Uncommanded rotation, Incident involving aircraft LN-RPL at Gothenburg/Landvetter Airport, O county, Sweden, on 7 December 2003

Micro-summary: **This Boeing 737-800 experienced an uncommanded rotation while accelerating for takeoff.**

Event Date: **2003-12-07 at 1845 UTC**

Investigative Body: **Swedish Accident Investigation Board (AIB), Sweden**

Investigative Body's Web Site: **http://www.havkom.se/**

Statens haverikommission
Swedish Accident Investigation Board

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Report RL 2005:20e

Incident involving aircraft LN-RPL at Gothenburg/Landvetter Airport, O county, Sweden, on 7 December 2003

Case L-59/03

SHK investigates accidents and incidents with regard to safety. The objective of the investigations is the prevention of similar occurrences in the future. It is not the purpose of this activity to apportion blame or liability.

The report is also available on our website: www.havkom.se.

Translated by Tim Crosfield, M.A., from the original Swedish at the request of the Swedish Accident Investigation Board. In case of discrepancies between the English and the Swedish texts, the Swedish text is to be considered the authoritative version.

Statens haverikommission (SHK) Swedish Accident Investigation Board

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2005-09-29 L-59/03

Swedish Civil Aviation Authority

SE-601 73 NORRKÖPING

Sweden

Report RL 2005:20e

The Swedish Accident Investigation Board (Statens haverikommission, SHK) has investigated an incident that occurred on 7 December 2003 at Göteborg/Landvetter Airport, O county, Sweden, involving an aircraft with registration LN-RPL.

In accordance with section 14 of the Ordinance on the Investigation of Accidents (1990:717) the Board herewith submits a report on its investigation.

The Board will be grateful to receive, by Mars 1 2006 at the latest, particulars of how the recommendations included in this report are being followed up.

Göran Rosvall

Henrik Elinder Gerd Svensson

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Appendices

1 The loadsheet
2 Excerpt from Register of Licences regarding the pilot (Swedish Civil Aviation Authority only)

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Report finalised 29-09-2005

Aircraft: registration, type	LN-RPL, Boeing 737-800
Class, airworthiness	Normal, valid Certificate of Airworthiness
Owner/operator	SAS Struktur Invest HB/SAS
Time of event	2003-12-07, 19.45 hrs in darkness *Note.: All times are given in Swedish daylight saving time (UTC + 1 hour)*
Place	Göteborg/Landvetter Airport, O county, Sweden (pos. 57 40N 012 18E; 154 m above sea level)
Type of flight	Charter
Weather	According to SMHI[1] analysis: Wind 250 degrees 7 kts, CAVOK[2], temp./dew point +4/+2 °C, QNH 1019 hPa
Persons on board:	
crew members	6
passengers	121
Injuries to persons	None
Damage to aircraft	None
Other damage	None
Commander:	
Sex, age, licence	Male, 53 years, ATPL
Total flying time	9 462 hours, of which 2 119 on type
Flying hours, previous 90 days	158, of which all on type
Number of landings, previous 90 days	58, of which all on type
Co-pilot:	
Sex, age, licence	Male, 36 years, CPL
Total flying time	3 750 hours, of which 1 340 on type
Flying hours, previous 90 days	176, of which all on type
Number of landings, previous 90 days	119, of which all on type
Cabin crew members	4

The Swedish Accident Investigation Board (SHK) was informed on 15 December 2003 that an incident involving an aircraft with registration LN-RPL had occurred at Göteborg/Landvetter Airport, O county, Sweden, on 7 December 2003 at 19.45 hrs.

The incident has been investigated by SHK represented by Göran Rosvall, Chair, Mats Öfverstedt, Chief Operational Investigator until 14 February 2005, Henrik Elinder, Chief Technical Investigator and Gerd Svensson, Chief Investigator Human Factors.

During the investigation SHK obtained information from SAS's internal organisation for the investigation of accidents and incidents, SOMIT. The investigation was followed by the Civil Aviation Authority in the person of Max Danielsson.

Accredited representative from the National Transportation Safety Board (NTSB) in USA, was Mr. Frank Hilldrup.

[1] SMHI – Swedish Metrological and Hydrologic Institute
[2] CAVOK – Visibility over 10 km, no cloud below 5 000 feet

Summary

The airline company was operating a series charter flight from Salzburg Airport in Austria to Stockholm/Arlanda Airport, with an intermediate stop at Göteborg/Landvetter Airport. In Göteborg 59 passengers disembarked while the remaining 121 remained seated in the cabin. No new passengers were taken on board.

According to the loadsheet that the pilots received prior to the continued flight to Stockholm the passengers were evenly distributed in the cabin and the mass and balance limitations in force were met.

At the start, when the aircraft was approaching 80 knots and before V1[3] had been reached, the co-pilot, who was the flying pilot, noted that the aircraft's nose was lifting spontaneously without him moving the control column. He reported this to the commander who took over the control and aborted the takeoff.

The pilots and the SAS-personnel later discovered that the particulars in the loadsheet concerning the distribution of passengers in the cabin did not tally with where the passengers were actually sitting.

The investigation has noted shortcomings in the routines and computerised systems used for the production of loadsheets. This resulted in that the takeoff was commenced with a centre-of-gravity position at more than 1/4 aft of the certified CG span.

The incident was caused by shortcomings in the routines and computer systems used in the production of loadsheets.

Recommendations

The Swedish Civil Aviation Authority is recommended:

- to seek in international air safety work to ensure that the supervisory authorities concerned place higher demands on the quality assurance, including verification and validation, with reference also to human factors, of operational aids systems that can affect flight safety *(RL 2005:20e R1),*
- require information and acknowledgement anytime a calculated or default value is used instead of a verified value for computer systems used by pilots for planning purpose and affecting flight safety, *(RL 2005:20e R2)*,
- for all passenger traffic with heavy aircraft, to introduce a requirement for physical checks of passenger seating throughout the cabin versus loadsheet data where computerised systems are used in the production of loadsheets *(RL 2005:20e R3).*

[3] V1 – Speed during takeoff above which takeoff cannot safely be interrupted.

1 FACTUAL INFORMATION

1.1 History of the flight

The airline company was operating a series charter flight, SK 7918, from Salzburg Airport in Austria to Stockholm/Arlanda Airport, with an intermediate stop at Göteborg/Landvetter Airport. The flight was return transport to Sweden of a charter group that had been flown to Salzburg previously.

On takeoff from Salzburg 180 passengers were on board and the flight to Göteborg was without remark. After landing in Göteborg 59 passengers disembarked while the remaining 121 remained seated in the cabin. No new passengers were taken on board. The aircraft was refuelled and de-iced for the continued flight to Stockholm.

While on the ground the cabin crew noted that most of the remaining passengers were sitting far back in the cabin. This was pointed out to the commander, who elected to wait before taking any action until he had seen the loadsheet.

The wait on the ground was longer than planned, owing to problems with refuelling and de-icing. This created some irritation because of the eagerness to get started. The pilots received the loadsheet just before the aircraft was ready to leave the terminal. Takeoff was then about 20 minutes delayed and the pilots were already sitting belted up in the cockpit. According to the loadsheet the passengers were evenly distributed in the cabin and the mass and balance limitations in force were met. The engines were then started and the aircraft taxied out for takeoff with the co-pilot as Pilot Flying (PF).

Acceleration on the runway for takeoff was normal. When the aircraft was approaching 80 knots and before V1 had been reached the co-pilot noted that the aircraft's nose was lifting spontaneously without him moving the control column. He reported this to the commander who took over the control. The commander immediately aborted the takeoff and taxied the aircraft to the terminal building. After parking the aircraft the pilots, together with the SAS-personnel went through the loadsheet they had received prior to takeoff. They discovered that the particulars in the loadsheet concerning the placing of passengers in the cabin did not tally with where the passengers were actually sitting.

The passengers were rearranged to achieve an even distribution in the cabin and a fresh loadsheet was produced. The aircraft then took off for Stockholm/Arlanda.

The incident occurred at position N 57 40 E 012 18; 154 m above sea level.

1.2 Injuries to persons

	Crew members	*Passengers*	*Others*	*Total*
Fatal	–	–	–	–
Serious	–	–	–	–
Minor	–	–	–	–
None	6	121	–	127
Total	6	121	–	127

1.3 Damage to aircraft

None.

1.4 Other damage

None.

1.5 Personnel information

1.5.1 *The commander*

The commander, a male, was at the time 53 years old and held a valid AT-PL.

Flying time (hours)			
Latest	*24 hours*	*90 days*	*Total*
All types	4	158	9 462
This type	4	158	2 119

Number of landings this class/type previous 90 days: 58.
Flight training on type undergone in November 1999.
Latest operator's proficiency check undergone 28-04-2003.

Duty schedule
The commander's duty tour started the same day as the incident. On the day in question he had carried out 2 flights with a total flying time of app. 4 hours.

1.5.2 *The co-pilot*

The co-pilot, a male, was at the time 36 years old and held a valid CPL.

Flying time (hours)			
Latest	*24 hours*	*90 days*	*Total*
All types	4	176	3 750
This type	4	176	1 340

Number of landings on type latest 90 days: 119.
Flight training on type undergone in May 2001.
Latest operator's proficiency check undergone 03-10-2003.

Duty schedule
The co-pilot's duty tour started the same day as the incident. On the day in question he had carried out 2 flights with a total flying time of app. 4 hours.

1.5.3 *Cabin crew members*

Four cabin crew members were on duty on board.

1.5.4 *The crew members' duty schedule*

The crew members' scheduled hours were within the requirements in force according to BCL-D.

1.6 The aircraft

1.6.1 General

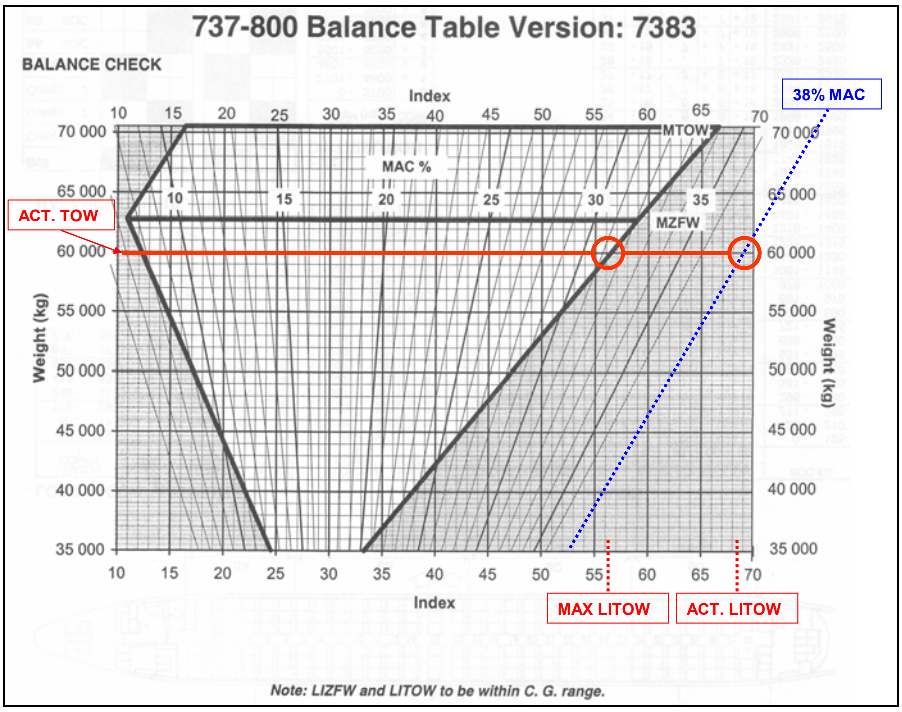
The Aircraft	
Manufacturer	Boeing
Type	B 737-800
Serial number	30469
Year of manufacture	2000
Gross mass	Max permitted takeoff mass 70 533 kg, actual 59 285 kg
Centre of mass	6.5 % MAC[4] aft of aft centre-of-gravity limit for actual mass (see below)
Total flying time	6 558 hours
Number of cycles	7 484
Flying time since latest inspection	4 hours (MSC check)
Fuel loaded before event	Jet A1

Engines		
Engine manufacturer	GE-SNECMA	
Model	CFM56 7B26 DAC	
Number of engines	2	
Total operating time	No 1	No 2
Operating time since overhaul	6 492	6 873
Cycles since overhaul	7 412	7 861

The aircraft had a valid Certificate of Airworthiness.

1.6.2 Centre-of-gravity (CG)

Actual start mass and centre-of-gravity position prior to takeoff from Göteborg/Landvetter Airport (LITOW[5]) is marked on the diagram below.



4 MAC - Mean Aerodynamic Chord.
5 LITOW - Load Index Take Off Weight.

It can be seen from the diagram that the aircraft's centre-of-gravity-position was approx. 38 % MAC, which is approx 6.6 % MAC aft of the aft certified CG limit for the actual takeoff mass, 59 285 kg. The deviation represents more than 1/4 of the certified CG span. (See also 1.18.1.)

According to the loadsheet the pilots received prior to takeoff, the aircraft's centre of gravity was at 25 % MAC. Based partly on this information, the stabiliser trim position was set to 4.5 units, with flap position no. 1

1.7 Meteorological information

According to SMHI analysis: Wind 250/7 knots, CAVOK, temp./dew point +4/+2 °C, QNH 1019 hPa.

1.8 Navigational aids

Not applicable.

1.9 Radio communications

Radio communications between the air traffic controller in the tower and the crew of SK 7918 were normal.

1.10 Aerodrome information

The airport status was according to AIP[6]-Sweden.

1.11 Flight recorders

1.11.1 Flight Data Recorders (FDR, QAR, GPS)

The aircraft was equipped with a digital FDR (DFDR). Recorded data have not been analysed.

1.11.2 Cockpit voice recorder (CVR)

The aircraft was equipped with a CVR, which has capacity to record 30 minutes of sound from microphones in the aircraft. The recording was not preserved after the incident and had thus been overwritten by the time the SHK was informed.

1.12 Site of event

The event occurred at Göteborg/Landvetter Airport, runway 21.

1.13 Medical information

Nothing indicates that the physical or mental condition of the crew members was impaired before or during the flight.

[6] AIP – Aeronautical Information Publication.

1.14 Fire

There was no fire.

1.15 Survival aspects

Not relevant.

1.16 Tests and research

1.16.1 Consequence analysis of incorrect centre-of-gravity position

To gain an idea of possible consequences of the incorrect centre-of-gravity position for the aircraft's performance and flight characteristics, the relevant data was sent to the manufacturer for analysis.

The manufacturer has never carried out an actual flight test on this aircraft type with a centre-of-gravity position so far aft of the certified limit. The analysis carried out was therefore based on simulator tests.

The simulator tests showed that the aircraft's nose with the actual takeoff mass and centre-of-gravity position would have lifted spontaneously from the runway at a speed of approx. 80 knots. (Normal speed on lifting would have been approx. 140 knots.) The tests further showed that it would have been possible to complete the takeoff and then land. With the actual trim setting, however, the pilots would have had to exert a constant forward force on the control column to keep the aircraft's nose attitude correct. At a centre of gravity of 38 % MAC, the aircraft would have been capable of safe flight, but would be more control sensitive in all flight regimes.

1.17 Organisational and management information

1.17.1 General

The airline company, Scandinavian Airlines Systems (SAS), operates heavy national and international air transport. The head office is in Stockholm. Main technical bases are in Stockholm, Copenhagen and Oslo. Technical responsibility for aircraft type Boeing 737 is at the Arlanda base in Stockholm.

The SAS Ground Services function includes a number of load control centres, Central Load Control (CLC) in and outside Sweden, which coordinates passengers, luggage, cargo and fuel, and perform weight and balance calculations prior to flight departures (see 1.18.3.)

1.17.2 SAS Flight Operations Manual (SAS FOM)

At the time of the incident SAS FOM was the company's approved document for flight operations. On 20 March 2005 this was replaced with SAS Operation Manual-A (SAS OM-A). There are no sizeable differences between the manuals regarding the points below.

Under FOM the commander always bears the responsibility for flight safety and for the flight being conducted according to instructions in force.

Prior to takeoff, cabin staff must report to the commander that the cabin is prepared for takeoff and inform him/her of the number of passengers on board. At the time of the incident there was no requirement as to reporting the distribution of passengers in the cabin.

Regarding loadsheets produced via the Passenger and Load Control (PALCO) system (see 1.18.3) FOM prescribes that the commander, or another person appointed by him, shall prior to each flight check that line number, aircraft registration, crew and fuel quantity are correct. The loadsheet shall be signed by the commander.

1.17.3 *Electronic loadsheets*

The company routine is for the loadsheet produced by the PALCO system to be sent directly to the pilots in the cockpit in electronic form via the aircraft's Aircraft Communications And Reporting System (ACARS). When using ACARS loadsheets the commander shall also check on the computer screen:

- Destination airports and alternative airports
- Flying time to destination
- Total endurance with actual fuel on board
- Possible takeoff alternative

The electronic loadsheet is signed by the commander keying in his personal code into the system.

1.17.4 *Cabin crew training*

Cabin staff members have general training in aviation technology and shall be aware that passenger distribution in the cabin can affect the stability and thus also flight safety.

1.18 Additional information

1.18.1 *Mass and CG*

For each aircraft type, values are specified for maximal takeoff mass and limits within which the aircraft's centre-of-gravity (CG) must lie for it to be fully manoeuvrable. The centre of gravity position, which is the equivalent point where gravity is applied to the aircraft, must lie near the centre of the wing lift force. The lift force centre is approximately 25 % into the wing chord, which is the length of the wing cross-section. Permitted centre-of-gravity limits are therefore often specified as percentages of the wing chord. For aircraft types with trapezoid wing configurations, as in the present case, the chord is specified as Mean Aerodynamic Chord (MAC).

Prior to each flight the aircraft's takeoff mass and centre-of-gravity position must be calculated based on the number and placing of passengers, cargo and fuel. This is done via a special index system. Thereafter, using a diagram (see 1.6.2), it is possible to check that start mass and centre-of-gravity position are within permitted limits.

Calculated centre-of-gravity position is also used to make an initial setting of the aircraft's longitudinal trim system so that control column forces are normal during takeoff.

Flight mass and centre-of-gravity position can be calculated with templates or using computer systems.

For the actual flight the forward CG limit was 7,8 % MAC and the aft CG limit was 31,4 % MAC.

1.18.2 *Loadsheets*

Before any flight a loadsheet must be produced and checked so as to ensure among other things that the aircraft's takeoff mass and centre-of-gravity position are within permitted limits. The loadsheet can be prepared manually by the pilots but, for schedule- and charter-traffic, usually via some form of computer system. Basis for this calculation are Dry Operating Weight (DOW) and Dry Operating Index (DOI). To prepare the loadsheet, information is needed on number and placing of passengers, weight and arrangement of cargo and quantity and disposition of fuel.

1.18.3 Passenger and Load Control (PALCO)

PALCO is an overall computer system used by SAS for handling and processing different types of information necessary for any flight. The system takes account of how much fuel is required for the flight and calculates how much cargo can be carried and how it must be arranged in the aircraft's cargo holds. PALCO also originates the loadsheet the pilots need to be able to conduct the flight.

Gathering and processing of information concerning a flight starts in PALCO several days before the actual flight. Processed information is sent continuously to the instances involved before the flight.

When the preparation of a loadsheet is complete it is passed manually to the pilots before takeoff or printed out automatically in the cockpit via ACARS. One condition for obtaining a loadsheet is that those responsible have confirmed that passengers, cargo and fuel have been handled according to directives submitted.

PALCO is used throughout the whole SAS line network, nationally and internationally, and is operated by Central Load Control (CLC) centres situated in Stockholm, Copenhagen, Oslo and Bangkok.

SK7918 was handled by the Stockholm CLC. The airport in Salzburg was not directly linked to PALCO at the time.

1.18.4 Passenger Check In (PCI)

One of the sub-systems that supply the PALCO system with information is Passenger Check Information (PCI), which handles passengers and their placing in the cabin in connection with check-in. In some cases, when check-in is done for a flight in which some of the seats are already occupied, the information on this is sent to the appropriate PCI function (departure station next in line) via what is termed a Seat Occupied Message (SOM).

At the time of the incident the PALCO system was so designed that the process for producing a loadsheet could, under certain conditions, continue even though an expected SOM was missing. For the calculations, the system then used a default value that involved an assumption that passengers were evenly distributed throughout the cabin.

In such situations the system sent a warning to the waiting PCI function in the form of a message ("DIFF/SOM LDM"). The message was shown on the computer screen as soon as the relevant PCI function was activated (the gate was opened) and alerted the gate staff of the need to report to the system the true arrangement of passengers in the cabin.

If the PALCO system used a "default value" instead of a verified value, the relevant CLC instance was informed of this with the message ”EVENLY DISTRIBUTED” printed out on a printer.

1.18.5 Handling of SK7918

SK7918 was a charter flight from Salzburg (SZG) to Göteborg (GOT) to Stockholm (ARN), with a closed charter group. The airline representative had no instructions to decide the passengers' arrangement throughout in the cabin, since the travel agents themselves saw to this. To simplify disembarkation in Göteborg, the Göteborg passengers were to be seated in the forward portion of the cabin and the Stockholm passengers in the aft portion. No information had been given to the travel agents regarding the significance of cabin seating arrangements for the aircraft's stability.

Salzburg Airport was not connected to the PALCO system, with the result that the SOM to PALCO regarding the seating of passengers who were continuing to Stockholm would be sent by telex. Since the Salzburg personnel sent the message to the wrong address, it was printed out on an unmanned printer and did not reach PALCO. The address used was no longer current and had been replaced with a new one, which was not clear from the manual received by the station.

The absence of a SOM from Salzburg meant that PALCO preparation regarding the subsequent flight between Göteborg and Stockholm took place with a default value for passenger seating, representing even distribution throughout the cabin.

Information on this circumstance was included in the PALCO system as a "DIFF/SOM LDM" warning addressed to PCI in Göteborg.

Since no passengers were taken on board during the intermediate landing in Göteborg, PCI there was never activated and the warning remained unread. There was no requirement to activate PCI at a station for a flight where no passengers were to be taken aboard.

In consequence, the continued PALCO preparation of the flight to Stockholm used the information that the passengers were evenly distributed in the cabin (default value). Information on this took the form of an "EVENLY DISTRIBUTED" message on a printer at CLC in Stockholm, but nobody there noted this.

Earlier, a LDM[7] had been sent from Salzburg, but in the wrong format. The error was that the aircraft's cabin was specified as consisting of two classes instead of one. Arlanda CLC received an indication of this since the message was not accepted by the PALCO system. CLC corrected the format, which was subsequently accepted by the system. CLC received no clear information that the PALCO system had not received a SOM.

The loadsheet produced by the PALCO system for the flight was thus based on erroneous particulars of the passenger seating throughout the cabin. It was not evident from the loadsheet that it had been calculated with a default value for passenger seating.

1.18.6 *Relevant loadsheet for SK7918*

The loadsheet (see appendix 1) that the pilots of SK7918 received via ACARS states that the passengers were evenly distributed throughout the cabin. The table below compares the seating according to this loadsheet with the true seating.

Aircraft section	Nos. of passengers in each section according to load-sheet	True nos. of passengers in each section
OA (Forward)	22	5
OB	37	26
OC	37	54
OD (Aft)	25	36

The centre of gravity position on takeoff is given in the loadsheet as MAC 25 %. As shown under 1.6.2 the true centre-of-gravity position was approximately MAC 38 %.

1.18.7 *Quality assurance of loadsheet*

Irrespective of what system is used for producing the loadsheet it is, according to the provisions in force of JAR-OPS 1 Subpart J, the operator who is responsible for the correctness of the information in it.

The Scandinavian Surveillance Office (STK), which has supervisory responsibility for the airline company, has not examined closely how the

[7] LDM – Load Message.

company has ensured that loadsheets prepared by the PALCO system are correct in every possible flight situation.

1.18.8 Working hours at CLC

The staff in Central Load Control (CLC) at Arlanda at the time of the incident was working a double shift. The morning shift started at 05.15 hrs and the afternoon shift ended at 23.45 hrs. The work schedule was so arranged that a morning shift was not directly followed by an afternoon shift. It happened that, if necessary, staff could work a double shift, i.e. approximately 18 hours.

The relevant official there were working double shift on the day in question and at the time of the incident had been on duty for about 13 hours.

Studies have shown that an early start to a morning shift (before 7.0 a.m.) often entails short sleep and lower sleep quality, which leads to increased tiredness. This affects recovery between shifts and can hence also lead to impaired performance.

There is very little research into double-shift working and its effects on sleepiness, attention, memory and decision-making. However it important that recovery between shifts is sufficiently long, that there are good opportunities to take rests and short breaks during work, and that the individual is involved in, and can influence, decisions about the duration and timing of work. Double-shift work where there are high requirements as to safety should nevertheless be avoided.

1.18.9 Action taken

Since the incident the STK has urged the airline company in a document designated TL 99 to introduce a manual check that the number and seating of passengers in the cabin tally with what is given in the loadsheet.

The airline company has introduced limited trials in which cabin staff report the number of passengers in each cabin section using a special form which is passed to the commander before takeoff.

Following the incident the airline company has taken the following steps to reduce the risk of a similar incident occurring again:

- Local instructions for Central Load Control (CLC) have been revised regarding steps to be taken in the absence of Load Message (LDM) and Seat Occupied Message (SOM).
- Procedures in the Station Passenger Manual (SPM) have been revised with regard to addresses to which SOM shall be sent.
- Procedures in the PALCO system have been revised. If information needed for the production of the loadsheet is missing or incorrect, a supplementary warning is given to the CLC involved. In addition, production of the loadsheet is interrupted and can only be restarted manually and with confirmation from the user.

2 ANALYSIS

2.1 The incident

An aircraft's mass and the position of its centre of gravity affect its performance, flight characteristics and flight safety margins. Flying with an aircraft whose centre-of-gravity position is outside permitted limits therefore always involves a flight safety risk.

In the present incident, the takeoff was started with a centre-of-gravity position more than 1/4 aft of the certified CG span which must be viewed as very serious in terms of flight safety. The aircraft manufacturer's simulator tests show that, while the aircraft was flyable in this configuration, it would have been sensitive in all flight situations.

This circumstance manifested itself during the acceleration on the runway when the aircraft's nose spontaneously started to lift at as low a speed as 80 knots, i.e. just over half the normal lift-off speed. Had the commander not aborted the takeoff, the aircraft would have become airborne in a configuration that was entirely different to what the pilots were accustomed to and trained for. The safety margins for other possible disturbances would have been appreciably reduced.

2.2 The chain of events

The fact that such a large deviation from standards in force could arise despite well-developed routines and the use of advanced computerised systems should be viewed as a warning signal for operators and authorities alike.

Most flights within heavy-traffic aviation are to and from established airports and follow recurrent and general procedures. It is primarily for handling operationally this type of aviation that procedures and computer systems have been developed. Such systems are necessary for the operators to be able to meet the demands of flight safety, efficiency and economy. They also constitute an aid that those involved must be able to rely on.

However, occasions sometimes arise when flights must be made that depart from the normal in one or more respects. The present incident shows how easy it is for an unexpected situation to arise, one which the designers of the ”general system” have not foreseen or been able to foresee.

As discussed in 1.18.5 this case involves several circumstances that led to the loadsheet the commander received prior to takeoff being incorrect. Nevertheless, none of the persons involved in the event departed directly from routines or instructions in force. Below follows an analysis of the course of events.

All passengers to Stockholm are placed in the rear of the cabin

The travel agents' seating of the Stockholm passengers in the rear of the cabin facilitated disembarkation in Göteborg, but was inappropriate from the flight-operational point of view. The travel agents were unaware that the passenger seating in the cabin was of significance for the aircraft's stability. Nobody had informed about this which is considered to be a shortcoming in the routines as the passenger seating always is the is responsibility of the airline

On the other hand, the airline company's person had no instruction or saw no reason to see to the passenger's seating in the cabin since the travel agents had chartered the whole aircraft.

Information about the passenger seating was sent to the wrong address

For the flight from Salzburg to Göteborg the special passenger seating arrangement was of no significance since the aircraft was almost full. The problem did not arise until the continued flight to Stockholm, when the seating in the rear portion of the cabin rendered the aircraft 'tail-heavy'.

This special circumstance would normally have been picked up when the SOM regarding passenger seating from Salzburg was reported to PALCO. But since the check-in at Salzburg was not linked to the PALCO system, the message was sent by telex instead. Since the station manuals were not up-to-date, the message was sent to the wrong address, for which reason it was never reported to PALCO.

The default-message "EVENLY DISTRIBUTED" was not noted by CLC

PALCO preparation for the flight therefore continued with erroneous information on the passengers' distribution in the cabin. A warning about this was sent to check-in at the next departure destination, i.e. to PCI in Göteborg. In the relevant control centre at Arlanda, the CLC, the departure from routine appeared as a discreet message on a printer with the text "EVENLY DISTRIBUTED", which nobody observed. There was no instruction to monitor this. The person in charge who handled SK7918 had, moreover, been on duty for about 13 hours, which may have reduced his alertness.

The passenger check-in in Gothenburg was not opened

The next circumstance was that nobody in Göteborg saw any reason to "start up" the check-in for the flight to Stockholm since no new passengers were to be taken on board. There was no instruction to do so for all departures irrespectively of whether passengers were to go on board.

The consequence was that the error message: "DIFF/SOM LDM", waiting in the system, remained unread.

This situation had not been foreseen in the design of the PALCO system. There was nothing to prevent the further PALCO processing or production of the loadsheet.

Loadsheet with incorrect information was sent to the aircraft

The loadsheet, so important for flight safety, and which the commander in the cockpit received from the ACARS system shortly before takeoff, was based on incorrect information and contained serious errors. The information on passenger seating in the cabin and the aircraft's centre-of-gravity position did not accord with reality.

The commander did not notice the incorrect data

There was no possibility for the commander to read from the loadsheet that it was based on a default value regarding the passenger seating. (Regarding the information from the cabin crew about the remaining passengers seating in the rear part of the cabin, see 2.3.)

The last regular barrier that could have prevented the incident was thus down, so that the aircraft taxied out for takeoff with 121 passengers and 6 crew members on board, in a more tail-heavy configuration where the CG was significantly aft of the certified limit for the airplane type.

The pilots' cooperation during the takeoff and the commander's decision to abort as soon as the aircraft was behaving abnormally represented the final – and functioning – barrier that prevented the aircraft from becoming airborne in this configuration.

2.3 The commander's action

During the period on the ground in Göteborg the cabin crew informed the commander that most of the passengers seemed to be sitting far aft in the cabin, which they knew could be inappropriate in terms of flight safety.

The commander understood this message and it may be asked why he did not check the situation before takeoff.

At this time the aircraft was parked at the terminal and many passengers were moving about in the cabin. For the commander, therefore, the seating was not entirely clear, and it was natural for him to delay any possible changes in seating until he had seen the loadsheet.

Problems in connection with refuelling and de-icing delayed the aircraft, which caused some irritation among the crew since all were eager to get going as quickly as possible. When de-icing was complete and the loadsheet arrived the pilots were already belted in their seats.

The general perception was that the PALCO system was very reliable and that a loadsheet could not be printed out unless it was correct in every detail. There was no requirement for checking the loadsheet, nor a routine for doing so. The commander had full confidence in both the loadsheet and the external handling systems used prior to takeoff.

When the commander as a matter of routine checked that the numerical information regarding the aircraft's takeoff mass and centre-of-gravity position were within permitted limits, he had forgotten the cabin crew member's earlier query about how the passengers were distributed in the cabin. Circumstances contributing to this were probably his reliance on the PALCO system and its loadsheet, based on long experience of the system; and also distraction from disturbances and other work tasks during the period between the remark and the arrival of the loadsheet.

2.4 The PALCO system

The PALCO system was so designed that the process for producing a loadsheet could continue even though it had not received any information on how the passengers were distributed throughout the cabin. The system thus started with its default value, that the passengers were evenly distributed. When this occurred, the system notified it as a discrete message to other parts of the system (”DIFF/SOM LDM” or ”EVENLY DISTRIBUTED”). There were inadequate routines and instructions on whether and how staff were to react to these messages. The term ”EVENLY DISTRIBUTED” is also misleading and the term “UNKNOWN” would be more appropriate.

In this respect the system resembled the kind of automated system that acts of its own accord with little feedback. Such systems can be vulnerable and place the user in difficult and sometimes surprising situations.

The weaknesses in the design of the PALCO system raise the question of whether human factors are taken into account in the design of the various types of information system and aids used by pilots. The importance of airline companies ensuring that knowledge of human factors is applied in the design of systems that can affect flight safety is evident. Stringent demands must be placed upon the verification and validation[8] of such systems, including their use in situations other than normal operation.

It appears that the airline company's action after the incident – to review the PALCO system procedures – may contribute to reducing the risk of loadsheets with factual errors being sent to pilots. However it is not clear

[8] Verification and validation – Confirmation by presenting proof that specified requirements or requirements for an intended special use or application have been met.

what measures have been taken to improve feedback to the various users of the system who are expected to note the messages and act on them.

The PALCO/ACARS systems is a typical example of computer systems that have replaced earlier manual systems performed by experienced and well educated personnel, like pilots, ramp agents, etc. With this there is always a risk that safety barriers, created with the manual handling, can get lost.

As the investigation shows, the reliability of the PALCO and other similar systems can directly affect flight safety. There is currently no requirement that the operator must show the supervisory authority how he systematically ensures that such systems are reliable and adapted to human conditions. In view of the fact that these systems are being used increasingly by airline companies, there is reason for the Civil Aviation Authority to act internationally to ensure that the authorities involved place greater demands on quality-assuring such systems, including verification and validation against the requirements of the human element and in situations other than normal operation.

2.5 Routines for ”non-routine flights”

Among the company’s flights the one in question was somewhat ”odd”, and had only been run a few times earlier. There were certain differences or deviations from the more normal regular flights. These differences helped to reveal inherent weaknesses which had not previously emerged. They also indicated, however, a need to review and strengthen the routines for preparing such “odd” and new types of flight. As already mentioned the contributory cause of the Seat Occupied Message (SOM) being wrongly addressed was that the Salzburg manuals were not updated.

Since the incident, the airline company has updated their Station Passenger Manual (SPM) so that SOMs are sent to the correct address. In the Board’s view, against the background of this investigation a review should be undertaken to further analyse the need for measures to reinforce preparation procedures for new and odd types of flight.

2.6 The commander’s responsibility

According to the regulations – Swedish, international and within airline companies – a commander shall satisfy himself that his aircraft is airworthy and correctly prepared for each flight. In practice, however, it is hard in heavy civil aviation for a commander to meet these requirements.

For commercial aviation to meet the requirements on flight safety, efficiency and economy, the technical operation and the commercial operation must both use advanced technical systems and sophisticated routines. The commander has neither the time nor practical possibility himself/herself to take the full responsibility imposed by current requirements. He or she is obliged to rely largely on other people’s checks and on the technical aids employed.

It is hard to draw a line between the checks commanders must be able to delegate to others and those that commanders must reasonably carry out themselves. To exemplify the complex situation one can note that the commander in most cases has the possibility to check the passenger seating in the cabin but corresponding check of baggage and freight in the cargo compartment is almost impossible under normal circumstances.

The reliability of the loadsheet processed before every flight is crucial for the safety of that flight. The present incident has shown that the routines and computerised systems used for the production of the loadsheet may contain unknown deficiencies. The extra work involved for the commander, using appropriate information from cabin crew members to check the loadsheet particulars of passenger number and seating in the cabin, would probably not exceed what is warranted by increased air safety.

The Board therefore supports the requirements the Scandinavian Surveillance Office has placed upon the airline company regarding physical checks that placing of passengers in the cabin tally with what is specified on the loadsheet. There are therefore reasons for the Civil Aviation Authority to introduce similar requirements on all heavy passenger traffic.

3 CONCLUSIONS

3.1 Findings

a) The pilots were qualified to conduct the flight.
b) The aircraft had a valid certificate of airworthiness.
c) The majority of the passengers were seated in the aft portion of the cabin.
d) Certain items of information in the loadsheet were incorrect.
e) Shortcomings have been noted in the routines and computerised systems used for the production of loadsheets and other things.
f) Takeoff was commenced with a centre-of-gravity position at more than 1/4 aft of the certified CG span.
g) The aircraft's nose lifted spontaneously at just over half normal lift speed.
h) There are no requirements regarding the quality assurance, including verification and validation in terms of human factors, of the computer systems used for the production of loadsheets.

3.2 Causes of the incident

The incident was caused by shortcomings in the routines and computer systems used in the production of loadsheets.

4 RECOMMENDATIONS

The Swedish Civil Aviation Authority is recommended:

- to seek in international air safety work to ensure that the supervisory authorities concerned place higher demands on the quality assurance, including verification and validation, with reference also to human factors, of operational aids systems that can affect flight safety *(RL 2005:20e R1),*
- require information and acknowledgement anytime a calculated or default value is used instead of a verified value for computer systems used by pilots for planning purpose and affecting flight safety *(RL 2005:20e R2)*,
- for all passenger traffic with heavy aircraft, to introduce a requirement for physical checks of passenger seating throughout the cabin versus loadsheet data where computerised systems are used in the production of loadsheets *(RL 2005:20e R3)*.

Appendix 1

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AOC BEGIN  03/12/07 19:02:04 .LN-RPL

LOADSHEET

MSG ID-190112-03
  TYPE-FINAL
FLT ID-SK7918
 NOTOC-N
  ORIG-CPHBOSK

LOADSHEET FINAL        2001 EDN 03
SK7918/07   07DEC03
GOT ARN LNRPL 7383 2/5
DOW     43320
ZFW     54025 MAX  62731  L
TOF      5260
TOW     59285 MAX  70533
TIF      2300
LAW     56985 MAX  66360
UNDLD     8706
PAX Y      121        TTL  123
DOI         35
DLI         41
LIZFW       42
LITOW       44
MAC-TOW     25
TRIM BY CABIN AREA - SECTION
0A   01-06   22
0B   07-16   37
0C   17-25   37
0D   26-32   25

LOADMESSAGE
-ARN.69/52/0/2.T1390.3/1390.PAX/121

BALANCE LIMITS BEFORE LMC
FWD/AFT 15/51 AT ZFW
        13/56 AT TOW
SI

END LOADSHEET
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