Boeing 727-223RE, EI-HCI

AAIB Bulletin No: 12/2002	**Ref: EW/C2001/09/04**	**Category: 1.1**
INCIDENT		
Aircraft Type and Registration:	Boeing 727-223RE, EI-HCI	
No & Type of Engines:	3 Pratt & Whitney JT8D-7B turbofan engines	
Year of Manufacture:	1969	
Date & Time (UTC):	14 September 2001 at 1105 hrs	
Location:	London Luton Airport	
Type of Flight:	Public Transport (Cargo)	
Persons on Board:	Crew - 3	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	None	
Commander's Licence:	Airline Transport Pilots Licence	
Commander's Age:	40 years	
Commander's Flying Experience:	5,500 hours (of which 1,500 were on type)	
	Last 90 days - 100 hours	
	Last 28 days - 60 hours	
Information Source:	AAIB Field Investigation	

History of the flight

The aircraft was employed on a scheduled cargo service operating to a number of European destinations on behalf of a Cargo Shipping Company. At 0330 hrs on 14 September 2001, the three flight crew members reported for duty at Copenhagen Airport, Denmark. The aircraft was loaded with a part load, consisting of containers and loose cargo, and then flown to Orebro, Sweden. All the cargo was unloaded at Orebro and the aircraft then flew empty to London Luton Airport, arriving there at 0835 hrs. The next scheduled departure was to Brussels at 1035 hrs.

At Luton, the aircraft was loaded with cargo by a contracted handling company. The actual Take Off Mass (TOM) was calculated to be 150,526 lb (68,339 kg), the maximum TOM was 177,600 lb (80,630kg). Calculations for a flap 5° takeoff were completed by the crew for Runway 26, which gave a combined V1/Vr of 121 kt and a stabiliser trim position of 4.66 units. The aircraft was

pushed back off stand at 1055 hrs and taxied for departure from Runway 26. The runway surface was dry and the surface wind was 330°/13 kt.

The commander, who was the handling pilot, initiated the rotation at 121 kt but the aircraft did not respond. He increased the rearward movement of the control column, to a much larger degree than for a normal takeoff, but still there was no response. He then applied nose-up trim using the control column electric trim switches and the aircraft rotated and then lifted off. After lift off, he delayed carrying out the initial turn, as published in the Standard Instrument Departure (SID), until he was sure that the aircraft was fully under control. Finding that normal control was available, he continued with the departure and then discussed the flight options with the other two crew members before deciding to continue to Brussels.

The landing at Brussels was made with full flap and was uneventful. After parking, when the cargo door was opened, the ground crew immediately discovered that the load was not distributed in the cargo bay in accordance with the load plan. The actual positions of the containers were recorded as the aircraft was unloaded and compared with the planned load (See Figure 1 *(jpg 54kb)*). Subsequently a revised loadsheet was produced which showed that the centre of gravity (CG) had been close to the forward limit for takeoff and that it was outside the forward limit for landing. Two additional aft trim units should have been set for takeoff.

Loading procedures

The contracted handling company at Luton had written operational procedures regarding the handling of cargo aircraft, which all their employees concerned were required to have read and signed. These procedures were principally designed for the busier night operations and there were some differences during daytime operations. The operator indicated that an audit of these procedures, which included a check on the documented training records of ramp personnel, had been conducted in June 2001. An audit of loading procedures was also carried out by the Cargo Shipping Company in August 2001. Neither of these audits highlighted any significant problem affecting aircraft loading.

The aircraft upper deck was configured to accept 12 bulk containers, which were of a shape and size such that each one occupied the full width and height of the fuselage load area once loaded. Each container had to be manhandled to its final position in the aircraft before being secured. Containers were secured in place by means of floor locks. There were four locks across the fuselage width for each container. (See Figures 2 and 3 *(jpg 92kb)*).

Inbound

For an empty positioning flight, the general procedure was that all the locks should be secured in the UP position. This was consistent with the requirement for all locks to be UP when a part load was carried. In practice, on an empty sector this was often overlooked. On arrival, the locks should then be kicked down (placed in the DOWN position) before being reset in accordance with the next loadplan.

Outbound

Details of the cargo and container weights would be passed from the cargo shed to a remote office, where a loadplan for the aircraft would be compiled. When finalised, it would be sent back to the cargo shed in the form of a computer printout. Aircraft loading could then commence. One member

of the loading crew would be designated the ramp co-ordinator, with the responsibility of overseeing the loading. Containers were moved by transporter to the aircraft, where they were lifted onboard by a highloader. Once on the aircraft, the containers were manhandled into position, this needed at least four persons. Each container occupied the width of the fuselage and did not allow personnel access beyond it once loaded. It was a requirement on the Boeing 727 for the first container loaded to be placed forward in Bay A (see Figure 4 *(jpg 50kb)*). Normally the next container would be loaded in the second bay (B), before the aft bays were loaded. Once the first container had been loaded, direct access from the flight deck to the load area was blocked. The commander would receive a copy of the final loadplan, and the loadsheet to sign, when loading was complete. There was no requirement in the airlines Operations Manual for the commander to check the final load status, nor was there any means by which he could normally have done so.

Loading history

Prior to the incident, the aircraft was last loaded in Copenhagen, where the load was such that the aft two bays in the aircraft (L and M) were not used. For this configuration, the standard procedure would have required all the locks to be up in these two bays.

All of the cargo was unloaded at Orebro, Sweden. The aircraft then flew empty to Luton, where it arrived two hours before its next scheduled departure time. At Luton, the compilation of the loadplan was delayed and therefore loading did not commence on time. The loading crew were available but, finding no work to do, were redeployed onto other duties nearby. At 1000 hrs, there was a three minute silence observed across Europe in commemoration of events in New York on 11 September. The airport authority arranged that all equipment likely to create noise would be switched off at that time. The loading crew and the flight crew stood on the ramp for this period of silence.

Aware that the departure would now be delayed if loading did not start, the dispatcher contacted the office by telephone. She was passed the details of the first container, destined for Bay A, and the rearmost container, destined for Bay M. The container identity numbers were jotted down, located in the cargo shed and then loaded onto the aircraft before the loadplan was available. In fact, the rearmost container was mis-identified for one with a similar number (AAC06877 instead of AAC06787). The mis-identified container was then loaded, not in the planned location (Bay M), but two bays further forward (in Bay K, see Figures 1 and 4). During the loading operation, the ramp co-ordinator, who was the person responsible for supervising the loading, was also driving the transporter. This duty meant that he would not normally have cause to go onboard the aircraft during the loading process, but gave directions from the ground. From the ground, it was not possible to see far enough into the rear of the aircraft to be able to check the container distribution.

The loadplan arrived at the aircraft and the co-ordinator was given a copy. He was the only member of the loading team to have one. The loadplan details produced by the computer were in a print size, font, and of a quality that could have made reading the container identity numbers difficult. However, the co-ordinator was familiar with this standard of paperwork.

The remainder of the containers were located in the cargo shed and each was loaded, in sequence, forwards from Bay K, with the exception of one which was loaded in the forward Bay B. This left one empty bay visible in the doorway after the loading was complete (see Figure 4), whereas there should have been 3 empty bays together (see Figure 5). This discrepancy was not observed by anyone. One of the loading crew on board was then asked to check that the locks were secure and

to sign the loadplan to say the locks were checked. The loadplan and the loadsheet were presented to the commander who accepted and signed the loadsheet.

When interviewed after the event, the members of the loading crew, including the ramp co-ordinator, were under the impression that the Cargo Shipping Agency, not their own company, was responsible for overseeing the loading of the aircraft. This was an incorrect assumption.

Flight recorders

Flight Data Recorder

The aircraft was fitted with a Sundstrand Digital Flight Data Recorder (DFDR) with magnetic tape as the recording medium. All mandatory parameters had been recorded successfully. Additional parameters, including control column position, had also been recorded. This enabled a detailed analysis of the incident to be made. The evidence obtained from the DFDR corroborated the crew statements related to the handling of the aircraft during the take-off incident.

A plot of the salient parameters against an arbitrary time datum is shown in Figure 6 *(jpg 91kb)*. From this, it can be seen that, at the initiation of rotation (taken to be when the control column was moved aft, at time 37544 seconds), the airspeed was about 122 kt. It can also be seen that there was no discernible change in aircraft pitch attitude until about 5 seconds later. Additionally, it can be seen that the control column was moved very close to the fully aft position, and remained significantly aft, until the aircraft left the runway. The calculated pitch rate during rotation was about 1° per second. This was less than the normal rate. Due to the low sample rate of the data and the lack of parameters, such as weight-on-wheels, it was not possible to determine precisely when the aircraft actually lifted off. However, it could be inferred that the aircraft became airborne at an airspeed of between 140 and 150 kt.

For comparison, a time history of a previous takeoff (with similar rotation speed target) was extracted from the DFDR data. It was found that there was little or no lag in pitch response to the aft control column at rotation. Additionally, the amount of aft control column to rotate the aircraft was much less than that seen for the incident and the calculated pitch rate during rotation was about 1.5° per second.

Cockpit Voice Recorder

The aircraft was fitted with a Cockpit Voice Recorder (CVR) which recorded crew speech and area microphone inputs on a continuous 30 minute loop when power was applied to the aircraft. The aircraft had flown a significant number of sectors since the incident took place before the removal of the flight recorder for replay at the AAIB. The CVR data relevant to the incident had thus been over-written.

Other information

For the purposes of the investigation, further loadsheets were prepared to reflect the actual loaded condition of the aircraft and also to examine the significance of transposing two containers. This showed that the CG had been close to the forward limit for takeoff. It was also outside the forward CG limit for landing. To correct the mis-trim condition at takeoff, an additional two aft trim units would have been required. Transposing the two containers alone did not have any significant effect.

The crew had not received any training or guidance as to the possible handling effects of operating the aircraft outside its normal CG envelope. In order to be approved for crew training, a flight simulator is required to be representative of an aircraft in all normal conditions of flight. Simulation of the as loaded condition of this particular aircraft type would not be available because it would fall outside the normal flight envelope. However, some operators do include misloaded and mistrimmed conditions in their recurrent crew training programmes. The initial flight test programme for the Boeing 727 explored out of trim conditions of up to three units. In this condition, it was reported that stick forces required were not excessive and aircraft handling did not pose a particular difficulty.

Automatic weight and CG detection systems are available. One such system consists of independent load sensors fitted to each landing gear. This system detects a discrepancy between the calculated weight and CG of the aircraft and the certified loading envelope limits, by displaying a GO/NO GO light to alert the crew. Other similar systems have been employed in the past but there is an apparent lack of industry confidence in the accuracy of such systems and therefore their value.

No single body is responsible for the safety oversight of ramp operations within the UK, but the aircraft operator retains responsibility for all operational aspects, including those completed by contractors.

The UK Civil Aviation Authority (CAA) conducts a safety oversight programme of UK cargo operators. This programme includes a specific number of ramp inspections in the UK of cargo loading procedures, which has the additional effect of indirectly monitoring the procedures of the cargo handling companies. When failings are identified during such inspections, the operator is required to ensure that corrective action is taken. By this means, most of the UK based cargo handling companies, and the procedures they use, are subjected to some degree of external supervision.

The Irish Aviation Authority (IAA) was the regulatory body responsible for safety oversight of this operator. In March 2001 the IAA, having identified a general trend of increasing numbers of reportable loading errors, issued an Operations Advisory Memorandum (OAM) 06/01. This reminded operators of their responsibilities under JAR-OPS, for overseeing the quality of the function of contractors, including ensuring that contractors personnel were properly trained in their duties and aware of their responsibilities.

JAR-OPS requires the operator to nominate a post holder to ensure that required standards are met. The OAM included several observations to operators as follows:

> *Staff should be clear not only of the scope and boundaries of their responsibilities, but also of those of the staff with whom they interface with regard to loading.*
>
> *Operators must also ensure that the person responsible for supervising the loading of the aircraft has inspected the load and reconciled the actual load distribution with the aircraft loading instructions or load report, has checked that the load is properly restrained throughout the cargo compartments and then confirms, by signature, that the load and its distribution are in accordance with the load and trim sheet. Sufficient time must be available for such checks to be carried out properly.*

Analysis

Two separate errors occurred during the loading of this aircraft. The first concerned the mis-identification of two containers that became transposed in the loading order. Two of the containers loaded were initially identified by a verbal transmission of numbers. This was not in accordance with normal procedure. This error alone however would not have caused a significant problem.

The second error was that the floor locks were not reset for the outbound load, which led to the subsequent incorrect positioning of the containers within the aircraft. The configuration of the aircraft locks from Copenhagen to Orebro matched that for the loading out of Luton. It is most likely that the locks were left in position after the offload at Orebro, and were never again effectively checked.

The ramp co-ordinator was responsible for the loading of the aircraft, but he was not aware of the extent of this responsibility, believing that personnel from another company had overall control. His supervision from the ground was in accordance with company procedures, but did not place him in a position to see the actual location of the containers on board the aircraft. This was compounded by the subsequent failure to reconcile the final load on board with the loadplan, which led to the aircraft being despatched in a significantly out of trim condition.

The flight crew, having passed V1, and thereby having passed the point where a stop decision could safely be made, were confronted with the possibility that the aircraft might not be able to fly. The action taken by the commander was to run the stabiliser trim, which moves at a rate of one unit per two seconds. The degree of loading error meant that an additional two units were required for the correct trim setting. The elapsed time before the aircraft was properly configured was thus four seconds from initiation of the stabiliser trim. Rotation commenced at five seconds after Vr and lift-off was some eight seconds after that. Despite flight test data having shown that up to three units of mistrim should be manageable, on this occasion the stick was held to almost the full aft position without any observable response from the aircraft. A subsequent problem was that once having established that the aircraft was controllable in flight, this could then change as a result of fuel burn or a change of configuration.

The commander of the aircraft accepted the responsibility for the correct loading of the aircraft by signing the loadsheet, but in practice he had to rely on third parties to ensure that procedures had been followed.

Two errors arose separately as a result of failures within the loading procedures themselves and in deviations from them. On this occasion, a simple visual comparison of the loaded aircraft against the loadplan would have showed up the discrepancy. The evidence from this incident is that shortcomings that directly affect flight safety exist within the procedures and common practices of UK cargo handling companies.

It could not be determined whether the three minute silence period interrupted any part of the loading procedure, but it was a departure from normal airfield operations and thereby may have constituted a distraction.

Safety action

During the course of the investigation, it was verbally recommended to the cargo handling company that their procedures needed to be amended in order to ensure that the person responsible

for overseeing the loading was in the best position to be able to do so. The cargo handling company has subsequently reviewed and implemented changes to its operating procedures which reflect this advice. It has also initiated a staff awareness training programme to highlight the impact that loading errors could have on aircraft performance. Therefore, no further safety recommendation regarding these aspects was made.

The following safety recommendation was made to the CAA on 14 November 2001:

Recommendation 2001-79

It is recommended that the CAA review their level of oversight of cargo operations with a view to increasing the number and depth of their inspections. In particular the CAA should insist that a final reconciliation of the actual load distribution with the loadplan is invariably carried out by an appropriate person.

On 16 January 2002 the CAA responded to the above safety recommendation as follows:

> *The CAA has reviewed its level of oversight of cargo operations and has appointed an Airworthiness Surveyor as the national coordinator of the Cargo Oversight Programme. In addition to other benefits, this will increase both the number and depth of the cargo inspections carried out.*
>
> *The CAA believes that a final reconciliation of the actual load distribution with the loadplan by an appropriate person is already a requirement. Article 35 of the Air Navigation Order 2000 and JAR-OPS 1.625 both contain a requirement that the actual load distribution is as shown on the loadsheet and that this is confirmed by the signature of the person supervising the loading (an appropriate person). This can only be achieved by a final reconciliation between the actual load distribution and the loadsheet. This loadsheet is then presented to the aircraft commander for examination and acceptance. Article 43(d) of the Air Navigation Order 2000 and JAR-OPS 1.290(b)(10) place a responsibility on the commander to ensure that the load is properly distributed and safely secured. The national coordinator of the Cargo Oversight Programme will pay special attention to this aspect of cargo operations and in the meanwhile cargo operators will be reminded of the requirements in a forthcoming Flight Operations Department Communication (FODCOM).'*

The most effective solution to aircraft loading errors is to endeavour to ensure that they do not occur. The Irish Aviation Authority had identified that a potential problem existed and issued OAM 06/01, which included a number of measures that, if carried out, would have prevented this incident from occurring. This memorandum also reinforced the fact that JAR-OPS clearly states that the area of responsibility for loading the aircraft rests with the operator. However neither the audit carried out by the operator, or that by the Cargo Shipping Company, detected the problems that led to this incident.

As a result of this incident, the operator has expressed an intention to expand its audit programme to address in more detail the subject of training records and the supervision of loading. The operator is also considering establishing a 'pooling' agreement with other operators, as permitted under the terms of JAR-OPS, to conduct a comprehensive audit programme of all contractors throughout their area of operation. Furthermore, details of this incident have been brought to the

attention of their flight crews, to help maintain awareness of correct loading procedures and to highlight the crew's role in ensuring that safe loading takes place.

The following safety recommendations are also made:

Recommendation 2002-48

It is recommended that Air Contractors (Ireland) Ltd reviews its Quality System to ensure that their audits include contractors and that the schedules contain items relating to the training and responsibilities of contractors staff.

Recommendation 2002-49

It is recommended that the Irish Aviation Authority, having reminded operators of their responsibilities under JAR-OPS for oversight of all aspects of flight operations, ensure that operators are conducting appropriately detailed audits of their contractors.