.

Regarding the autopilot, the EICAS "LAND 2" message indicates the operability of two of the three autopilot computers. In the event of CAT III operations, each of the three computers (left, right and center) is supplied by the left, standby and right busses, respectively. When not under CAT III operations, the three computers are supplied by the right and left busses.

As for the spoilers, the EICAS SPOILERS message indicates the inoperability of a spoiler pair. The spoilers are controlled by three left and three right control modules. The left control modules are supplied by the standby busses, meaning that a fault in these busses will render a spoiler pair inoperative. This message only appears when the speed brake handle is in a position other than the down detent position.

As for the yaw dampers, the (L or R) YAW DAMPER message indicates a fault in one of the two control modules (left or right). The left module is supplied by the standby busses, meaning that a fault in one of these busses will render this module inoperative, with the other module taking control of the actuators.

1.5. Meteorological information

The incident occurred during daytime hours under CAVOK weather conditions that permitted visual flight.

1.6. ATC information

The recording of the communications held with ATC showed that the emergency was reported at 09:39 h using the words MAYDAY MAYDAY MAYDAY and informing of smoke in the cockpit. The aircraft was on course south toward TEBLA at an altitude of 4,500 ft and descending to 2,300 ft.

At 09:42 it was transferred to Barcelona TWR, which was already aware of the emergency. The crew reported that it was going to stop on the runway and evacuate, and that it needed emergency services standing by.

1.7. Flight recorders

The aircraft was equipped with a CVR and FDR. The FDR data were available after the incident but the CVR was overwritten.

The FDR data show the aircraft on course 186° before the emergency, after which a turn was initiated to course 205° and during which flaps 1 was selected. Seconds later, the aircraft continued turning until it intercepted the runway heading at 2,400 ft, at which time the gear was lowered. At 2,000 ft flaps 30 were selected. The descent rate was slightly over 700 ft/min. The aircraft was stabilized at 1,500 ft.

The autopilot was disengaged at an altitude of 300 feet.

The landing took place at 09:44 h at a speed of 130 kt. The airplane decelerated rapidly and the engines were turned off at 09:45 h.

1.8. Survival aspects

The recordings from the airport's surveillance cameras provided images of both the aircraft evacuation sequence on the runway as well as of the transfer of the passengers to the terminal.

The emergency was relayed by the approach controller to the TWR, which activated the general alarm in accordance with the Barcelona Airport Emergency Plan at 09:43 h. The first responders at the airplane were the firefighters, followed by medical personnel, signalmen, the airport manager duty and an airline maintenance technician.

The airplane landed at 09:44 h and stopped near the D-B taxiways, where the passengers were evacuated using 7 of the 8 slides. By the time the slides were deployed, there were three firefighting vehicles alongside the airplane, two in front and one behind.

The aircraft was evacuated using four ramps on the left side of the aircraft and three on the right. The video of the evacuation showed that door 2R, located forward of the right wing, did not open completely and the slide did not deploy. The door started to open but was not fully opened. After completing the evacuation, one of the firefighters who boarded the airplane pushed the door fully open, after which the slide deployed properly.

After the landing of the aircraft, runway 25R was closed and the configuration changed to 25L. The runway remained closed until 10:55 h, at which time it was reopened following a check by the signalmen.

The passengers exited via both sides of the aircraft and were directed toward two areas, one to the front left of the aircraft and another at the right rear, where they were

picked up by shuttle busses a few minutes later. The holding area for the uninjured specified in the airport's emergency plan was occupied by passengers from four flights. Airport authorities decided it would take too much time to clear that area, so the evacuated passengers were taken to boarding gate 57 in terminal 2 instead. At this gate there were passengers waiting to board a flight scheduled for an hour later. The video surveillance footage for this boarding gate showed that the offloaded passengers merged with the passengers awaiting to depart and were unable to sit. It was under these conditions that they were given medical attention and interviewed.

The alert at the airport was declared over at 10:28 h. The slides were removed and at 10:45 h the aircraft was towed to stand 65.

At 11:00 h, the passengers were taken to the airplane to gather their belongings, except for the passenger with the twisted ankle, who was taken to a hospital.

Figure 3. Evacuation footage from airport surveillance cameras

1.9. Tests and research

1.9.1. *Inspection of the static inverter*

An assessment was made of the damage to the static inverter. Based on the location and extent of the damage, it was determined that the problem resulted from overheating of an carbon composition resistor, R170.

The process began with the deterioration of that resistor and its overheating, which affected first the capacitor located next to the resistor and then, as the fire grew, spread to other nearby capacitors. These elements can combust for a period of time, which can result in the smoke that was detected in the passenger cabin and cockpit.

According to information provided by the manufacturer, the static inverter is always running in flight. It means that certain electronic components can be heat in the same way they would when the inverter is powering the standby bus.

1.9.2. *Previous static inverter overheating incidents*

The problem of static inverter overheating in the B737, B747, B757, B767 and B777 fleets has been known about since 1995. Boeing and the FAA have issued Service Bulletins and NPRMs (Notice of Proposed Rulemaking), respectively, to address the issue.

Finally, in December 2009, the FAA issued an Airworthiness Directive (2009-26-03), effective 1 February 2010. The directive required replacing the R170 resistor with a new one and changed its location in the inverter to avoid resistor overheating and the transfer of heat to adjacent components within the resistor (capacitors C50 and C51). For Boeing 757s, this change had to be made within the 42 months following the entrance into effect of the AD, that is, before 1 February 2012.

The operator had a previous case in which a burning odor was detected and the same STBY INVERTER message was received prior to the flight. In that incident there was no smoke in the cockpit and the inverter was replaced. The operator's and FAA's documentation showed the existence of another case in which after engine start-up on a 757, a fire in a static inverter produced smoke in the cabin, resulting in an evacuation of the passengers.

1.9.3. *Inspection of door opening mechanism*

Each emergency door and exit features a pneumatic slide that inflates automatically (when armed) when the door is opened from the inside. When the door is opened from the outside, the slide disarms automatically. The door has a pneumatic system that aids in opening the door fully such that from the initial opening motion, the system activates and deploys the slide as the door rotates. If the open-assist mechanism fails, the door can still be opened, though it requires a much greater physical effort.

The open-assist system on the door consists of a pneumatic actuator that is supplied air pressure from a reservoir. The reservoir pressure is released when a frangible disc in the reservoir is perforated under the action of a trigger mechanism that is activated by means of a cable attached to the door when it is opened from the inside.

When the airplane returned to London, the operator conducted an inspection of the door's open-assist system. The door did not appear to be seized or display any other signs that would have physically prevented it from being opened. The arming and disarming mechanism on the door functioned perfectly. The rigging of the cable that transmits the opening motion of the door to the activation mechanism was checked and found to be normal. The adjustment and operating tests of the trigger mechanism were satisfactory. The inspection of the reservoir and frangible disc indicated that while the

disc had been perforated, little or no gas had escaped from the reservoir to the actuator. A subsequent inspection of the reservoir did not reveal any anomalies in the seals that could have allowed the gas to leak. As a result, the most likely cause was a defect in the frangible disc. The investigation could not ascertain whether the reason for the loss of gas through the frangible disc was due to a defect in the disc or an error in the fitment of it to the bottle.

1.9.4. *Statement from flight crew*

After arming the localizer, the crew noticed that there was smoke on the flight deck. After the purser confirmed the presence of smoke in the passenger cabin as well, and despite the situation in the cockpit not being critical, they decided to use the oxygen masks as a precautionary measure. The copilot put his mask on first, followed by the captain. They felt no discomfort in their eyes, and thus decided not to put on the glasses. Their top priority was to land as soon as possible in light of the increasing amount of smoke. The use of the mask was uncomfortable and increased their workload. They made a conscious decision not to perform the "Smoke, Fire or Fumes" checklist.

The copilot focused on flying the aircraft and avoiding distractions, while the captain handled communications with ATC and the cabin crew, as well as managing the emergency and the changes to the aircraft's configuration. The captain disengaged the autopilot, which he had kept engaged in case the amount of smoke increased. He disconnected it because he knew that the problem they were experiencing was electrical in nature and that the aircraft's capabilities could be compromised.

1.9.5. *Statement from cabin crew*

The smell of an electrical fire was noticed as far back as row 16, and grew stronger near the cockpit. The fasten seat belt sign was lit. The purser initiated a series of exchanges with the captain regarding the presence of smoke. The captain conveyed the possibility of having to evacuate, and to inform the remaining flight attendants (FAs) of the situation. The purser briefed the other FAs during the approach using the intercom. Once on the ground, the captain contacted the purser to inquire on the status of the situation. The purser reported that there was still smoke in the passenger cabin, to which the captain replied to initiate the evacuation.

The FA at door 2R stated that the opening handle on the door was very stiff, and thought that the open-assist system on the door had failed. She opened the door but not fully, thus the slide did not deploy. As a result, she blocked off the door, redirecting the passengers both ways in the cabin.

1.10. Additional information

1.10.1. *Holding area for the uninjured*

The need for airports to designate a holding area for passengers who are evacuated uninjured or seemingly uninjured is set out in the Airport Services Manual, ICAO Doc. 9137-AN898, Part 7, Airport Emergency Planning. Its purpose is to provide a place for uninjured or slightly injured passengers away from the site of the emergency where they can be treated properly while keeping them from interfering with efforts to combat the emergency. Regarding its use for other activities, Section 9.4.12 in said manual states that this holding area "should be available".

In Spain, the holding area for the uninjured is defined in the Emergency Plans that are part of the self-protection plans, regulated by RD 393/2007, Basic regulation on the self-protection of centers, facilities and offices dedicated to activities that may result in emergency situations. The following agencies are involved in the self-protection plans for airports:

- AENA: Writes the Self-Protection Plan.
- AESA: Receives the Self-Protection Plan, enforces its requirements and inspects and monitors for compliance.
- The Ministry of the Interior's General Directorate for Civil Protection and Emergencies, which gathers background information.

Lastly, RD 862/2009 on the certification of airports under the purview of the State, specifies that the AESA shall conduct inspections of the airports in order to certify them, and that one of the aspects to inspect is the airport's emergency plan.

1.10.2. *Actions taken by the operator*

In September 2009, and as a result of its own internal investigation into the incident, the operator took the following improvement actions:

- Implementation of the service bulletin (the associated Airworthiness Directive had not yet been issued) that modifies the static inverter in the entire Boeing fleet, with priority given to the 757s.
- Review the policies and crew awareness regarding the performance of QRH (Quick Reference Handbook) procedures.
- Reminder to cabin crews of the great physical effort required to open a door in the event of a failure of the door's open-assist system.
- Protection of CVR in the event of a serious incident.

2. ANALYSIS

2.1. Technical aspects

2.1.1. *Fire in the static inverter*

While on approach to the destination airport, the Boeing 757-236 aircraft, registration G-CPEM, experienced a fire in a static inverter, P/N 1-002-0102-1000 and S/N CJ000370, made by Avionic Instruments Inc. This component, a part of the standby electrical system, had a problem that caused one of its resistor, R-170, to exceed its design temperature, and whose location resulted in this excessive temperature affecting nearby capacitors, which caught fire. Due to the inverter's location, in the avionics compartment, the smoke and smell of electrical fire affected the entire aircraft.

Both the extent of the damage (the fire only affected the inverter) and the effects in the cabin were consistent with those in previous incidents.

Though the static inverter is a component that works under high load in "non-normal" operating conditions (CAT III autoland and failure of the main AC bus), it is a component that is always running. This means that some of its elements, such as resistor R-170, heat up as if they were under load, and as such can overheat during any phase of flight. This was the case with aircraft G-CPEM, in which the static inverter overheated and caught on fire despite not being under load.

The manufacturer and the authority were aware of this problem, and had been the subject of Boeing service bulletins and FAA NPRMs, leading to the issuing of an AD in late 2009 to replace the resistor and change its location within the static inverter. This Directive, therefore, is believed to address the need to solve the existing problem with the static inverter.

The EICAS STANDBY INVERTER message was consistent with the problem of the inverter´s inoperability. The subsequent messages described by the crew (YAW DAMPER, SPOILERS and LAND 2) are consistent with the inoperability of the standby AC bus after the failure of the static inverter. The phase in which the EICAS warnings appeared is consistent with the activation logic for said phases: position of spoilers lever and selection of approach phase.

2.1.2. *Failure of door 2R to open*

The open-assist mechanism on door 2R failed during the evacuation of the aircraft, though a subsequent attempt by a firefighter showed that it was possible to open, though with greater physical effort.

As for the slide, any problem with its installation or maintenance can be ruled out, since it deployed properly when the firefighter fully opened the door. The inspections of the open-assist mechanism indicated that there was very little gas flow from the tank to the actuator after the rupture of the frangible disc, and that it was insufficient to overcome the inertia and resistance of the door during the opening sequence. It was not possible to determine with certainty the cause for the lack of pneumatic fluid in the tank though, by the process of elimination, it appears to have been caused by a problem with the frangible disc.

Once the door's open-assist system failed, the physical effort required to fully open it was much greater, making it impossible for the flight attendant to finish opening it.

2.2. Operational aspects

Five minutes elapsed from the emergency declaration by the crew until the landing. The crew's priority was on landing safely as quickly as possible. The copilot focused on flying and on making a stable approach so as to ensure a landing on the first attempt and avoid having to go around. Proof of this is the fact that the aircraft was stabilized at 1,500 ft.

The use of the autopilot is regarded as an adequate and recommended practice that reduces the workload on the crew and that, in the event that the smoke in the cockpit had obstructed the view of the instruments, would have been of great help. The captain made a conscious and deliberate decision to disengage the autopilot at 300 ft in light of the electrical origin of the emergency. As for the "Smoke, Fire or Fumes" list, it was not executed on purpose. The proximity to the field and the amount of smoke in the cockpit are elements that could justify the captain's decision not to initiate that procedure. The fact that they were not wearing glasses indicates that the amount of smoke was not excessive, meaning the deployment of the masks was more a preventive than a necessary measure, but proper nonetheless. This indicates that the decision not to carry out the procedure was a risk assumed by the captain following a deliberate and considered thought process.

The emergency was reported in a concise and clear manner. The crew used the standard MAYDAY MAYDAY MAYDAY terminology, described the nature of the emergency, reported their intention to evacuate and requested the presence of ground equipment. For its part, the approach control station that received the report relayed the notification to a collateral station. ATC's handling of the incident by giving aircraft G-CPEM absolute priority and facilitating the most direct flight path to the airport was proper. The ATC's activation of the emergency at the airport was adequate and three firefighting trucks were standing by when the aircraft landed.

The captain's decisions to stop the aircraft on the runway, check the amount of smoke in the cabin and evacuate are considered correct. The evacuation took place quickly and

the FA's action to block access to door 2R and redirect passengers to other doors was proper. The FAs were aware of the situation and about the possible evacuation and were prepared for it.

The actions and coordination of the airport services was fast. The firefighters were standing by when the aircraft landed, assisted the passengers on the slides and redirected them to one of two assembly areas. The smoke was confined to the cabin and did not extend outside the aircraft, meaning the front left and aft rear areas did not pose any risk to the passengers. The shuttle busses arrived a few minutes later and picked up the passengers immediately.

2.3. Handling of passengers after the evacuation

The passengers were taken to a boarding lounge at the airport that was being used as part of normal operations for the boarding of passengers scheduled to depart an hour later. The arrival of the 176 passengers from aircraft G-CPEM filled the boarding lounge. The evacuated passengers could not be seated and were not kept separate from the other passengers. Most were standing and the medical assistance some of them received was provided in this same lounge in the presence of persons not belonging to that flight.

Providing information to passengers, and even identifying them, is more difficult when the passengers are not in a separate area. In addition, mixing passengers who have just been evacuated with other passengers waiting to board could lead to fear or unrest among the latter group. While the evacuation was normal, fast and incident free, it is not recommended that evacuated passengers be mixed with passengers from other flights.

To avoid such inconveniences, emergency plans define holding areas for the uninjured where passengers who have been subjected to an emergency can be attended to. The Barcelona Airport had defined such a holding area where the passengers should have been taken, but since ICAO regulations do not require that these areas be kept clear, it was not available when it was needed. As a result, a safety recommendation is issued regarding the need for holding areas for the uninjured to be available at all times and not be intended for other airport uses.

3. CONCLUSIONS

3.1. Findings

Technical aspects

- The static inverter burned as a consequence of the overheating of resistor R-170.

- The fire in the static inverter produced fire and smoke in the cockpit and passenger cabin.
- The manufacturer was aware of the problem with the static inverter, which had been the object of service bulletins and an airworthiness directive.
- The open-assist mechanism on door 2R failed during the evacuation.
- Door 2R, which had been partially opened during the evacuation, was pushed open by a firefighter, after which the slide deployed correctly.
- An inspection of the opening system indicated that the activation mechanism had functioned correctly, but that insufficient gas had been discharged from the reservoir to the actuator, suggesting a loss of gas.
- The reason for the loss of gas could not be determined.

Operational aspects

- The aircraft was stabilized at 1,500 ft.
- The crew declared the emergency using the word MAYDAY.
- The aircraft was evacuated while on runway 25R.

Airport aspects

- Airport services were notified of and ready for the emergency.
- The holding area for the uninjured was occupied.
- After the incident, passengers from the incident flight were mixed with passengers from other flights in a boarding lounge.

3.2. Causes

The cause of the incident involving aircraft G-CPEM, a Boeing 757, was a fire in the static inverter caused by overheating of one of its components, resistor R-170, which affected adjacent capacitors. The fire in this element generated smoke in the cabin that led the crew to order an emergency evacuation. The fire source was contained within the protective box of the static inverter and did not spread or ignite any further equipment.

4. SAFETY RECOMMENDATIONS

Providing care for passengers after an evacuation is a particularly sensitive subject, one that is addressed by the ICAO through the requirement to assign an area specifically to treat and stabilize evacuated passengers. Though the ICAO indicates that such holding areas for the uninjured should be available, it does not require it, meaning that the lack

of space at airports routinely results in such holding areas being used for other purposes. This could give rise to situations in which clearing the holding area for the uninjured might take too much time, with the concomitant mixing of evacuated passengers and other passengers, or in having to take the evacuees to areas that are not set up to take care of them.

As a consequence, the following safety recommendations are issued:

REC 54/11. It is recommended that AENA, as the body responsible for preparing self-protection plans:

Consider a full-time restriction on using holding areas for the uninjured to carry out airport operations so as to ensure their immediate availability in the event of an emergency. In case of the impossibility of keeping the holding areas out of use full-time, it will be necessary to develop procedures and decisions to clear them in short periods of time quickly, estimating the time needed to carry it.

REC 55/11. It is recommended that the AESA, as the body responsible for certifying airports and for receiving the self-protection plans and enforcing, inspecting and monitoring for compliance with self-protection criteria:

Consider instituting a requirement for the purposes of certifying, inspecting and monitoring airport emergency plans that said plans impose a full-time restriction on using holding areas for the uninjured to carry out airport operations so as to ensure their immediate availability in the event of an emergency. In case of the impossibility of keeping the holding areas out of use full-time, it will be necessary to develop procedures and decisions to clear them in short periods of time quickly, estimating the time needed to carry it.