

ACCIDENT

Aircraft Type and Registration:	British Aerospace HS.748 Series 2A, G-BGMN	
No & Type of Engines:	2 Rolls-Royce Dart 534-2 turboprop engines	
Category:	1.1	
Year of Manufacture:	1979	
Date & Time (UTC):	28 January 2005 at 0533 hrs	
Location:	East Midlands Airport, Derbyshire	
Type of Flight:	Public Transport (Cargo)	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Minor scratch on wing upper surface, severe damage to over-wing exit hatch	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	48 years	
Commander's Flying Experience:	3,330 hours (of which 1,600 were on type) Last 90 days - 77 hours Last 28 days - 33 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft's left over-wing emergency escape hatch detached from the aircraft during takeoff from East Midlands Airport. A deferred technical defect in the aircraft's pressurisation system meant that the loss of the hatch, was only discovered after landing at Ronaldsway Airport on the Isle of Man. The investigation established that a protective cover, in the cargo area, intended to prevent inadvertent operation of the over-wing emergency escape hatch handle, was not attached prior to loading and that movement of the cargo probably caused the handle to move to the 'open' position, allowing the hatch to detach from the aircraft. The investigation also established that a number of deficiencies existed in the

operator's training and oversight of contracted loading staff. Four safety recommendations are made.

History of the flight

The commander and co-pilot had operated the aircraft from Ronaldsway Airport to East Midlands Airport the previous evening, arriving at East Midlands at 2032 hrs. The crew had then taken overnight rest in a local hotel as part of a 'split duty' roster pattern before reporting at the aircraft at 0505 hrs for a 0520 hrs departure for the return flight to Ronaldsway. The crew had overseen refuelling prior to retiring to the hotel, but the loading of 5,098 kg of mail had taken place overnight in their absence.

The crew arrived at the aircraft and commenced their pre-flight duties. Among the deferred defects in the technical log was one pertaining to the front access door which, as the result of a defect, was restricted to 'emergency use only'. However, as the aircraft was routinely bulk loaded with mail, this door was the only means of access to the flight deck and the flight crew had no option but to use it. The co-pilot prepared the flight deck while the commander carried out an external inspection which revealed nothing untoward. The only unexpected problem encountered was that the ground power unit electrical supply tripped off, so an engine start on battery power only was planned.

As part of the commander's pre-flight inspection, he checked the only two visible cargo bays which were full to the ceiling with mail bags and loose packages. These were Bay 2, which was the foremost bay and visible from the flight deck / forward access door area, and Bay 5, visible from the rear door which the commander opened during his external inspection.

During the start process the ground crew performed their normal checks which included the security of doors and hatches. The aircraft taxied for Runway 27 at a 'brisk' pace, but with no unusual bumps or noises. Takeoff appeared normal, but during the climb the crew noted that the aircraft was not pressurising. The crew negotiated a revised cruising level with ATC and the commander instructed the co-pilot to open the pressurisation dump valve. The crew did not refer to the checklist for this procedure as un-pressurised flight was not an uncommon occurrence on company HS748 freight aircraft. The crew was not concerned by the failure to pressurise, as an ongoing poor performance of the pressurisation system had been entered in the technical log as a deferred defect. The technical log entry consisted of a statement on the poor performance

of the system, together with a Minimum Equipment List (MEL) reference and the words 'unpressurised flight'. The MEL reference concerned dispatch with one or more cabin superchargers unserviceable, and stipulated that dispatch was permitted provided that the flight was conducted un-pressurised. Thus, by implication, the fault with the system had been attributed to the cabin supercharger (only one was fitted), though the technical log did not explicitly state this nor that flight should be conducted un-pressurised. Although the aircraft commander had noted the technical log entry, it was not clear to him whether it was cautioning the crew about poor system performance or was stating a requirement for un-pressurised flight. The crew had, therefore, not consulted the MEL prior to departure from Ronaldsway, and in the absence of an explicit statement in the technical log to the contrary, had planned for normal, pressurised flight. The flight from Ronaldsway had been flown pressurised, and the expected poor system performance was noted.

Prior to descent, on the incident flight, the crew noted two other unrelated failures: one concerned the TCAS system and the other concerned an engine anti ice system, which they attempted to troubleshoot without success. The approach and landing at Ronaldsway were normal. After the aircraft had come to a stop on the parking ramp, the ground crew drew the commander's attention to the fact that the left over-wing emergency escape hatch was missing. The commander thought that the hatch had most likely been missing since takeoff and alerted ATC with a request that East Midlands Airport be notified. The commander left the aircraft through the front access door to inspect the structure but no damage was visible. However, mail bags were protruding from the hatch aperture and appeared to have jammed themselves in place. When the mail had been unloaded he entered the cabin and noted that two covers, which were designed

to protect the over-wing escape hatch operating handles, were not in place over their respective hatches but were loose on the cabin floor.

The missing hatch was subsequently found adjacent to the runway at East Midlands Airport. There was no reconciliation made of the cargo load to determine if any had fallen from the aircraft in flight. Police forces along the aircraft's track were alerted to the possibility, but no items that might have been from the aircraft were recovered, and none were later reported missing or overdue.

A loading supervisor at Ronaldsway Airport later reported that, when the aircraft was being loaded for the previous sector, the hatch covers were not positioned over the emergency exits, but were left standing on the floor against the cabin side walls. This was the position they had been found in when loading commenced. He recalled that the commander, during his external inspection, had boarded the aircraft through the rear access door to discuss loading with him. At this stage cargo had been loaded into the foremost section only, which was a non standard loading pattern, made necessary by the requirement not to use the front door. The commander later reported that he did not enter the rear fuselage during his external inspection, as the rear door was obstructed by loading equipment and personnel. Neither the supervisor nor the commander made any reference to the covers being off. Loaders interviewed at East Midlands Airport were divided as to whether the covers were or were not fitted at the time of loading at that location.

Aircraft layout

The incident aircraft had been operating for a number of years as a freighter, having been converted from its original passenger layout to enable it to operate in a Class 'E' freighter configuration. This configuration allowed for the cabin section to be fully loaded with bulk freight with

no provision remaining for crew members to pass through the fuselage once loading was complete. The conversion included equipping the cabin interior with a liner which covered the parallel section of the cabin above the floor line, and was held in place by longitudinal wooden battens. The cabin liner covered all the windows except those within the two over-wing emergency escape hatches, located in Bay 3. Apertures in the liner were positioned to enable each of these hatches to be accessed, opened and removed from inside or outside the aircraft in the normal way. This access was necessary in order to permit the hatches to be removed during scheduled inspections of the structural aperture in the pressurised fuselage, in accordance with the Maintenance Manual. The conversion also involved adding a series of net attachment points on the floor, cabin sides and roof at intervals along the cabin length. These nets divided the load volume into short sections and restrained the load in each of those sections against longitudinal movement. Cargo would normally be loaded into Bays 2 to 5, which ran from immediately aft of the forward access door to immediately in front of the rear access door. If necessary, freight could be loaded in Bay 1, which was adjacent to the forward door, or Bay 6 which was in the aircraft tail, though freight in Bay 6 would require restraint in the form of nets and lashings.

The over-wing hatches were not normally accessible from within a loaded aircraft and performed no emergency exit role in the freight operation. Rectangular covers, of similar material to the liner, were normally affixed over the hatches during these operations. On the incident aircraft, these covers were approximately two inches higher and two inches wider than the apertures in the liner and were secured over the latter by means of Velcro strips at their edges and corresponding Velcro pads on the inner faces of the liners alongside and above the apertures. Other aircraft in the operator's HS.748 fleet utilised differing systems to retain the hatch cover in place.

Each of the two over-wing emergency escape hatches on the HS.748 is of a design which is secured at its upper and lower edges. The hatch opens outwards and incorporates two abutment spigots protruding from its lower edge member which engage in corresponding recesses in the lower edge of the structural aperture. A pair of over-centring latches, protruding from the upper edge member of the hatch, engage in corresponding recesses in the upper edge of the aperture. During hatch installation, movement of either internal or external handle towards the closed position rotates the two catches in such a way that the upper edge of the hatch is drawn inboard, compressing the edge seal until the latches over-centre allowing a slight relaxation of seal pressure. Conversely, movement of either operating handle on a closed hatch in a 'hatch open' direction initially draws the upper edge of the hatch slightly inboard, against cabin pressure loading (if any), also compressing the edge seal, before allowing the upper edge to move outboard, permitting release of the hatch from the aperture.

The inner handle is stowed parallel with the cabin axis and pivots inboard against light spring pressure before rotating downwards during hatch opening operation. A shaped paxolin block, positioned just below the inner handle, ensures that inboard handle movement occurs before significant rotation of the handle shaft takes place.

In view of the absence of a need to supply air to passengers, the pressurisation and air conditioning system on aircraft of this fleet had been subjected to a weight saving modification which involved removal of one of the two cabin blowers together with certain other components and redundant parts of the distribution system.

Examination of the hatch

The left over-wing hatch was subsequently found close to the point where the aircraft would be expected to have

rotated during the take-off run. Extensive impact damage was evident on both lower corners. The remainder of the hatch, including the transparency, the abutment spigots and the locking mechanism appeared undamaged.

Examination of the hatch latching mechanism indicated that it operated correctly and little force was needed to move the internal handle inboard, away from its recessed position. Thereafter, a greater, but not excessive, force was needed to rotate the handle downwards to the open position. It is understood that handle forces are largely the result of the presence of springs and mechanical friction in the door mechanism and are not greatly increased when the hatch is installed in the fuselage aperture. The aperture in which the hatch had been mounted was reported to have been free from damage on inspection at Ronaldsway.

Aircraft pressurisation defect

The aircraft had been operating with a deferred defect in the pressurisation system. Although the technical log indicated that the cause of the loss of pressurisation was diagnosed and rectified shortly after this incident, in practice the low pressure differential persisted until a maintenance input some weeks later. It was then found that the cable operating the cabin pressure dump valve was frayed and jamming within its conduit. This had prevented the dump valve from seating although the operating handle was in its normal flight position.

Recorded data

The aircraft was equipped with a 30 minute, magnetic tape Cockpit Voice Recorder (CVR) and a 25 hour, solid state Flight Data Recorder (FDR).

Review of the flight data was significantly delayed because the data frame layout document for decoding the FDR was not available and had to be generated after

the investigation was initiated. The data frame layout is required in order to be compliant with the requirements of Article 53 of the UK Air Navigation Order and/or JAR-OPS 1.160. The investigation process highlighted significant deficiencies with the operator's CVR and FDR systems, which the operator has committed to resolving. As an initial action, the operator has generated a data frame layout document to support the FDR installation.

The FDR recorded: altitude, airspeed, pitch, roll, flap angle, normal acceleration, VHF keying, GPWS and TCAS warnings, manual event marker, trip and date and time powered. The quality of the recorded parameters was not good. The normal acceleration parameter was very noisy and the pitch and roll parameters were not providing useful data due to a problem traced by the operator to the hidden failure of the dedicated output of the gyro. The airspeed, altitude and VHF key discrete data suffered from intermittent, simultaneous, spikes.

The recorded data covered the entire flight but its limited data set did not provide any useful information regarding the loss of the hatch. The quality of the CVR audio recordings was intermittent on two of the channels due to a defective summing amplifier and a missing screw/lock device in a connector. Due to the limited recording period of the CVR, only the second half of the flight audio was captured. Whilst this did not cover the point at which the hatch was lost, it did substantiate the fact that the aircraft was suffering from a number of technical problems including one related to pressurisation.

Other than confirming that the aircraft had pressurisation problems and other unrelated system failures, the recordings offered little to the investigation. Information regarding the quality issues of the recordings has been passed to the CAA and to the operator, which has since taken corrective action to address the issues.

Aircraft loading

The operator was contracted to the Royal Mail for the carriage of small parcels, packages and mail, and each aircraft was contracted to carry up to a certain weight. The operator's loading operation at East Midlands Airport utilised Royal Mail's loading facility and staff. No technical personnel of the aircraft operator nor of any contract maintenance company having responsibility for this fleet were stationed at East Midlands. A handling company was contracted to observe engine starts and carry out pushback operations, but its personnel did not attend the aircraft during the loading process.

Instructions for loading the aircraft were contained in the operator's traffic manual. When loading with mail and small parcels, the freight compartment of the HS.748 could normally be filled before the weight limit was reached and, provided that the freight was evenly distributed, the centre of gravity limitations would not be exceeded. In view of this fact, the operator used a 'standard load plan' (SLP), which simplified loading and aircraft trim procedures, and this was used on the incident flight. Using the SLP, it was normal practice to load each freight hold section, between pairs of cargo nets and up to the cabin ceiling, before fully securing the relevant net(s). Enquiries by AAIB with the CAA after the incident established that the operator did not hold approval to operate to a SLP. This had already been identified by the CAA and raised as a finding during an audit of the operator, two weeks prior to the incident flight. The operator was subsequently required by the CAA to issue revised loading instructions which were not based on a SLP.

Loading at East Midlands prior to the incident flight followed the normal procedure. Although the front door was labelled as inoperative, loading staff had seen flight crews using it and did likewise. Bays 3 and 4, the sections

between the two over-wing exits, were loaded first using access from both the front and rear of the cabin. Nets in front of and behind the section were then fully attached to top, sides and floor before Bays 2 and 5, the outer sections, were loaded. Thus, with the aircraft loaded and prepared for flight, it was not possible to inspect Bays 3 or 4 visually.

The operator had commenced operations at East Midlands some years before but was not able to produce records for any training given to staff there. An inspection of the Royal Mail loading facility at East Midlands Airport established that none of the operator's manuals or other written instructions regarding loading were present, nor had they been at the time of the incident. There was no record at East Midlands of any Royal Mail loading staff having undergone training by the aircraft operator, and no record of any audit having been carried out by, or on behalf of, the aircraft operator.

The operator had no formal requirements for initial or recurrent training for loading personnel at its outstations. When a new base was established, a suitably experienced person would conduct training for supervisory staff, which would include the procedures detailed in the traffic manual. However, the content of such training was left to the person conducting the training. Training of ramp personnel would then be left to the supervisory staff at the station.

Operator's Safety Management System (SMS)

In accordance with the requirements of JAR-OPS, the operator had in place a SMS, established in 2001, which was in the form of an integrated safety management and quality system. This system provided for audits of contractors in accordance with JAR OPS and the CAA's recommendations (see '*regulatory oversight*' below), with the first audits taking place in January 2002.

The audit schedule allowed for a maximum of three outstations to be audited each year. At the time of the incident, six of the outstations or bases had been audited and those with a greater number of movements had been audited twice in the period. The operator flew to a total of 23 bases and outstations, where loading operations were performed, though at some of these destinations frequency was as low as one movement per week. At the time of the incident there had not been an audit carried out on the operation at East Midlands, nor was an audit scheduled in the coming year. Because of the large number of bases concerned and the limited number of audits per year, only a relatively small percentage of bases had been audited at the time of the incident. A safety recommendation is made in this regard.

Regulatory oversight

As part of its safety oversight audit programme, the CAA carried out annual audits in areas such as flight operations, ramp operations, management and quality systems. The operator had been subject to audits at its outstations and these had raised a number of findings which included deficiencies regarding the provision of written instructions to loading staff. At the time of writing several such findings remained open, having not been satisfactorily addressed by the operator, and a safety recommendation is made in this regard.

In recent years the Civil Aviation Authority's Safety Regulation Group (SRG) has sought to reduce the number of safety related incidents connected with aircraft loading, and has issued a number of Flight Operations Department Communications (FODCOMs) on the subject. In FODCOM 12/2000, operators were reminded of the responsibility placed on them under JAR-OPS to ensure that:

"...all personnel assigned to, or directly involved in, ground and flight operations are properly instructed, have demonstrated their abilities in their particular duties and are aware of their responsibilities and the relationship of such duties to the operation as a whole." (JAR-OPS1/3.205)

The SRG's communication went on to cover the common arrangement whereby loading duties are contracted to third parties, and reminded operators that:

"An operator contracting other organisations to provide certain services retains responsibility for the maintenance of proper standards. In such circumstances a nominated post holder must be given the task of ensuring that any contractor employed meets the required standards." (Appendix 2 to JAR-OPS 1/3.175)

The FODCOM went on to state in summary that:

"...operators should ensure that flight crew, cabin crew and loading staff, or ground handling agents, are appropriately trained, qualified and periodically examined for competency to carry out their duties."

In FODCOM 6/2002 the SRG noted that there were 44 loading incidents reported to the CAA in 2001. Whilst the main area of concern was differences between actual and reported loading configurations, the SRG made four recommendations, one of which was specific to trim and centre of gravity issues and not covered here. It was recommended that operators take note of previous related FODCOMs and re-familiarise themselves with the relevant requirements of JAR-OPS and the Air Navigation Order. The final recommendation is reproduced here in full:

"Operators should review the instructions they provide to all who can have responsibility for loading their aircraft, and the training that is required to ensure that these instructions are properly understood and implemented. This should ensure that the risk of incidents or accidents arising from loading errors is kept to a minimum."

Finally, in response to a specific serious incident, the SRG issued the following recommendation to operators in FODCOM 2/2003:

"Operators engaged in cargo services should review their Quality Systems and revise them as necessary to ensure that their audits include companies contracted to provide loading services. The schedules should contain items relating to the training and responsibilities of contractors' staff."

Safety action already taken

Following the incident, the operator introduced a fleet modification to fit larger inner covers to the liner apertures at the over-wing hatches. These were secured at top and bottom by the timber battens which held the liner in place and on forward and aft edges by adhesive 'speed-tape' strips. They thus became permanent parts of the liner only readily removable when the battens were unscrewed. This, in turn, would be expected to occur only during maintenance intervals, when the battens and speed tape strips were removed to enable the inner covers and thereafter the hatches to be removed for structural inspection of the apertures. At all other times, the hatches and inner handles would be covered and fully protected by the inner covers. As an interim measure, the operator issued an instruction to all handling agents regarding security of the protective covers. However, this instruction was not addressed to Royal Mail specifically,

and does not appear to have been forwarded to them by the aircraft handling agent at East Midlands.

Analysis

Assuming that the emergency hatch was correctly closed at the beginning of the loading operation and taking account of the absence of damage both to the structural aperture and lack of pre-incident damage to the hatch, the only way in which the latter could have opened was by the inner handle moving inboard and rotating downwards, (ie as in the normal sequence of hatch opening from within).

Both hatch covers were detached and loose in the cabin when the aircraft left Ronaldsway. They may have become detached due to worn Velcro pads, though there is also the possibility that they could have been deliberately removed to allow more light into the cabin during night loading operations if the aircraft was not electrically powered. Although the aircraft did experience problems with the ground power supply at East Midlands, it was powering the aircraft, and hence the lighting system, during loading. Had this not been the case loading staff there would have ceased operations, in accordance with local procedures.

No-one at East Midlands reported fitting the covers, so although loading personnel there were divided about the state of the covers, they were almost certainly not in position covering the hatches when loading commenced. The left hatch handle would therefore have been exposed to contact with items of freight loaded in the cabin. The curved shape of the cabin side above the aperture, coupled with any settlement of freight items during loading, would have permitted articles of certain shapes and dimensions to have moved downwards and outboard in such a way as to have gradually positioned themselves between the handle and the hatch structure. Under such

circumstances, the handle would readily move away from the stowed position, pivoting inboard, as settlement of load items continued. Thereafter, such settlement would have been capable of rotating the now protruding handle downwards. If sufficient rotation took place, the over-centring action of the latches would occur, permitting the hatch to open outwards. Presence of any positive cabin pressure differential would increase the force required to over-centre the catches and initiate release of the hatch above that required without pressurisation being present. It is presumed that no differential pressure was present at this point.

The location from which the hatch was recovered indicates that all or most of the take-off ground run had occurred when the hatch detached. Since considerable rotation of the handle is required to over-centre the catches, it would appear that inboard movement and hence un-stowing of the handle most probably occurred during loading, possibly accompanied by some degree of initial handle rotation. The nature of the loading operation results in the hatch area becoming obscured by freight as soon as that section of the aircraft is loaded above the window line.

The technical log entry and the low cabin pressure differential experienced by the flight crew on the previous leg were likely to have created an expectation of similar problems during the incident flight. It thus came as no surprise to the crew that no cabin pressure differential was achieved on the flight to the Isle Of Man and accounts for the fact that they did not consider the possibility that a faulty hatch or door may have been responsible for the lack of pressurisation.

Clearly the importance of the protective covers over the hatches was not appreciated by the loading staff at East Midlands. It was notable that, although the loading

operation at Ronaldsway had been the subject of an audit inspection by the operator, the loading supervisor there was also unaware of the significance of the hatch covers and did not therefore notify the commander or take steps to ensure they were re-fitted. The actions of staff at both stations suggested deficiencies in the training of staff with regard to the aircraft type, and a safety recommendation is made in respect of this.

The aircraft was correctly loaded and documented in accordance with the operator's SLP (albeit an unapproved procedure), though the loading operation appeared to rely on the experience of the loading staff and perhaps training given by other operators rather than specific guidance from the operator itself. Although the lack of written loading instructions did not result in an unsafe load configuration, this is considered to be a serious deficiency and one which has contributed to fatal accidents to cargo aircraft in the past. The lack of instructions or training regarding the technical aspects of the aircraft, including the importance of the hatch covers, contributed directly to the loss of the hatch. A safety recommendation is made with regard to the adequacy of written instructions and training at the stations used by the operator's aircraft.

Some anomalies with the acceptance and recording of aircraft defects were noted. The technical log instructions to the crew regarding the exact state of the pressurisation system were somewhat ambiguous and this was borne out by the fact that the crew operated the first sector with the aircraft pressurised, albeit slightly. The aircraft's front door was recorded and labelled as being usable in an emergency only, though this was the only means of access and egress when the aircraft was loaded. This was not a practical proposition given the nature of the operation, as the crew would have to enter the aircraft before loading commenced and would only

be able to leave after unloading was complete. The door should have been rectified, or the operation adjusted to accommodate the restrictions that the inoperative door imposed, but neither of these was done.

Safety Recommendations

Notwithstanding that the operator's use of a standard load plan had not been approved by the CAA, the aircraft was loaded in accordance with the operator's procedures and, with regard to the load distribution, was in a safe condition for flight. However, the investigation revealed shortcomings in the operator's training, safety management system, and provision of written instructions. The investigation also established that several findings from the CAA's own safety oversight programme audits remain outstanding, particularly with regard to the provision of written instructions at several of the operator's bases. The following safety recommendations are therefore made:

Safety Recommendation 2005-140

The Civil Aviation Authority should ensure that Emerald Airways reviews its procedures for initial training and periodical examination of contracted loading staff at outstations, including the provision of written instructions and aircraft technical training, to ensure that Emerald Airways fully meets the responsibilities placed on it by JAR-OPS 1.205.

Safety Recommendation 2005-141

Emerald Airways should review its safety management system with a view to accelerating the current audit schedule for outstations, and conduct a risk assessment of them all to establish those most 'at risk', prioritising audit inspections accordingly.

Safety Recommendation 2005-142

Emerald Airways should take immediate action to ensure that applicable, detailed and current written instructions are readily available to loading staff at all bases and outstations.

Safety Recommendation 2005-143

The Civil Aviation Authority should pursue the findings of its own audits of Emerald Airways' loading procedures, particularly in respect of the provision of written instructions, with a view to enforce compliance as soon as practicable.