
Engine vibration on approach, Airbus A321-231, G-OJEG

Micro-summary: This Airbus A321 experienced significant #2 engine vibration on approach.

Event Date: 2002-02-27 at 1718 UTC

Investigative Body: Aircraft Accident Investigation Board (AAIB), Great Britain

Investigative Body's Web Site: <http://www.aaib.dft.gov/uk/>

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Boeing 737-8AS, EI-CSA

AAIB Bulletin No: 7/2004	Ref: EW/C2002/02/07	Category: 1.1
INCIDENT		
Aircraft Type and Registration:	Boeing 737-8AS, EI-CSA	
No & Type of Engines:	2 CFM56-7 turbofan engines	
Year of Manufacture:	1999	
Date & Time (UTC):	27 February 2002 at 1718 hrs	
Location:	London Stansted Airport, Essex	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 7	Passengers - 117
Injuries:	Crew - None	Passengers - 4 (Minor)
Nature of Damage:	Internal damage to No 2 engine	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	33 years	
Commander's Flying Experience:	7,894 hours (of which 1,486 were on type)	
	Last 90 days - 266 hours	
	Last 28 days - 84 hours	
Information Source:	AAIB Field Investigation	

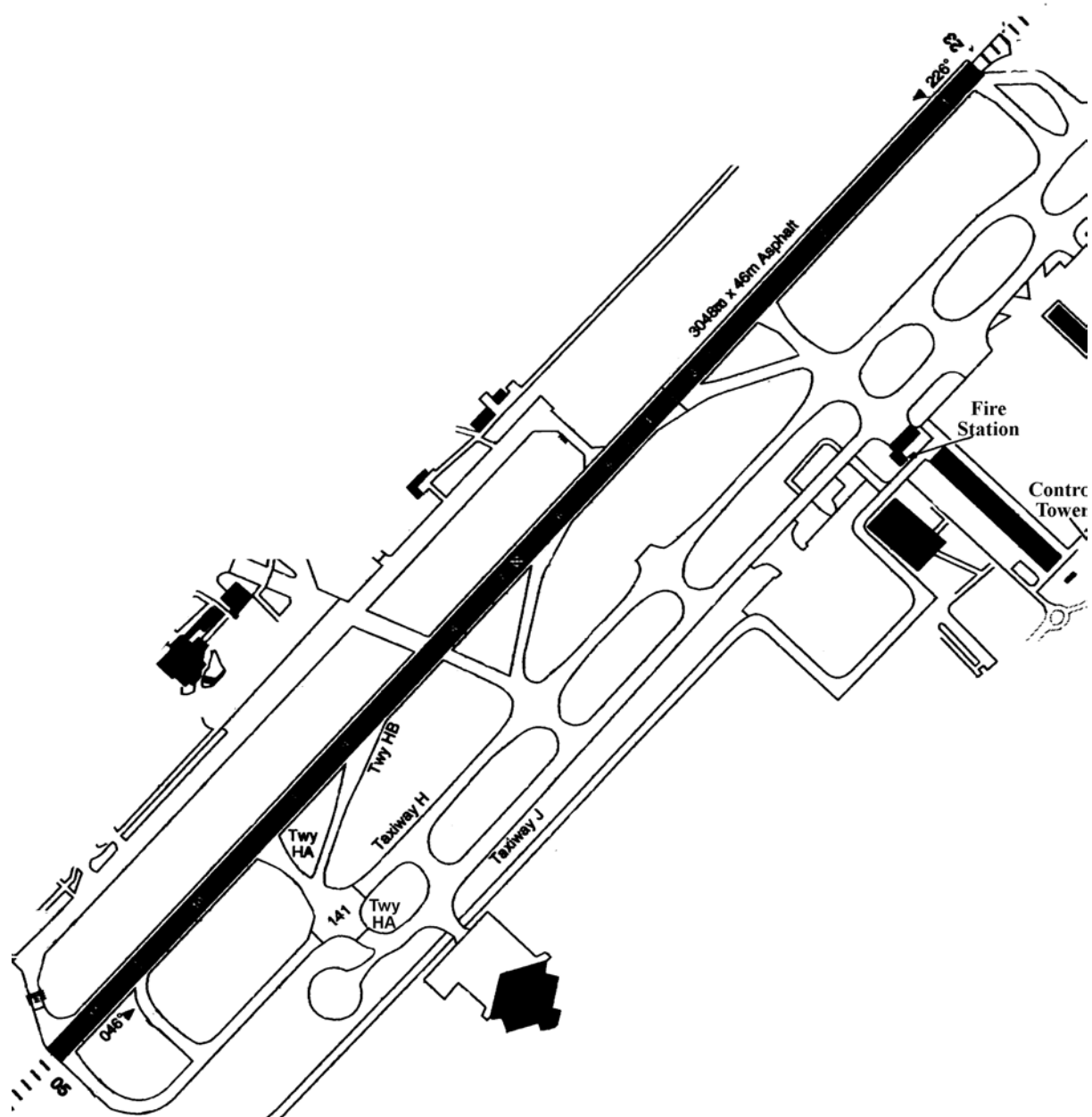
History of the flight

The aircraft was inbound to London Stansted from Dublin on the last of four consecutive sectors of duty for the whole crew. The first officer was undergoing line training during this sector and had been designated the handling pilot.

The aircraft was established on final approach to Runway 23, with the surface wind from 250° at 12 kt, when, shortly after lowering the landing gear, the flight and cabin crew became aware of an increased level of vibration in the aircraft. The flight deck instruments indicated that this was due to increased vibration in the No 2 engine; the peak observed level of vibration was 2.6 units. Although this indication was within the prescribed limit of 4.0 units, the commander instructed the first officer, to use only idle reverse after landing. The touchdown was normal but, shortly after touchdown, the cabin crew became aware of a smell of burning.

During the landing roll, the commander took control of the aircraft, in accordance with standard operating procedures. Because of the reduced retardation during the landing roll, the aircraft vacated the runway at the second 'high speed' exit, Taxiway 'HB' (see Figure 1).

Figure 1 - Stansted Airfield Layout



This took it past an airfield operations vehicle (Ranger One), which was holding on the north side of the runway at Hold 'GA'. As it passed, the airfield operations officer in the vehicle saw flames emitting from the rear of the aircraft's right engine. This was not visible from the Tower Visual Control Room. She advised ATC on the Tower radio frequency that:

"THE [Operator] THAT'S JUST LEAVING THE RUNWAY - THERE SEEMS TO BE FIRE COMING FROM THE RIGHT HAND ENGINE."

The Tower controller acknowledged this, replying: "RANGER ONE, ROGER"

Just before this conversation between the tower and the officer in 'Ranger One' took place, the aircraft had been transferred to the Ground Movements Controller's (GMC) radio frequency and, as a result, the aircraft's crew missed the reference to signs of fire coming from their right engine.

On establishing contact with the GMC, the flight crew were informed that:

"TOWER REPORT FROM RANGER THAT YOU MAY HAVE SOME SMOKE COMING FROM YOUR RIGHT HAND ENGINE. CAN YOU COME BACK AND TELL US IF IT'S OK"

The first officer requested the GMC to "... SAY AGAIN, DIDN'T COPY..."

The GMC repeated the transmission:

"TOWER REPORTS FROM A VEHICLE THAT SAID THERE'S SMOKE COMING FROM YOUR NUMBER TWO ENGINE. CAN YOU CONFIRM THAT FOR ME. LOOKS LIKE THERE IS SOME SMOKE"

The time was 1718 hrs. The commander instructed the first officer to shut down the right engine, and the first officer advised the GMC that:

"WE'RE SHUTTING DOWN, WE HAVE VIBRATIONS"

The GMC asked the aircraft to repeat the response. The commander took over the radio from the first officer and instructed him to start the Auxiliary Power Unit. The commander then informed the GMC that:

"WE'RE SHUTTING DOWN THAT ENGINE. CAN YOU GET THE FIRE SERVICE OUT TO US TO CHECK IT OUT THEN"

At 1718:15 hrs, the GMC initiated an Aircraft Ground Incident using the Omni Crash Alarm, alerting Airfield Operations and the Airfield Rescue and Fire Fighting Service (RFFS) by telephone.

By this stage the aircraft had been brought to a halt on the taxiway at Block 141, across Taxiway 'H' and heading 140° (see Figure 1). This placed the aircraft crosswind with the right engine on the upwind side. Some of the cabin crew at the rear of the cabin were now aware of smoke outside the aircraft on the right hand side. The commander briefed the Senior Cabin Crew Member (SCCM), informing him that ATC had reported smoke coming from the right engine and that the Fire Service were on their way to investigate. The commander also briefed that, at that stage, there was no indication on the flight deck that an evacuation would be necessary. The SCCM returned to the cabin and briefed the other cabin crew members on the situation, telling them not to leave their doors.

At 1719 hrs, GMC cleared 'Fire One', the lead fire vehicle, to proceed to Taxiway 'HA' via Taxiway 'J'. The aircraft was cleared to taxi on to Taxiway 'J' to hold short of Taxiway 'HC'. However, it held its position because of the approaching fire vehicles. Communication was established between the aircraft and 'Fire One' on 121.6 MHz at 1720 hrs. The commander briefed 'Fire One' that the aircraft had experienced vibration on the right engine, that there were no indications of a fire, but smoke had been noticed by ATC. With the No 2 engine shut down, the commander requested the RFFS to investigate the state of the engine. The commander re-emphasised that there were still no indications of fire and there was no intention "AS YET" of evacuating.

'Fire One' informed the aircraft that:

"YOU DO HAVE SMOKE BILLOWING OUT OF THE REAR OF NUMBER TWO ENGINE, OVER"

The commander replied:

"OK. JUST HOLDING POSITION. NUMBER ONE ENGINE IS STILL RUNNING. DO YOU WANT US TO SHUT IT DOWN ? PLEASE TELL US"

Fire One advised:

"A COMPLETE SHUTDOWN AND AN EVACUATION AT THIS TIME BECAUSE YOU DO HAVE SMOKE BILLOWING FROM NUMBER TWO ENGINE"

The commander replied:

"IN THAT CASE, WE WILL EVACUATE THE AIRCRAFT"

'Fire One' acknowledged. The time was 1720:55 hrs.

The commander briefed the SCCM on the impending evacuation, confirming that slides would be used and that the evacuation would be initiated on his command. While completing the flight deck evacuation drills, the commander noticed that the flaps were travelling very slowly. To expedite the evacuation he decided to shut down the left engine with the flaps at about 2°. At this point the Cockpit Voice Recorder ceased recording. There was no evidence that the Auxiliary Power Unit was running. As part of the evacuation procedure, the fire bottles were discharged into each engine.

At approximately 1721:30 hrs, the commander ordered the passengers and crew to evacuate the aircraft. In accordance with Company Standard Operating Procedures, he left the decision as to which exits were to be used to the cabin crew. At that time 'Fire One' called the aircraft saying:

"[Operator] FROM FIRE ONE, CAN YOU MAKE SURE YOU EVACUATE PORT SIDE"

This was not acknowledged. The cabin crew opened the Type I exits at the front and rear of the cabin. The No 2 CCM found the forward right door (R1) difficult to open and sought the assistance of the SCCM after he had opened his door (L1). Likewise the No 3 CCM required help from a male positioning cabin crew member to open the rear right door (R2). Both the SCCM and the positioning crew member were each able to operate these doors unaided. Passengers opened the overwing exits. Four positioning cabin crew assisted the operating cabin crew during the evacuation. About 40 passengers evacuated onto the right side of the aircraft, including six onto the right wing. This placed them in the vicinity of the right engine and the area where the fire crews were directing their firefighting efforts. These six passengers were instructed by the fire crew to return inside the aircraft and seek an alternative exit. The passengers who evacuated on the left side used the doors. Members of the fire crew, cabin crew and airfield staff escorted the passengers away from the aircraft.

The commander transmitted on 121.6 MHz at 1722:02 hrs saying:

"FIRE SERVICE, WE HAVE EVACUATED THE AIRCRAFT"

At 1722:45 hrs, the first officer advised ATC that the aircraft was being evacuated.

At 1724:10 hrs, 'Fire One' advised ATC that there was a fire in No 2 engine and that all occupants had evacuated the aircraft. Evacuation was estimated to have taken 90 seconds. The passengers were escorted away from the aircraft into two groups, depending on which side they had evacuated. Those who had exited to the left side congregated to the east, downwind of the aircraft. This placed them in an area where smoke drifted downwind from the right engine. Those who had exited to the right side assembled to the south of the aircraft on the grass adjacent to Block 51. Coaches were dispatched from the Terminal to pick up the passengers. All passengers and crew were accounted for. Four passengers were treated for minor injuries received during the evacuation. None required hospital treatment.

Engineering investigation

The No 2 engine was removed and despatched to an overhaul facility where it was examined by the engine manufacturer. It was quickly ascertained that there had been a complete failure of the engine's No 4 bearing. Failure of this bearing releases oil into the hot gas path and causes oily smoke to be emitted. There were no signs of any fire as such, but tar oil deposits and copious quantities of fire extinguisher agents were found. The bearing, Part Number 340-167-901, had achieved 7,908 hours and 5,485 cycles since new and was so heavily damaged that the underlying cause of the failure could not be established.

The No 4 bearing, the inter-shaft roller bearing between the High and Low Pressure rotors, is common to all models of the CFM56 engine and has been the least reliable of its bearings. The same component (but with a different part number) failed on an Airbus A321 aircraft, F-GTAF, immediately after takeoff on 21 April 2002 and resulted in the aircraft returning to Heathrow. In the

report on investigation into the F-GTAF incident (see report in this edition of the AAIB Bulletin) there is a more detailed history of the failure record of this bearing and the improvement action taken and envisaged by the manufacturer.

Fire Fighting

The Omni Crash Alarm was initiated by ATC at 1718:15 hrs. This alerted the RFFS and Airfield Operations to the Aircraft Ground Incident. They were briefed on the aircraft type, location, and nature of the emergency and evacuation status. All the RFFS Appliances responded and were in attendance at the scene two minutes after being alerted.

The Fire Officer in charge liaised with the commander of the aircraft as described above. After it had been agreed that an evacuation was required, the fire crews, who had by now deployed hose lines, began attacking the right engine with water jets and Monnex dry powder. Water jets were applied at the front and rear of the engine, and two 35 kg Monnex dry powder wheeled units were applied from the rear only. The indications of fire did not cease until approximately 1,000 litres of water and 40 kg of powder had been expended into the engine. The incident was attended by the Local Authority Fire Service, as back up.

The evacuation of some passengers out of the right hand overwing exits hindered the firefighting operation. The guidance given to Fire Officers tackling *'Incidents Involving Aircraft Engines'* is provided in the CAA International Fire Training Centre's Junior Officer Course notes. These state that *'the Officer in Charge should consider the need to evacuate the aircraft and notify the flight deck accordingly if this is not under way on arrival at the scene.'* This was done in this incident. The decision as to which exits were used was left to the cabin crew. Half a minute after the decision to evacuate had been made, the Fire Officer advised the commander, by radio, to evacuate on the "PORT SIDE ONLY". This was not acknowledged.

After indications that the fire was extinguished, the aircraft interior was inspected for heat transfer and to confirm a full evacuation. There being no further developments, the incident was downgraded to a Local Standby Ground at 1755 hrs and the incident was stood down at 1807 hrs.

Survival Aspects

The aircraft was evacuated in approximately 90 seconds using all the exits. A positioning company commander reported that, although he observed some pushing and shoving in the cabin during the evacuation, generally he felt that the procedure had run smoothly and in a "text book" fashion. There were four minor injuries, which were treated locally by paramedics.

The No 2 and No 3 CCMs had difficulty opening their respective doors, R1 and R2. However, the crew members who lent assistance experienced no trouble in operating these exits. At the time of the incident, whilst a few of the new entrant cabin crew personnel would operate the emergency exit doors in the armed mode during Conversion and Differences training, most would not. For the latter the door opening forces which they encountered during training were considerably less than those that would be encountered in a real evacuation with an armed evacuation slide. Although their instruction was supplemented with the advice that the fully rigged door would be more resistant to opening in the real event because of the integral slide deployment, during training they would have acquired no sense of the forces they would normally encounter trying to open an armed door.

The operator conducts cabin crew training in accordance with the requirements of JAR-OPS 1.1010, which is reproduced below. During this, all normal and emergency exits on an aircraft are opened but only occasionally with the main doors in the armed mode.

Appendix 1 to JAR-OPS 1.1010 (Conversion and Differences training) states:

Operation of doors and exits. An operator shall ensure that:

Each cabin crew member operates and actually opens all normal and emergency exits for passenger evacuation in an aeroplane or representative training device.

Appendix 1 to JAR-OPS 1.1015 (Recurrent training) states:

An operator shall ensure that, at intervals not exceeding 3 years, recurrent training also includes:

The operation and actual opening of all normal and emergency exits for passenger evacuation in an aeroplane or representative training device.

Ambiguity exists as to whether the above requirements include the need to operate these exits in all modes of operation. The importance of realistic door operation during evacuation training was the subject of two previous AAIB Safety Recommendations, namely 2000-33 (G-VSKY, AAIB Air Accident Report Number: 4/2000) and 2002-44 (G-UKFI, AAIB Bulletin: 3/2003).

The commander's order to evacuate was as detailed in the company procedures and, accordingly, did not specify by which exits passengers should leave the aircraft. The command given was:

"this is an emergency, evacuate, evacuate, evacuate."

The decision as to which exits were to be used was made by the cabin crew, after a visual check, again in accordance with company procedures. These state that the cabin crew member is to '*check through the door or pax window for signs of fire, smoke, ground vehicles, other obstructions*'.

While obstructions may not have appeared through the R1 and R2 door windows at the time the evacuation was ordered, the proximity of the RFFS crews attacking the right engine created a conflict. In the operator's procedures for a '*No Time Available Evacuation on Land*', as in this case, no extra brief is given to the passengers adjacent to the overwing exits, beyond that provided after boarding. The overwing exits were opened and the six passengers who climbed onto the right wing were instructed to re-enter the aircraft and seek an alternative exit, to clear them away from the area of the right engine. It is understandable that the passengers did operate these exits since they could not be expected to be as aware of the safety issues, nor to exercise the same discretion as trained cabin crew.

Procedures

Having brought the aircraft to a stop and shut down the No 2 engine, the next flight crew procedure followed was the operator's '*Passenger Evacuation*' checklist. This was prompted by 'Fire One's' advice to shutdown and evacuate. The procedure states that '*If time permits, verify flaps are full down before placing the start levers to CUTOFF.*' The commander decided that time was of the essence and did not wait for the flaps to travel to their full extent.

The operator's '*Engine Tailpipe Fire*' drill, for use when a '*tailpipe fire is reported with no engine fire warning*', was not actioned.

Analysis

Air Traffic Control

The flight crew were not aware of anything unusual, other than a perceptible increase in vibration on the No 2 engine, which flight deck instrument readings indicated to be within limits, until they had already turned off the runway after landing. This turn put the aircraft in a crosswind position with the right engine on the upwind side. The initial signs of flames and smoke were not visible from the Tower Visual Control Room because they were on the far side of the aircraft. When they were first observed from the airfield operations vehicle, the aircraft was some distance from the tower and was taxiing further away.

The initial report from the operations vehicle, Ranger One, of a "FIRE" from the right engine was communicated to the flight crew by the GMC controller as "SMOKE". It was while repeating this information that the GMC reported being able to see the smoke himself. Having brought the aircraft to a halt and shut down the No 2 engine, the flight crew still had no abnormal indications on the flight deck, although the cabin crew could smell smoke in the cabin. The aircraft was brought to a halt in a crosswind position, with the wind just aft of the beam on the right hand side. It remained in that position until the evacuation was completed.

The effects of crosswind on the destructive potential of an aircraft fire are well documented (see AAIB Aircraft Accident Report Number: 8/88, Boeing 737 G-BGJL, at Manchester). Had the right engine developed an uncontained fire, the relative wind would have exacerbated the situation and adversely affected the survivability of such an event.

It is important that such a potential is identified at an early stage, and actions taken accordingly. Had the word 'fire' been communicated to the flight crew initially, instead of 'smoke', it may have triggered them into giving greater consideration as to where to bring the aircraft to a stop, and on what heading. In the absence of any indications on the flight deck, the faithful reporting of external observations can markedly affect the subsequent crew actions. If the surface wind had been included in the GMC's first transmission, this would have helped resolve any question about the relative wind at an early stage. The surface wind is given during a clearance for takeoff and landing. Its inclusion during an initial ATC transmission relating to an aircraft fire, or possible fire, on the ground would provide the flight crew with similarly important information. It is recommended that this aspect is reviewed.

Flight Deck Procedures

Analysis of this situation might suggest that the operator's Non Normal Procedure '*Engine Tailpipe Fire*' checklist should have been considered appropriate. However, this procedure is normally associated with a failed engine start when unburned fuel can accumulate in the core of the engine, although no such association is made in the relevant checklist. In the circumstances which obtained, this situation was highly unlikely to arise and, therefore, it is considered reasonable that the '*Tailpipe Fire*' checklist procedure was not actioned; also the despatching of the RFFS to the aircraft obviated the need to consider this option. The decision to shut down the right engine, due to the presence of both vibrations and smoke associated with it, and request for the RFFS to attend the aircraft was considered to be an appropriate initial response to the situation.

Since the flight crew had no indications of a fire, the commander's decisions relied on the accuracy of the reports he received from the cabin crew and observers outside the aircraft. While the signs of smoke were visible from the cabin, there is no evidence that the cabin crew's observations were sought by the commander or given to him. The flight crew were busy and there may have been a reluctance, on the part of the cabin crew, to interrupt or an assumption that the flight crew already knew what could be seen. The volumes of smoke reported were such that, by evacuating the aircraft, all concerned were erring on the side of safety and this is wholly understandable. The time from shutting down the No 2 engine to the decision to evacuate was 2 minutes and 40 seconds.

Evacuation

The RFFS attended the aircraft without delay and rapidly established communications with the commander on 121.6 MHz. On the basis of 'Fire One's' recommendation, the commander ordered an evacuation. 'Fire One's' subsequent recommendation to evacuate on the left side was not heard by the flight crew. Inside the aircraft, that decision was left to the cabin crew. They and the passengers opened exits on both sides. Had evacuation been restricted to the left side only, conflict with the fire fighting activities on the right side would have been prevented. In the event, the evacuation was timely and this conflict did not adversely affect the outcome. It is considered that the CAA's advice to Officers in Charge of RFFS crews should be reviewed, in order to encourage them to give commanders of aircraft the optimum information when advising an evacuation. In cases of external fire, the RFFS crews may be in a better position to advise on the best evacuation routes. By including

that information in the Fire Officer's advice to aircraft commanders, then amended evacuation orders can be broadcast accordingly by the commander. This is particularly relevant when the cabin crew are not able to have control over the operation of the overwing exits.

Preservation of Evidence

This incident developed from a No 4 bearing failure in the No 2 (right) engine. The indications of fire were detected and attacked with extinguishants without delay and the aircraft was evacuated successfully. However, useful lessons can be learnt from this event which could make a significant difference in any future larger scale aircraft fire on the ground. Any such lessons derive from the information that was gathered during the investigation. Much of this relates to what was seen, heard, said or felt. The CVR and RTF recordings provided a lot of data, but this could have been greatly enhanced if there was video evidence as well. In this instance, a video recording could have given a good record of the sequence of events, the relative positions of all involved and, in conjunction with the other evidence, a better reconstruction of what happened. Video recordings have been very valuable sources of evidence in previous incident and accident investigations. There is currently no requirement for aerodromes to have this facility for recording incidents and there was none available on this occasion. It is recommended that consideration be given to the provision of suitable video recording facilities at airports operating public transport flights.

Safety Recommendations

Safety Recommendation 2004-50

It is recommended that the Civil Aviation Authority review the instructions to Air Traffic Controllers, when they are advising an aircraft on the ground of signs of fire, to include the surface wind in their notification transmission.

Safety Recommendation 2004-51

It is recommended that the Civil Aviation Authority review the instructions to Fire Officers, when attending an aircraft fire, to ensure that they consider advising the flight crew on the best route for evacuation, as well as advising on the need to evacuate.

Safety Recommendation 2004-52

It is recommended that the Civil Aviation Authority encourages aerodrome operators to provide suitable video recording facilities at airports operating public transport flights in order to preserve best evidence in the event of an accident or incident.

Safety Recommendation 2004-53

It is recommended that the Irish Aviation Authority and JAA review the requirements for cabin crew initial and refresher training in respect of the operation of all normal and emergency exits, to ensure that crew members become, and remain, familiar with the different operating procedures, and opening characteristics, in both normal and emergency modes of operation.