1998-07-14 L-36/97

Swedish Civil Aviation Administration

601 79 NORRKÖPING

Report C 1998:23e

The Swedish Board of Accident Investigation (Statens haverikommission, SHK) has investigated an aircraft accident which occurred on 7 June 1997 at Stockholm/Arlanda airport, AB county, Sweden, involving an aircraft with registration YR-BCM.

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

Olle Lundström

Monica J Wismar Henrik Elinder

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Aircraft: registration and type	**YR-BCM,** BAC 1-11 525 FT
Owner	TAROM, Bucharest, Romania
Time of accident	7 June 1997 at 13.50 hours in daylight *Note:* All times in the report are given in Swedish summer time (SST) = UTC +2 hours
Place	Stockholm/Arlanda airport, AB county, Sweden (pos 5939N 1755E, 121 ft (37 m) above sea level)
Type of flight	Scheduled traffic
Weather	Arlanda 13.50 hrs: wind 160°/13kts, visibility > 10 km, no clouds below 5 000 ft, temp./dewpoint +24°/+4°C, QNH 1025 hPa
Numbers on board:	Crew: 3/3 Passengers: 20
Personal injury	None
Damage to aircraft	Substantial
Other damage	Limited on grass
Commander's age, and licence	48 years, Airline Transport Pilot's Licence (ATPL) with instructor's rating
Commander's total flying hours	Around 12 500 hours of which 12 000 hours on the type
First Officer's age and licence	33 years, Commercial Pilot's Licence (CPL)
First Officer's total flying hours	1 866 hours, of which 50 hours on the type
Observer's age and licence	45 years, ATPL
Observer's total flying hours	8 330 hours, of which 433 hours on the type

The Swedish Board of Accident Investigation (SHK) was notified on 7 June 1997 that an accident involving an aircraft with registration markings YR-BCM had occurred at Stockholm/Arlanda airport, AB county, Sweden on the same day at 13.50 hours.

The accident has been investigated by SHK represented by Olle Lundström, chairman, Monica J Wismar, chief investigator flight operations, and Henrik Elinder, chief technical investigator.

The investigation has been followed by Max Danielsson, Swedish Civil Aviation Administration.

The purpose of the investigations performed by SHK is solely to prevent accidents and incidents in the future.

SUMMARY

After a sceduled flight from Bucharest the aircraft, a BAC 1-11, was going to land on Stockholm/Arlanda airport, runway 26. The landing was performed visually. The commander was the flying pilot and was assisted by a first officer, who was under so called route training. In the cockpit was also an observer, whose ordinary position was first officer and whose duties were to assist or relieve the first officer if necessary.

According to the commander the approach was normal but there was occasional turbulence and wind gusts from the south. The touchdown was in the normal touch-down zone on the left main gear and nose up. Shortely thereafter came a strong wind gust whereupon the right main gear touched down and the nosegear heavily hit the runway. The commander reversed the engines and braked lightly. When the speed had decreased and he reverted to nosewheel steering he noticed that it was not functioning. He continued to brake but could not prevent the aircraft from veering to the right. At a speed of approximately 60 knots it left the runway and rolled out on the grass field. The retardation was soft. The passengers disembarked through ordinary exit.

The airport rescue service was speedily on the scene but no action was necessary.

The examination of the nose gear showed a break in the shock-absorber strut housing, which was the result of one or more overloadings.

The study of the aircraft's flight data recorder (FDR) revealed that the first ground contact was with high vertcal acceleration and with pitch up and that the aircraft thereafter twice bounced and touched down with high acceleration and pitch down.

The sound-recording from the cockpit voice recorder (CVR) showed that during the approach the commander was annoyed and strongly irritated with the first officer.

The accident was caused by the collapse of the nose gear as a result of overload when the aircraft touched down with its nose wheel first after two bounces. A contributing factor was shortcomings in cockpit's CRM (Cockpit Resource Management) during the flight.

Recommendations

None.

1. FACTUAL INFORMATION

1.1 History of the flight

Flight ROT 335, a BAC 1-11 coming from Bucharest, was about to land on runway 26 at Stockholm/Arlanda airport. The pilots had visual contact with the field and the landing was performed according to visual flying rules (VFR).

The commander, who was pilot flying (PF), has stated the following. The approach was normal with occasional turbulence and wind gusts from the south. When the aircraft was on 8 nautical miles[1] final, the air-traffic controller in the tower reported the wind 160°/13 kts. To begin with the aircraft was somewhat above the glide slope but was on the glide slope when it passed the threshold. The touchdown on the runway was in the normal touchdown zone on the left main gear and nose up. Shortly thereafter came a strong wind gust whereupon the right main gear touched down and the nose gear heavily hit the runway. The commander controlled the aircraft with rudder, reversed the engines and braked lightly. He did not notice anything special in the behaviour of the aircraft at that point. When - after the speed had become so low that rudder steering was no longer possible - he reverted to nose wheel steering he noticed that it was not functioning. He continued the light wheel braking but could not prevent the aircraft from veering to the right. He then braked fully but the aircraft continued towards the right runway edge. It left the runway at a speed of around 60 knots out onto the grass field. The retardation was soft and the passengers disembarked through ordinary exit.

The airport rescue service was speedily on the scene but no action was necessary.

The accident occurred on 7 June 1997 at 1350 hours in position 5939N 1755E; 121 ft (37 m) above sea level.

1.2 Personal injuries

	Crew	*Passenger*	*Other*	***Total***
Fatal	-	-	-	-
Seriously injured	-	-	-	-
Slightly injured	-	-	-	-
No injuries	6	20	-	26
Total	**6**	**20**	**-**	**26**

1.3 Damage to the aircraft

Substantial.

1.4 Other damage

Limited damage to grass.

[1] Nautical mile = 1 852 meters

1.5 The crew

1.5.1 *Experience*

The commander was 48 years old at the time of the accident and had a valid ATPL licence with instructor's rating.

Total flying hours were around 12 500 of which 12 000 on the type.

The first officer was 33 years old at the time of the accident and had a valid CPL licence.

Total flying hours were 1 866 of which 50 on the type.

The observer, whose ordinary position was first officer, was 45 years old at the time of the accident and had a valid ATPL licence.

Total flying hours were 8 330 of which 433 on the type.

1.5.2 *The crew disposition*

The commander served on this flight both as pilot and instructor for the first officer.

The first officer was under training on the aircraft type and had performed 50 hours of route training at the time of accident, see 1.17.2. His duties on this flight were normal pilot not flying (PNF) duties such as radio communication, call-outs and checklist reading.

The observer's duties were mainly to assist the first officer and relieve him if necessary.

1.6 The aircraft

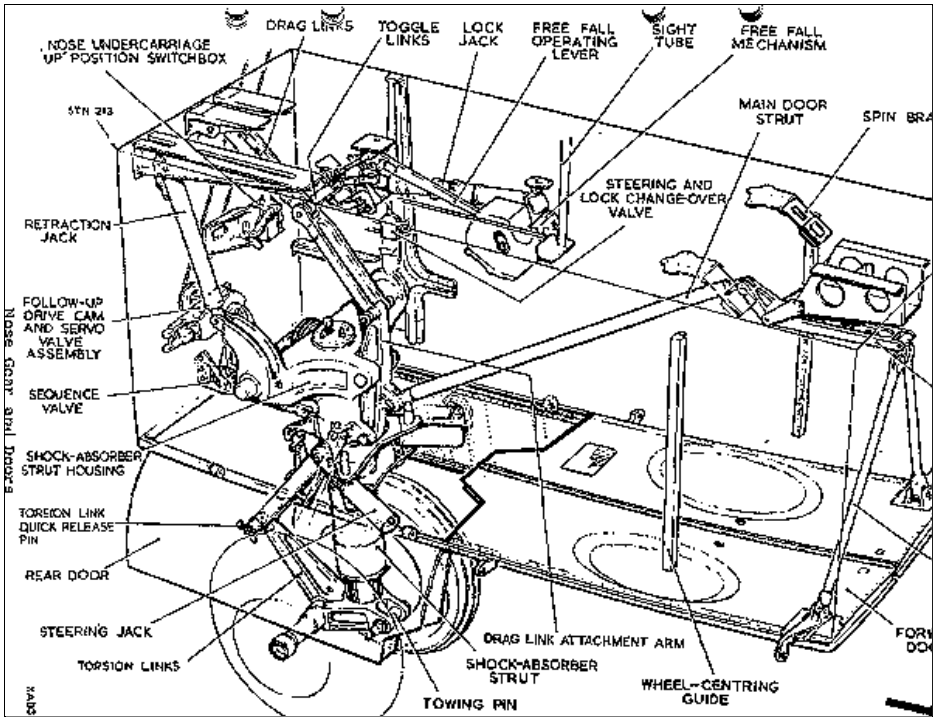
1.6.1 *Basic data*

Owner:	TAROM, Bucharest, Romania	
Type:	BAC 1-11 525 FT	
Serial number:	256	
Year of manufacture:	1977	
Gross weight:	Unknown	
Engine manufacture:	Rolls Royce	
Engine model:	Spey 512-14DW	
Number of engines:	2	
Fuel loaded before flight:	Unknown	
Aircraft		
Total flying time:	23 901 hours	
Total cycles:	17 888	
Time since latest periodic check:	2 hours	
Engines:	#1, S/N 7102	#2, S/N 7896
Total operating time	12 831 hours	17 255 hours
Number of cycles:	8 564	8 603
Time since overhaul:	5 905 hours	2 776 hours
Cycles since overhaul:	3 153	1 603
Nose gear		
Overhaul date:	31 January 1993	
Time since overhaul:	2 224 hours	
Cycles since overhaul:	2 054	

The aircraft had a valid Certificate of Airworthiness.

1.6.2 *Nose gear*

The aircraft type has a hydraulically operated nose gear, hinged in two pins and retracted forward. The two bearing supports are riveted to the aircraft structure.



Time between overhauls of the nose gear is 11 years or 15 000 cycles.
It was overhauled by the manufacturer, BAe in England, on 31 January 1993 and had since accumulated 2 224 hours and 2 064 cycles.

1.7 Meteorological information

Reported weather at Stockholm/Arlanda airport at:

1250 hrs 170°/12 kts, variable 140-210°, CAVOK[2] temp./dewpoint +23/+03°C, QNH 1025 hPa.
1320 hrs 170°/12 kts, CAVOK, temp./dewpoint +24/+04°C, QNH 1025 hPa.
1350 hrs 160°/13 kts, CAVOK, temp./dewpoint +24/+04°C, QNH 1025 hPa.
1420 hrs 170°/13 kts, variable 130-190°, CAVOK, temp./dewpoint +23/+04°C, QNH 1025 hPa.
1450 hrs 150°/14 kts, variable 140-210°, CAVOK, temp./dewpoint +23/+04°C, QNH 1025 hPa.

The wind meter for runway 26 is situated south of the touchdown zone and is considered representative when winds are southerly. The wind speed presented is a mean wind speed recorded during 2 minutes. A change of direction is presented if it varies 60° or more during the previous 10 minutes.

[2] CAVOK = visibility > 10 km, no clouds below 5 000 feet and no precipitation

The wind of 160°/13 kts gives a cross-wind component of 13 kts for runway 26 (253°).

The wind profile recorded at Stockholm/Arlanda airport at the time of the accident was:

Altitude m/feet above sea level	Direction °	Speed m/s / kts
537/1 762	177	8,1/15,7
463/1 519	174	8,0/15,5
435/1 427	173	8,2/16
408/1 339	176	7,7/15
381/1 250	170	8,1/15,7
344/1 128	177	7,9/15,3
316/1 036	172	7,7/15
286/938	170	8,0/15,5
226/741	168	8,2/16
196/643	169	7,8/15,2
166/545	170	7,4/14,3
145/476	167	7,6/14,7

1.8 Navigational aids

Runway 26 has an Instrument Landing System (ILS) and the aircraft was equipped for this.

1.9 Radio communications

There were normal communications between the aircraft and the tower.

1.10 Airport data

Stockholm/Arlanda airport´s status was according to AIP Sweden.

1.11 Flight and sound recorders

1.11.1 *General*

The flight and sound recorders (FDR and CVR) were removed from the aircraft after the accident and sent to the Air Accident Investigation Branch in England (AIIB) for decoding.

1.11.2 *Flight Data Recorder*

Essential parameters are presented graphically in enclosure 1. Touchdown time is defind as the zero time in the graphs. From the enclosure the following can be noted:

- The sink rate during the last 40 seconds before touchdown was close to constant.
- The first ground contact was with high vertical acceleration and with pitch up.
- Thereafter the aircraft bounced and touched down again with high vertical acceleration and pitch down.
- Finally the aircraft bounced again and touched down with high acceleration and pitch down.

1.11.3 *Cockpit Voice Recorder*

The sound recording from the cockpit during the last ten minutes before the landing has been transcribed in Romanian. An English translation is included in enclosure 1.

Reading the translation it becomes evident that the first officer had difficulties to keep up with the different phases of the flight. The observer had to assist him with cabin pressure regulator settings, ”call-outs” and radio communications.

This created a marked irritation in the cockpit not fully evident from the transcription. Several times during the approach the commander shouts his orders and reprimands the first officer in an irritated and aggressive way. The observer also seems to have been annoyed with the first officer.

1.12 Site of accident and aircraft wreckage

1.12.1 *Site of accident*

Leaving runway 26 the aircraft came to a stop on the grass around 25 m outside the right runway edge and around 600 m short of the west threshold. The left main wheel and the nose wheel had ploughed around 20 cm deep into the ground.

1.12.2 *Aircraft wreckage*

The nose gear leg and its attachments to the aircraft were damaged. Also some interior roof panels came loose.

1.13 Medical information

Nothing indicates that the physical condition of the pilots had been impaired before or during the flight.

1.14 Fire

There was no fire.

1.15 Survival aspects

The retardation was soft and no-one on board was injured**.**
The Emergency Locator Transmitter (ELT) was not triggered.

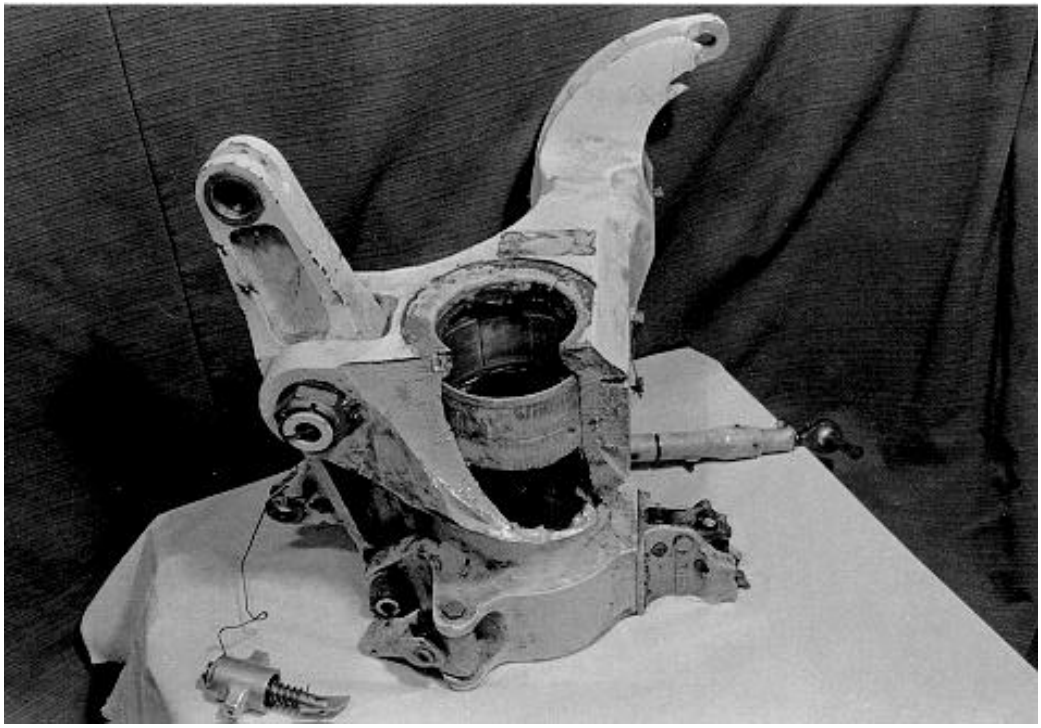
1.16 Special tests and investigations

1.16.1 *Examination of the aircraft on the accident site*

A preliminary examination and documentation of the aircraft was done before it was taken away. No other substantial damaged than that on the nose gear and its attachments was seen.

1.16.2 *Technical examination of the nose gear and support assembly*

The examination of the nose gear showed that the primary failure had occurred in the shock-absorber strut housing, which is a central construction element of the landing gear. Besides this damage extensive secondary damage had occurred in the nose gear well.



The shock absorber strut housing was first examined by experts from the metallurgic laboratories of Volvo Aero Engines Services. It was subsequently sent to British Aerospace Airbus Limited Materials Laboratory in Filton/England for examination. The outcome of these examinations made it unequivocally clear that the housing was manufactured and maintained following current specifications and that it had no defects or damage before the accident which may have contributed to the course of events. The failure was a result of one or more overloadings.

1.17 The company's organisation and management

1.17.1 *General*

The TAROM airline is based in Bucharest, Romania, and is engaged in national and international heavy air traffic.

1.17.2 *Routines for type-training of first officers*

The type-training in the company consists of a theoretical operational and technical part followed by practical simulator flying and flight training without passengers. After that the student flies en route accumulating 100 hours of "route training" with a commander with instructor's rating, before he or she is qualified to fly as an regular crew member.

1.17.3 *Crew disposition during route training*

The commander is responsible for the flight as well as for the training of the future regular first officer. The company's policy for en route training is to add an extra first officer on the flight deck as observer ready to relieve the student if necessary.

1.18 Other information

1.18.1 *Crew Resource Management*

In investigated accidents and incidents world-wide over the past few years lack of co-operation and poor communication between crew members has been the main or contributing cause. This fact has led to a programme for better crew co-operation, called Crew Resource Management (CRM).

CRM means optimal use of knowledge and resources available within a flight crew in order to achieve maximum safety, efficiency and comfort during flight. CRM emphasises communication between crew members and how good co-operation and "team spirit" on board as well as away from the aircraft may be achieved.

Many of the world's major airlines train their flying crews in CRM. It is given as basic training as well as part of periodic flight training (PFT).

2 ANALYSIS

2.1 The landing

The landing conditions were good apart from certain turbulence on final and touchdown. The FDR graphics show that the aircraft sink rate on final was close to constant until the main wheels touched the runway. This indicates that the touchdown was performed without the normal flare and is the probable cause of the hard touchdown of the main wheels (around 1.7g). In the bounce that followed, the nose was high to begin with but when the aircraft touched down again it had fallen to -6°. This second touchdown, also hard (slightly more than 1.7g), was therefore with the nose gear first which involved abnormal and hard stress on it and its attachments. Also the second bounce ended with the nose gear first and with roughly the same high g-load as the previous ground contacts.

Metallurgic examinations of the nose gear disclosed no faults on it before the accident. Everything therefore points to the primary fracture of the nose gear leg being caused by the overloadings on the nose wheel during the two touchdowns.

It is difficult to explain why such an experienced pilot as the commander, with around 12 000 hours of experience of the aircraft type, did not manage to control the aircraft after the first touchdown and avoid the two subsequent bounces. From the CVR transcription it can be seen that before the landing the commander ordered the first officer to take the wheel and roll up-wind immediately after touchdown. From the transcription it is also clear that both the commander and the observer, in connection with the touchdown, shouted at the first officer to desist. ("-Let it be "and "Leave it" respectively.) SHK therefore considers it likely that the first officer, in connection with the touchdown, grabbed the wheel intending to roll up-wind following the earlier order by the commander. He may then, being unaware of it, have pushed the wheel and thus contributed to the lowering of the nose. As can be seen in section 2.2 the first officer at this time was probably somewhat stressed after the reprimands given to him by the commander and the observer.

2.2 Crew Resource Management

As described in section 1.18.1 the forming of good communication and good co-operation among crew members is a corner stone of CRM. It is clearly evident that the commander, ultimately responsible for the CRM on board, did not succeed with this task on this flight. He seems to have been very annoyed with the first officer, which he clearly showed, both when giving orders and in intonation. The atmosphere on the flight deck before the landing seems to have been tense.

Even if the first officer was insecure in his task there is no excuse for the commander's annoyance with his fellow pilot during a critical phase of the flight. Being an instructor he should, assisted by the observer, have instructed his student and made the student´s work easier until the flight was over instead of criticiseing him in this way. In addition to probably increasing the first officer's insecurity, the commander's irritation probably influenced negatively on his own way of performing the landing, and thereby contributed to the accident.

3 CONCLUSIONS

3.1 Findings

a) The pilots were qualified to perform the flight.
b) The aircraft had a valid Certificate of Airworthiness.
c) The first officer was route training on the aircraft type.
d) The atmosphere on the flight-deck was irritated during the landing.
e) The touchdown was executed at a high sink rate.
f) The aircraft landed on the nose gear after each of two bounces.
g) The fracture in the nose gear leg was caused by overloading.
h) No technical fault has been found on the aircraft.

3.2 Causes of the accident

The accident was caused by the collapse of the nose gear as a result of overload when the aircraft touched down with its nosewheel first after two bounces. A contributing factor was shortcomings in cockpit's CRM (Cockpit Resource Management) during the flight.

4 RECOMMENDATIONS

None.