DOCKET NO. **SA - 510**

EXHIBIT NO. **10 F**

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

Cockpit Video Information

Page 171
From
AAIB Report of Boeing 737 Accident of 8-22-1985

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AIRCRAFT ACCIDENT REPORT 8/88

Air Accidents Investigation Branch

THE DEPARTMENT OF TRANSPORT

Report on the accident to Boeing 737-236 series 1, G-BGJL at Manchester International Airport on 22 August 1985

HER MAJESTY'S STATIONERY OFFICE

4 Safety recommendations

4.1 Procedures should be developed to enable the crew to position an aircraft, when a ground fire emergency exists, with the fire downwind of the fuselage. Visual indicators of local wind direction located within the manoeuvre areas would be valuable aids to the implementation of such a procedure.
(letter to CAA 14 March 1986)

4.2 Research should be undertaken into methods of providing the flight deck crew with an external view of the aircraft, enabling them to assess the nature and extent of external damage and fires.

4.3 Operators should amend their Operations Manuals, if necessary, to direct crews on any rejected take-off or emergency landing to stop on the runway and review the situation before a decision on clearing the runway is made.

4.4 Consideration should be given to the requirement to fit an evacuation alarm permitting flight deck crew to instruct cabin crew to initiate an evacuation immediately, or if the aircraft is still moving to prime for an evacuation immediately the aircraft is brought to a halt.

4.5 Emergency equipment for use by cabin crew during an emergency evacuation should be stowed at the cabin crew stations.
(letter to CAA 19 September 1985)

4.6 The Civil Aviation Authority should continue to work with other regulatory authorities to define a mandatory international code of practice for identifying the appropriate method of promulgation for manufacturers' safety information. This code should include a procedure for ensuring that, at the earliest opportunity, preliminary/advisory information should be followed up and superseded by appropriate Bulletins, Airworthiness Directives or manual ammendments.

4.7 If manufacturers are to continue to supply maintenance guidelines which require the operator and his regulatory authority to determine maintenance intervals, particularly for critical components, a re-evaluation should be undertaken of the methods employed to judge residual component lives, particularly following repair.

4.8 Direct fusion weld repair of circumferential cracks in JT8D engines combustor cans should be deleted from all approved Engine Overhaul Manuals, unless the safe life of the repaired can has been demonstrated for the anticipated overhaul/inspection period.

Pages 127 & 151
From
AAIB Report of Boeing 737 Accident of 1-8-1989

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Air Accidents Investigation Branch

THE DEPARTMENT OF TRANSPORT

Report on the accident to Boeing 737-400 G-OBME near Kegworth, Leicestershire on 8 January 1989

HMSO

The only secondary parameter of importance to this investigation, namely vibration, is discussed in paragraph 2.4.4. There was no evidence that the technical performance of the secondary EIS unit affected the flow of information available to the crew of ME.

Checks on the wiring to and from both EIS units found no signs of incorrect connection with regard to left/right sense.

2.4.6 Airborne closed circuit television monitoring

The accident would probably have been averted if the pilots had been able to observe the pulsating flames and blue sparks which emanated from the No 1 engine after the primary fan blade failure and which were clearly apparent to many in the passenger cabin.

The technology is currently available to provide flight crews with an external view of major areas of their aircraft by means of closed circuit television. Internal zones such as cargo bays and areas of the passenger cabin can also be covered. Such a facility would enable the flight crew to assess various types of external problem such as fire, landing gear status, airframe damage, icing etc. Internal coverage would provide an additional means of assessment of cargo bay problems and cabin status, in addition to ground security monitoring.

This accident has also highlighted another area in which the availability of television monitoring could have benefit. With the increasing use of electronic 'glass-cockpit' display technology the facility to process information, prior to its display, has been greatly enhanced. This can improve the presentation of information to a crew and, importantly, can also be used to greatly assist their decision-making by giving them computer-assisted diagnosis. With such improved information techniques however it becomes increasingly vital to be able to demonstrate, during any post incident/accident investigation, the displayed information with close fidelity. This may present problems depending upon the type of signal processing employed, and particularly where the sensors have been attempting to 'track' an abnormal situation. In short, the question which arises concerns whether the information displayed to a crew may always be faithfully replicated after an incident. It is therefore considered that it would greatly benefit future crews and associated investigations if all such displayed information were recorded by means of television monitoring coverage of the flight deck. If, in addition, a playback facility were included, pilots could recall instrument display information after acting to contain an in-flight emergency.

4.16 The type certification requirements for gas turbine engines should be amended so that it is mandatory to perform instrumented flight tests to demonstrate freedom from damaging vibratory stresses at all altitude conditions and powers which an engine will encounter in service (Made 30 March 1990).

4.17 The potential for fuel and oil system leakage within the fan case area of high by-pass turbofan engines, during conditions of excessive vibration, should be reviewed by the engine manufacturers and the CAA with a view towards modifying such systems to minimise such leakage, and the associated fire risk (Made 30 March 1990).

4.18 The CAA should review the existing Joint Airworthiness Requirements concerning fuel tank protection from the effects of main landing gear and engine detachment during ground impact and include specific design requirements to protect the fuel tank integrity of those designs of aircraft with wing-mounted engines (Made 30 March 1990).

4.19 The CAA should expedite current research into methods of providing flight deck crews of public transport aircraft with visual information on the status of their aircraft by means of external and internal closed circuit television monitoring and the recording/recall of such monitoring, including that associated with flight deck presentations, with a view towards producing a requirement for all UK public transport aircraft to be so equipped (Made 30 March 1990).

4.20 The manufacturers of existing flight data recorders which use buffering techniques should give consideration to making the buffers non-volatile and hence recoverable after loss of power, and EUROCAE and the CAA should reconsider the concept of allowing volatile memory buffering in flight data recorders (Made 30 March 1990).

4.21 Where engine vibration is an available parameter for flight data recording, the CAA should consider making a requirement for it to be recorded at a sampling rate of once every second (Made 30 March 1990).

4.22 The CAA should actively seek further improvement in the standards of JAR 25.561/.562 and the level of such standards should not be constrained by the current FAA requirements (Made 30 March 1990).

4.23 The CAA should require that, for aircraft passenger seats, the current loading and dynamic testing requirements of JAR 25.561 and .562 be applied to newly manufactured aircraft coming onto the UK register and, with the minimum of delay, to aircraft already on the UK register (Made 30 March 1990).

4.24 In addition to the dynamic test requirements, the CAA should seek to modify the JARs associated with detailed seat design to ensure that such seats are safety-engineered to minimise occupant injury in an impact (Made 30 March 1990).

CAA Follow-up Action on Accident Reports

F4/90 - October 23, 1990

Civil Aviation Authority

Follow-up Action on Accident Reports

Safety Data and Analysis Unit
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F4/90
23 October 1990

ACCIDENT TO BRITISH MIDLAND AIRWAYS BOEING 737-400 G-OBME NEAR KEGWORTH ON 8 JANUARY 1989

(AAIB ACCIDENT REPORT NO 4/90)

SYNOPSIS (Extracted from the AAIB Report)

G-OBME left Heathrow Airport for Belfast at 1952 hrs with 8 crew and 118 passengers (including 1 infant) on board. As the aircraft was climbing through 28,300 feet the outer panel of one blade in the fan of the No 1 (left) engine detached. This gave rise to a series of compressor stalls in the No 1 engine, which resulted in airframe shuddering, ingress of smoke and fumes to the flight deck and fluctuations of the No 1 engine parameters. Believing that the No 2 engine had suffered damage, the crew throttled that engine back and subsequently shut it down. The shuddering caused by the surging of the No 1 engine ceased as soon as the No 2 engine was throttled back, which persuaded the crew that they had dealt correctly with the emergency. They then shut down the No 2 engine. The No 1 engine operated apparently normally after the initial period of severe vibration and during the subsequent descent.

The crew initiated a diversion to East Midlands Airport and received radar direction from air traffic control to position the aircraft for an instrument approach to land on runway 27. The approach continued normally, although with a high level of vibration from the No 1 engine, until an abrupt reduction of power, followed by a fire warning, occurred on this engine at a point 2.4 nm from the runway. Efforts to restart the No 2 engine were not successful.

The aircraft initially struck a field adjacent to the eastern embankment of the M1 motorway and then suffered a second severe impact on the sloping western embankment of the motorway.

39 passengers died in the accident and a further 8 passengers died later from their injuries. Of the other 79 occupants, 74 suffered serious injury.

CAA Response

The Authority accepts this Recommendation. The existing Requirements have been reviewed and are considered to be satisfactory.

From the reported evidence on this particular accident it is noted that the landing gear attachment 'fuse' pins failed as intended, however the Authority is reviewing the design of the engine pylon to wing attachments of the Boeing B737.

CAA Status - Open

Recommendation 4.19

"The CAA should expedite current research into methods of providing flight deck crews of public transport aircraft with visual information on the status of their aircraft by means of external and internal closed circuit television monitoring and the recording/recall of such monitoring, including that associated with flight deck presentations, with a view towards producing a requirement for all UK public transport aircraft to be so equipped (Made 30 March 1990)."

CAA Response

The Authority accepts this Recommendation which covers two distinct areas of concern. Namely flight deck crew awareness of the status of their aircraft and the recording and recall of flight deck presentations. With respect to the first concern, following receipt of a similar AAIB recommendation which arose as a result of a previous accident, the Authority has investigated the potential for such a system and now has an agreement with British Airways to conduct a joint engineering trial of externally mounted miniature closed circuit television (CCTV) cameras on a B747 aircraft. This trial is intended to investigate the engineering feasibility of such a system, and will employ 'carry-on' recording and monitoring equipment which will be operated from the passenger cabin. The Authority has selected a vendor to supply a system suitable for this trial, which is scheduled to commence in February 1991. Consideration is also being given to the associated human factors aspects including the presentation of visual information to the flight crew. Further work will be needed to study these aspects and associated cockpit procedures.

In parallel with this activity Royal Aerospace Establishment (RAE) are carrying out trials of similar equipment on their BAC 111 aircraft and on a Citation and Jetstar aircraft.

The Authority will evaluate the results of all these trials to determine whether such installations are sufficiently effective and practicable to justify the subsequent introduction of an appropriate requirement.

With respect to the recording of cockpit presentations, it is the Authority's intention to undertake trials using a second BAC 111 aircraft operated by RAE Bedford to gain knowledge of the factors involved. When completed the results of these trials will be available to the AAIB to assist in determining the future policy for possible requirements for such recording.

CAA Status - Open

CAA Position Paper & Research Project Update Sheet

POSITION PAPER ON AIRCRAFT EXTERNAL VIEWING DEVICES

1. INTRODUCTION

The second of thirty one recommendations by AAIB in their report published in March 1989 on the Manchester accident (August 1985) is that "Research should be undertaken into methods of providing the flight deck crew with an external view of the aircraft, enabling them to assess the nature and extent of external damage and fires". The report does not discuss the recommendation but it suggests that, if the crew had been in possession of an external view of the aircraft and the developing fire, they may have stopped more promptly, possibly improving the prospects for passenger survival. However, it is also clear that the crew were extremely busy during the whole period following the decision to abandon the take-off. Consequently, the provision of external view information in circumstances such as these without distracting the attention of the crew from primary tasks is problematic.

In the period following the Manchester accident, CAA concentrated its regulatory and research activities on the problems related to fire and evacuation which were seen to be critical to improving survival prospects over a wide range of possible accidents. Work on cameras started during 1989. CAA had discussions with several organisations which were interested in carrying out "proof of concept" trials. However, in October 1989 CAA approached British Airways with the suggestion of a joint operational trial. This was given additional impetus by the AAIB recommendation of March 1990 related to the Kegworth accident (January 1989). The report suggests that "the accident would probably have been averted if the pilots had been able to observe the pulsating flames and blue sparks which emanated from the No.1 engine after the primary fan blade failure and which were clearly apparent to many in the passenger cabin."

2. NECESSARY INVESTIGATIONS

Within the CAA Safety Regulation Group the view was taken that a series of investigations was required in order to assess the practicability of making External Viewing Systems mandatory. These investigations were planned as follows and are based on the assumption that Closed Circuit Television (CCTV) is used as the expected form of external viewing although other means should not be ruled out:

(a) an engineering trial to ascertain if currently available cameras could be fitted to a transport aircraft and function in the environment of world-wide operations,

(b) an assessment of the problems of integrating pictures from such a system into flight deck procedures,

(c) a safety benefit study to determine if, based on accident data, there could be any expected benefit from external viewing systems, and

(d) investigations of the current shortfalls in current technology and their possible solutions.

2.1 *Engineering Trial*

Early in 1990 agreement in principle was reached with British Airways to fit a trial CCTV installation on one of their Boeing 747 aircraft. An invitation to tender was sent to companies with expertise in miniature CCTV camera technology and its use in difficult environments. A contract was awarded to W Vinten Ltd in June 1990. The trial installation involving three cameras was fitted to a British Airways Boeing 747 aircraft in June 1991. At that time it was considered not appropriate to provide a display on the flight deck but the necessary cabling was installed. Nevertheless CAA and BA staff had an opportunity to view the system in operation from the passenger cabin and to make video recordings. To date the equipment has stood up well to airline operation and performed well under a wide range of operational conditions. The main criticisms relate to the performance at low light levels. The pictures become unusable at dusk.

As an adjunct to this work some of the video recordings were subjected to a video compression technique which removes the need for recording tape and considerably increases the speed of access to previously recorded pictures. The exercise appeared to be successful and suggests that a replay facility, essential to investigate transient events, is feasible without the need to use devices with mechanical components.

2.2 *Integration into Flight Deck Procedures*

The prime concern of the Safety Regulation Group regarding the introduction of CCTV is the possibility of the crew being distracted by the pictures to the detriment of the operation of the aircraft using well certificated procedures which are based on long industry-wide experience. The operation of aircraft systems by the crew both normally and in emergencies is carried out using quantitative information backed up by discrete warning systems. No qualitative assessment is necessary at least in the shorter term. The use of CCTV information introduces such qualitative information. The problems introduced are threefold. First, there is always a danger of misinterpreting qualitative information and the form of any display must attempt to minimise such a risk. Second, the visual picture may give cues which are at odds with the information being displayed on conventional primary flight deck instrumentation. The visual cues will prove very persuasive in the minds of the crew and may cause them to reject conventional information which in general has proved to be reliable. The use of a number of cameras giving a series of different views and the facility to replay recordings of events which are only transient introduces a further source of human factors issues. There is therefore the potential for decisions made in the presence of CCTV to be wrong or delayed thus introducing a new source of risk of an accident/incident. Finally the compulsive nature of TV pictures must not be underestimated. Their mere presence on the flight deck can be a source of distraction whether or not the information being displayed at the time is relevant.

A contract was placed with a Human Factors Group at DRA Farnborough to try to identify the likely sources of confusion. This work went some way towards providing guidance on the problems to be expected but it also stressed the need to define exactly what was required of the system and carry out trials in a realistic environment. In order to get some feedback from operating crew plans were made to provide them with a flight deck display. When the cameras were installed on the BA B747 there were no suitable monitors on the market and a purpose built monitor would have cost about £40,000. There are now monitors available which would suit a trial fit (although they would not be suitable for a fleet-wide installation) and one has been delivered to British Airways. However a period of major maintenance is needed in which to schedule the fitting of the display. It was expected that such a period in December 1992 would

provide the opportunity but BA were unable to produce a design installation and fit the screen in the time available. The screen was fitted during a period of major maintenance lasting from August to October 1993. The views of aircrew will be elicited during line operations using a questionnaire in an attempt to identify more specifically the major human factors issues.

2.3 *Safety Benefit Study*

In considering the justification for the mandatory provision of items of equipment a study of past accidents to determine the benefits which can be expected from the introduction of that equipment is an important indicator. In the past such studies have been carried out by SRG but it was felt that in this case the work should be carried out by an "independent" external contractor under CAA funding. After enquiries were made within the Industry only one proposal was elicited and a contract was awarded to the College of Aeronautics at Cranfield. The report, delivered in August 1993, identified those past accidents where information provided by external viewing cameras might have supplemented existing flight deck information to the extent that the crews might have acted differently. The analysis covered serious accidents world-wide between 1976 and 1992 to passenger carrying aircraft with more than 30 seats. Cranfield identified seven categories of accident where they felt there might have been a benefit in providing an external view. These categories were:-

(a) Ground operations where ground crew were killed or injured by moving aircraft near to the stand.

(b) Accidents caused by ice on lift surfaces.

(c) Accidents on take-off caused by snow on lift surfaces.

(d) Accidents on take-off caused by the wrong setting of flaps/slats.

(e) Fire in the undercarriage area.

(f) Engine fire.

(g) Undercarriage mismanagement

The CAA is now considering these accidents having regard to:-

(i) The practicability of CCTV in providing the necessary clarity of view on which to make a judgement

(ii) The actions which the crew would need to take to ensure that the system was consulted at an appropriate time.

(iii) Alternative remedies including revised procedures and the use of current facilities.

Initial indications are that there is not a strong case for a mandatory fit.

2.4 *Night Viewing Capability*

An aircraft system which is mandated must operate in all weather conditions by day and by night but the current system does not work at low light levels. Night viewing

devices would either make use of infra-red floodlights or operate in the far infra red. In the former case there are severe practical problems for an aircraft fit and in the latter the pictures are not simply monochrome images of the outside world but reflect the thermal characteristics of the scene rather than the visual image, making interpretation difficult in some circumstances. In addition such cameras are very expensive and physically much larger than those working in the visible and near infra-red spectra. Any further work by the CAA is dependent on the results of the safety benefit study.

3. DISCUSSION

The prime concern within the CAA on the mandatory fitting of CCTV is that it must be integrated into the flight deck in a way that it does not detract the crew to the detriment of the operation, delay important actions especially in emergency conditions and does not have the potential to confuse. The human factors issues are the most important and yet the most difficult to solve. Notwithstanding the AAIB recommendations, there is still doubt as to whether CCTV would have been of any help at either Kegworth or Manchester. There is still a great deal of uncertainty about the potential benefits of external viewing and it would be unwise to consider any form of mandatory fit until the outstanding issues are resolved. The basic question to be asked is "What extra information is available from CCTV over and above that available from the instrumentation?" and, given that extra information "what will the crew do with it?".

If CAA were persuaded of the need for a Requirement it could not act unilaterally since it is now bound by the provision of the EEC Regulation No.3922/91 "on the harmonisation of technical requirements and administrative procedures in the field of civil aviation". The JAR codes of requirements are now Community Law and amendments can only be made through the Commission and this would require consensus, at least of the Authorities of the Community States.

Given that no other JAA country is investigating or promoting the use of external cameras, such consensus is unlikely. Furthermore, when CAA raised the question informally with FAA at the Annual Meeting in October 1992, FAA staff expressed doubts on the net value of making their provision mandatory. In particular they pointed to the addition to flight deck work load.

4. CONCLUSIONS

4.1 *Technical Issues*

(a) The trials carried out by the CAA with British Airways have indicated that there are no technical obstacles to the use of closed circuit television cameras to provide external views of an aircraft in flight in daylight: The picture quality can be maintained without undue effort.

(b) However, none of the possible techniques for night vision have yet been tried, for example infra-red or low light level cameras with appropriate external illumination of the airframe.

4.2 *Pilot Interface*

(a) The coverage and detail/discrimination required will dictate the number of camera positions and whether there is a need for panning.

(b) Given that significant events may be transient, recording with search/replay facilities would be needed.

4.3 *Cockpit Resources*

(a) Controls, instruments, procedures and allocations of crew duties reflect the experience built up, sometimes painfully, over the years that it has taken for modern civil aviation to develop. The installation and procedures for the use of external viewing cameras would need to ensure that pilots would not be distracted or misled during critical phases of flight, including the handling of an emergency.

(b) A comprehensive installation would involve a number of views, presenting potential pitfalls and delays in interpretation. The controls for panning and search/replay would present a new and probably distracting task.

(c) Until a satisfactory solution to the night viewing question is found it would not be possible to mandate a system.

4.4 *Safety Need*

A Safety Benefit Analysis has been carried out to identify those accidents where knowledge provided by external viewing cameras might have so supplemented the existing flight deck instrument indication that the pilot is likely to have reacted in a different manner. The analysis being evaluated within the CAA but preliminary investigations do not suggest that there is a case for a mandatory fit. The analysis does, however, suggest procedural improvements which should be considered.

4.5 *Other Authorities*

No other European authority is active in this field and FAA has expressed doubts on the safety benefit. Any proposal for regulating action seems unlikely to succeed, at least for the foreseeable future.

Issue 1
October 1993
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FIELD OF ACTIVITY	CODE
Flight and Operational Standards	9.2

PROJECT TITLE

External viewing for flight crews

OBJECTIVES

To examine the possible uses of external viewing systems by flight crew to enhance flight safety

Background

Recent accident reports have suggested that the provision of an external viewing system might have provided the flight crew with information on the condition of an aircraft which could have reduced the risk of loss of life.

Current Work

The system fitted to a BA B747 has been modified to allow the pictures from the system to be viewed on the flight deck. The attitudes of line crews to the usefulness of such a system will be elicited using a questionnaire developed in conjunction with BA and DRA (Farnborough). DRA have completed a study of the human factors problems likely to be encountered in developing and using external camera systems. A safety benefit study has been carried out at Cranfield Institute of Technology to assess the potential number of accidents that might have been avoided if an external viewing system had been fitted. The results suggest that there is no case for mandating the fitment of such devices.

Future Work

The results of the crew attitudes study on the BA B747 will be analysed to give guidance in producing Regulatory Requirements that will be necessary for the use of such systems when fitted on a voluntary basis.

Timescale/Milestones

March October-1994	-	complete data collection on BA B747 trial
summer 1994	-	publish safety benefit report

(Size)	Contractors	Aviation Authority
Small	DRA	UK CAA
Project Sheet Issue Date		**Contact Person**
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