

INTERSTATE AVIATION COMMITTEE  
AIR ACCIDENT INVESTIGATION COMMISSION

**FINAL REPORT**

**on the investigation into the accident  
involving the Armavia A320  
near Sochi Airport on 3 May 2006**

*This document is an English translation of the Final Report on the accident on 3 May 2006 in the Black Sea, off the coast of Sochi, to the Airbus 320-211 registered EK-32009 operated by Armavia Airlines.*

*The use of this translation for any purpose other than for the prevention of future accidents could lead to erroneous interpretations*

*As accurate as the translation may be, the original text in Russian issued by the Interstate Aviation Committee is the work of reference*

*Ce document est une traduction en langue anglaise du rapport final sur l'accident survenu le 3 mai 2006 en mer Noire, au large de Sotchi, à l'Airbus 320-211 immatriculé EK-32009 exploité par la compagnie aérienne Armavia.*

*L'utilisation de cette traduction à d'autres fins que la prévention de futurs accidents pourrait conduire à des interprétations erronées.*

*Aussi précise que puisse être la traduction, le rapport original en russe établi par l'Interstate Aviation Committee fait référence.*

Moscow - 2006

FINAL REPORT  
On the aviation accident investigation

Aircraft type	A320
Registration No.	EK-32009
Serial Number	547
State of Registry	Armenia
Owner	Funnel, George Town, Cayman Islands
Operator	Armavia Airlines
Aviation Oversight Authority	Civil Aviation Administration of Republic of Armenia
Date and time of the accident	2 May 2006 at 22.13 UTC (3 May 2006 at 02h13 local time)
Accident site	In the Black Sea near Sochi airport,

In accordance with the standards and recommendations of the International Civil Aviation Organization (ICAO) and PRAPI-98 this report is issued for the sole purpose of preventing future aviation incidents or accidents.

The investigation undertaken in the context of this report is not intended to apportion blame to any party.

Any criminal aspects of the accident are dealt with by criminal proceedings.



## Final Report

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List of abbreviations used in this Report

AATC	Automatic Air Traffic Control
FCTM	Flight Crew Training Manual
expl.	expletive
CAA of RA	Civil Aviation Administration of the Republic of Armenia
RSRB	Regional Search-and-Rescue Base
AMIS	Automatic Meteorological Information and measurement System
IAC	Interstate Aviation Committee
MH	Magnetic Heading
AOAR	Aerodrome Operations Airworthiness Requirements
ATS	Air Traffic Service
ATM	Air Traffic Management
PRAPI-98	Rules for civil aircraft accidents/incidents investigation in the Russian Federation, 1998
ROLRGA RA-2000	Guidance on flight operations management of the Republic of Armenia
ATC	Air Traffic Control
FTOA	Federal Transport Oversight Authority of Russian Federation
Mhland	Magnetic heading of the runway

## Organisation of the Investigation

On 2 May 2006 at 22 h 13 min (hereafter UTC time is used, local time coincides with Moscow time and differs from UTC by +4 hours), the A320 registered EK-32009, operated by Armavia Airlines of the Republic of Armenia, was undertaking a passenger flight from Yerevan to Sochi at night in instrument meteorological conditions (IMC) and crashed into the Black Sea near Sochi airport. The Air Accident Investigation Commission of the Interstate Aviation Committee was advised of the accident on 3 May 2006 at 02:15 (Moscow time).

By Order No. 11/368-P of 3 May 2006, issued by the Chairperson of the Interstate Aviation Committee, the following investigation commission was nominated to investigate the accident:

Chairman of the investigation commission L.A. Kashirsky  
- acting Vice Chairman of the Interstate Aviation Committee

Vice Chairman of the investigation commission: G.M. Galstyan  
- Chief pilot-inspector of the Flight Safety Inspection of the CAA of  
RA

- Chairman of the IAC Air Accident Investigation Commission A.N.Morozov

Commission members:

- IAC Commission Chairman N.F. Zobov

- Chief Specialist of Flight Safety Inspection of the FTOA Y.V. Fedyushin

- ATM Director, Federal State Unitary Enterprise "State Corporation for  
ATM" S.N. Pogrebnov

- Specialist Category 1, Flight Safety Inspection of the FTOA E.P.  
Glukhovskaya

-Deputy Head of the Southern Department of Rosaviation N.N.Chubarov

Dates of investigation:

From 3 May 2006 to 12 February 2007.

## **1. Factual Information**

### **1.1. History of Flight**

On 2 May 2006 the Armavia A320, registered EK-32009, was undertaking passenger flight RNV 967 from Zvartnots (Yerevan, Armenia) to Adler (Sochi, Russia).

Preliminary preparation of the crew was conducted on 23-24 May 2006 under the guidance of the airline's Flight Director, in accordance with the requirements of ROLRGA RA-2000, Section 7.2.1.

Pre-flight briefing of the crew was conducted on the day of departure, under the guidance of the Captain, in accordance with the requirements of ROLRGA RA-2000, Section 8.2.1

On 2 May 2006 at 19.30 the crew passed the pre-flight medical examination.

The crew's pre-flight rest period exceeded 24 hours. In accordance with ROLRGA RA-2000 and Work-Rest Norms for civil aircraft crews from the Republic of Armenia, each crew member is individually responsible for adherence to the pre-flight rest regime. It should be noted that it was difficult for the crew to take adequate rest during the day before the night flight, due to impairment of bio-rhythms. That is most likely why, in their cockpit conversations the crew members mentioned that they had not got enough sleep.

In order to make their decision for departure, the crew obtained the observed weather data and the weather forecast for the takeoff, landing and alternate aerodromes that met the requirements for IFR flights.

According to the documents submitted, the airplane takeoff weight and the centre of gravity were 62,712 kg and 29.9% mean aerodynamic chord, i.e. within the A320 FCOM limitations.

There were 113 occupants on board: 105 passengers (including 5 children and 1 baby), 2 pilots, 5 flight attendants and 1 engineer.

The airplane took off from Zvartnots airport at 20:47. Takeoff, climb and cruise were uneventful.

The first communication between the Sochi approach controller and the crew took place at 21:10:20. At that moment the airplane was beyond the coverage area of Sochi aerodrome radar.

Up until 21:17 the approach controller and the crew discussed the observed and forecast weather, and as a result the crew decided to return to Yerevan. At 21:26:37, after the decision had already been made, the crew asked the controller about the latest observed weather. At 21:30:49 the controller informed the crew that visibility was 3,600 m and the cloud ceiling 170 m. At 21.31.14 the crew decided to continue the flight to Sochi airport.

The next communication with the approach controller was at 22:00:45. At that moment the airplane was descending to an altitude of 3,600 m heading to GUKIN point and was being tracked by the Sochi radar. The approach controller cleared the airplane for descent to 1,800 m and reported the observed weather at Sochi, as at 22:00, for runway 06, which was above the aerodrome minimum. Then the crew was handed over to the holding and tower controllers, and was cleared for descent to 600 m, as per aerodrome pressure QNH 1016 hPa, before entering the turn to final. While performing the turn to final, the runway extended centreline was overshoot.

Having eliminated the deviation, the airplane started descending along the glide slope, following the approach pattern.

At 22:10:45 the crew reported extension of the landing gear and their readiness for landing. In response they were advised of the distance of 10 km and weather 4000 x 190, and were cleared for landing. However, about 30 seconds later, the controller advised the crew of the observed cloud ceiling at 100 m and instructed them to stop their descent and carry out a right turn and climb up to 600 m and also to get in touch with the holding controller.

The last communication with the crew was at 22:12:35. After that the crew did not respond to any of the controller's calls.

At 22:13:03 the airplane struck the water, was destroyed and sank.

### **1.2. Killed and Injured**

Injuries	Crew	Passengers	Other
Fatal	8	105	-
Major	-	-	-
Minor/None	-	-	-

According to results of the medico-legal investigation, the cause of death of the 105 passengers and 8 crew was severe trauma incompatible with life and typical for an aviation accident.

### **1.3 Aircraft Damage**

The aircraft was completely destroyed due to impact with the water.

### **1.4 Other Damage**

There was no other damage.

### **1.5 Personnel Information**

#### **Captain**

Born in 1966.

Had completed primary training at the Krasnokutsk civil flight school, graduated from there in 1986 after obtaining a qualification as An-2 pilot; in 1997 graduated from Moscow Institute of Civil Aviation Engineers.

Flying experience:

From 22.08.86 to 01.05.88 –An-2 co-pilot in Balaklavsky united flight unit of Privolzhsky Civil Aviation Department;

From 05.05.88 –An-2 co-pilot in flight unit 113 under the Armenian Civil Aviation Department;

From 07.05.90 –Yak-40 co-pilot in flight unit 2 under the Armenian Civil Aviation Department;



From 16.10.97 –Yak-40 Captain for Ararat airline under the Armenian Civil Aviation Department;

From 19.05.2004 –A320 co-pilot in Armavia airline under CAA of RA;

From 01.09.2005 –A320 Captain in Armavia airline under CAA of RA.

In the period from 01.03.2004 to 17.04.2004 the Captain had passed a training course for A320 pilots at the SAS FLIGHT ACADEMY, Stockholm, Sweden. In tests his average rating was between “satisfactory” and “good”. His piloting test result was 94%, with the allowable minimum of 85%. The result of his classroom training test was 88%. He completed the A320 flight entrance programme with "Siberia" airline, under the guidance of a pilot-instructor. There was no record of his experiencing any difficulties in the course of his initial traineeship on the airplane.

The Captain obtained his type rating as a co-pilot and a Captain in accordance with the A320 Flight Crew Training Manual (FCTM) approved by CAA RA. No shortcomings were noted during his traineeship.

He obtained a qualification of a Class I airline pilot in 12.09.2002.

Total flying hours – 5,458 hours.

Flying hours on the A320 type – 1.436 h, including 566 h as an A320 Captain

Flying hours during the previous month – 47 h, flying hours on the day of accident – 1.27 h, the flying hours and number of landings in the last three days - 05.05 h, two landings.

The rest time before the flight was more than 24 hours, at home.

Pilot’s license No. 000186, valid until 06.06.2006.

The last flying skills check was conducted by the Airline’s A320 Fleet Captain, on 22.02.2006, the rating obtained was “excellent”.

Weather minimum 60x550, takeoff 200 m.

In the past no aviation accidents or incidents were the responsibility of The Captain.

No discipline violations were noted.

His last preliminary training was conducted on 23.03.2006 in course of seasonal training under the guidance of M.M. Khachatryan, Fight Director of the airline.

Simulator training was conducted on a regular basis in the Dubai training centre. His last training course took place on 20.12.05 in Dubai, under the supervision of an instructor.

Training flights to Adler aerodrome (Sochi) were performed in the course of his training as a Captain, and before that he had performed many flights to Sochi on Yak-40 airplane.

Past FDR and CVR readouts showed no deviation from standard piloting techniques on the previous aircraft types.

On 31.03.2006 the Captain passed a medical re-examination, following an order from the Head of GCAD-RA.

### **Co-pilot**

Born in 1977.

Had completed primary training at the Ulyanovsk higher civil flying school, speciality “engineer-pilot”, graduated in 1999 having obtained a qualification as a Tu-154 pilot.

Flying work:

From 03.06.99 to December 2001 –Tu-154 co-pilot for Chernomor-Avia airline;

From January 2002 to January 2003 –Tu-154 co-pilot for Armenian Airlines under CAA RA;

From 26.02.2004 –ATR-42 co-pilot in Armenian Airlines under CAA RA;

From 11.10.2004 –A320 co-pilot in Armavia airline under CAA RA.

In the period from 01.07.2004 to 13.09.2004 the Co-pilot had passed a training course for A320 pilots at the SAS FLIGHT ACADEMY, Stockholm, Sweden. In tests his average rating was between “satisfactory” and “very good”. His piloting test result was 100%, with the allowable minimum of 85%. The result of his classroom training test was 96%. He completed the A320 flight entrance programme with "Siberia" airline, under the guidance of a pilot-instructor.

He obtained a qualification of a Class II airline pilot in 02.11.2005.

Total flying hours – 2,185 h

Flying hours on the A320 type – 1,022 h

Flying hours during the last month – 77 h, flying hours on the day of accident – 1.27 h, flying hours and number of landings in the last three days - 09.25 h, one landing.

Rest time before the flight was more than 24 hours, at home.

Pilot’s license No. 00255, valid until 29.03.2007.

The last piloting skills check was conducted by M.M. Khachatryan, the Flight Director, on 19.04.06, the mark obtained was “excellent”.

In the past no aviation accidents or incidents had been his responsibility.

No violation of discipline was noted.

His last preliminary training was conducted on 23.03.2006 in course of seasonal training under the guidance of the Flight Director of the airline.

Simulator training was conducted on a regular basis in the Dubai training centre. His last training was conducted on 26.04.06 in Dubai, under the guidance of the Flight Director.

On 31.03.2006 the Co-pilot passed a medical re-examination, following an order from the Head of GCAD-RA.

## 1.6 Aircraft Information

Type	A320
Registration	EK-32009
MSN	547
Manufacturer	Airbus
Date of manufacturer	28.06.1995

Certificate of Registration	No. 2343, issued by CAA RA on 22.12.2005
Owner	«Funnel», George Town, Cayman islands
Operator	Armavia airline, from 06.04.2004
Flying hours since entry into service	28,234 h 49M 14,376 landings
Number of overhauls	One
Flying hours since Overhaul	2,533 h 14 min 929 landings
Overhaul	Budapest (Hungary), by Lufthansa Technik, on 03.05.2005
Last A-check	Zvartnots airport (Yerevan), by Sabena Technics, on 21.04.2006
Flying hours after the last check	102 h 20 min
42 landings	
Last line maintenance («Daily check»)	Zvartnots airport (Yerevan), by Sabena Technics, on 2 May 2006

The airplane flight weight and balance were within established limitations (the maximum takeoff weight is 73,500 kg). The airplane's takeoff weight was 62,712 kg, and the centre of gravity was 29.9%. The total amount of fuel on board was 10,202 kg, and at takeoff the amount of fuel was 10,000 kg.

### 1.7 Meteorological Information

Meteorological support to flight RNV-967 was provided by a duty team at the Aviation Meteorological Centre of Yerevan aerodrome (Zvartnots), and meteorological support from a duty team from the Air Traffic Service of Sochi aerodrome was provided by Sochi 1<sup>st</sup> level Civil Aviation Meteorological Station, which was part of the Specialized Black Sea and Sea of Azov Hydrometeorology and Environment Monitoring Centre (license No. B 420592, registration No. R/2002/0126/100/L, issued by Roshydromet on 25 December 2002, valid till 25 December 2007) in accordance with the regulatory documents on meteorological support to flight operations (ICAO Appendix 3, Guidance for Meteorological Support in Civil Aviation 95, and the Instructions for meteorological support of the Sochi aerodrome).

On May 2, 2006 the synoptic situation near Sochi was determined by the influence of a secondary low formed in a pressure trough above the Eastern part of the Black Sea.

A cold front with waves was formed along the Caucasian Edge and further to the East of Turkey. There was continuous precipitation along the front, and rain showers in Adler.

With frequent cyclogenesis above the Black Sea coast of the Caucasus, especially in the spring transition period, low cloud often forms, which was registered by Sochi Agrometeorological Station situated nearby and Sochi Civil Aviation Meteorological Station. The recorded cloud height was 100-200 m.

Before taking off from Yerevan, the crew of A320 EK-32009 had a flight weather briefing at the Aviation Meteorological Centre of Yerevan airport (Zvartnots), where they got the flight documentation (a form with forecast and observed weather at Sochi and alternative aerodromes, the forecast wind and temperature chart at FL 300, as at 18:00 on 02.05.06, and weather phenomena chart at FL 250-630, as at 18:00 on 02.05.06).

At the briefing, at 19:35, Captain G. Grigoryan signed the flight documents, which were handed over to him in accordance with ICAO Annex 3, Section 9.4.1.

By the time the decision for departure was made, the observed weather at the destination airport (Sochi) was the following, as at 19:00.

Surface wind – calm, visibility 2700 m, light rain showers, mist, considerable clouds (5-7 octant), cloud ceiling at 1,200 m, temperature +11°C, dew point +11°C, pressure 1018 hPa; the two-hour weather forecast for landing: no major changes, the mountains partially in cloud, friction coefficient 0.5.

The weather forecast for Sochi on 02.05.06 from 18:00 to 03:00 was the following.

Wind 060°, 6 m/s, visibility more than 10 km, light rain showers, mist, scattered clouds (3-4 octant), cloud ceiling at 210 m; considerable (5-7 octant) cumulonimbus, cloud ceiling at 450 m; considerable (5-7 octant) medium clouds, cloud ceiling at 3000 m; moderate turbulence beyond the clouds, frequent turbulence in the layer from the ground to 600 m; in the period from 18:00 to 03:00 variable wind 2 m/s; visibility 800 m, fog, vertical visibility 600 m.

***Note:** While transmitting the weather report for the period from 18:00 to 03:00 into the automatic data transmission system (for its further transmission into the aviation meteorological database), a forecaster at the Sochi Civil Aviation Meteorological Station mistakenly specified the vertical visibility in fog to be 600 m, rather than 60 m.*

According to the Adler weather radar data, as at 20.50, 21.50, 22.50 on 2 May 2006 , there were mostly sheet clouds with separate cumulonimbus producing light rain showers. The mean cloud top was at 4200-5700 m. There were no potential thunderstorm cells or heavy showers.

On May 2, 2006 the synoptic situation was not considered favourable for vortex, which was proved by the Tuapse radiosonde data, as at 12:00 on 2 May 2006 , and by calculation of the probability of a vortex. In the period from 12:00 on 2 May 2006 to 00:00 on 03.05.06 the probability of a vortex was zero.

After A320 EK-32009 took off from Yerevan airport (Zvartnots) and climbed to FL-300, its cruise flight on the route from Yerevan to Sochi was going on in a fuzzy low pressure field. Along the route the wind was South-Westerly, 80-100 km/h, and the temperature was minus 48°C. The airplane was flying above the clouds, no icing conditions were present.

By the time the airplane entered the Sochi aerodrome zone at 22:00, the weather conditions there were determined by the postfrontal area of a cold front with waves: cumulonimbus producing precipitations, mist, and low broken nimbus.

- Starting from 22:00 the weather conditions at Sochi aerodrome were the following:

As observed at 22:00: surface wind 100°, 1 m/s, visibility 4000 m, light rain showers, mist, considerable clouds (5-7 octant), with the cloud ceiling at 180 m, overcast

cumulonimbus with the cloud ceiling at 820 m, temperature +11°C, dew point +11°C, pressure 1016 hPa; the mountains partially in cloud, friction coefficient 0.5.

- Two-hour forecast for landing:

- at times visibility 1,500 m, mist, vertical visibility 150 m.

- 22:07 check measurement upon the tower controller's request:

- visibility 4,000 m, light rain showers, mist, considerable clouds (5-7 octant), with the cloud ceiling at 160 m, overcast cumulonimbus with the cloud ceiling at 820 m.

- 22:09 check measurement at the holding controller's request:

- visibility 4,000 m, light rain showers, mist, considerable clouds (5-7 octant), with the cloud ceiling at 190 m, overcast cumulonimbus with the cloud ceiling at 820 m.

In connection with the abrupt descent of the cloud ceiling, at 22:11 an observer informed the controller via loudspeaker: "...the top...at 100 m, at the second runway 400 m", having made a mistake in the phraseology (she said 'the top', rather than 'the ceiling').

The final controller immediately advised the flight RNV 967 crew of the cloud ceiling: "Flight RNV 967, abort descent, cloud ceiling at 100 m...".

At 22:16 the observer got an alarm signal "Search and Rescue Service" from the tower controller and urgently measured all meteorological parameters.

- Observed weather at Sochi aerodrome measured after the alarm signal at 22:17:

Surface wind 130°, 2 m/s, forecast wind at the holding area level 080°, 4 m/s; visibility 4,000 m, light rain showers, mist; considerable clouds (5-7 octant), with the cloud ceiling at 160 m, overcast cumulonimbus with the cloud ceiling at 820 m; air temperature +11°C, dew point +11°C, atmospheric pressure 1016 hPa; the mountains partially in clouds, the wet runway, friction coefficient 0.5; the two-hour weather forecast for landing: at times visibility 1,500 m, mist, vertical visibility 150 m.

While lining up on the final course, the crew of flight RNV 967 was kept informed of the observed weather conditions at Sochi aerodrome.

The observed weather at Sochi aerodrome was measured by means of the certified Automatic Meteorological Information and Measurement System of the Russian Federation (AMIS), Type Certificate No. 89.

The meteorological equipment of Sochi aerodrome passed a metrological check, had the appropriate certificates, and was serviceable at the time of the A320 EK-32009 accident.

#### **1.4 Aids to Navigation**

The aerodrome in Sochi is equipped with navigation, landing and ATC aids to control flights and assist their navigation and landing in the day and night time in accordance with the established aerodrome minima.

1.8.1. The aerodrome is equipped with landing system equipment with MHland=24° and a non-directional radio beacon (NDB) with MHland= 60° to support airplane descent and approach.

The landing system equipment on RW 02 consists of the inner marker beacon located on the runway extended centre line at a distance of 1,025 m from its end, and the outer marker beacon located on the runway extended centre line at a distance of 2,646 m from its end;

The radio marker beacon for RW 06 is located on the runway extended centre line at a distance of 1,454 m from its threshold.

1.8.2. Two radio-beacon instrument landing systems with MHland= 024° and 060°:

- Radio-beacon system SP-80U, installed with MHland=024° and consisting of:

- a localizer located on the runway extended centre line at a distance of 250 m from the RW 02 end.

- a glide-slope beacon located at a distance of 300 m down RW 02 end and 129 m to the right from its centre line. The glide slope is 2° 50'.

- a SP-80U radio-beacon system, installed with MHland=060° and consisting of:

- a localizer located on the runway extended centre line at a distance of 835 m from the opposite end of RW.

- a glide-slope beacon located at a distance of 317 m from the RW 02 end and 130 m to the right from the runway centre line.

Glide-slope beacon 060° is installed together with a distance measuring beacon (RMD 90NP) combined with the SP-80U radio instrument landing system with MHland=060°, which measures the distance from the airplane to the runway end. The glide slope is 2°50'.

1.8.3. A VOR-DME beacon located at a distance of 4,425 m to the right of RW 06.

1.8.4. For ATC purposes, the aerodrome is also equipped with a “Synthesis” ATC automation complex operated from the approach, holding and tower control points and functioning in coordination with the airplane’s on board transponders.

1.8.5. The aerodrome’s “Irtys” surveillance radar (2 sets – “Irtys-M” and “Irtys-CK”) is installed at a distance of 235 m from the threshold of RW 06, in the direction of the NDB

beacon and 592 m to the left from the runway centre line, and is oriented on the magnetic meridian.

1.8.6. The automatic ground VHF radio direction finder ARP-75, located at a distance of 46 m from the RW 06 threshold, in the direction of the NDB beacon and 641 m to the left of the runway centre line, provides for monitoring aircraft within the aerodrome area and along the routes.

1.8.7. In case of in-flight radio communication failure, the holding controller can use the 365 kHz frequency (outer marker beacon), MHLand=024°, or 761 kHz (non-directional radio beacon), MHLand=060°, and transmit information via the airplane's automatic radio compass.

1.8.8. All radio aids used for air traffic control within the area of responsibility of Sochi airport and for aircraft navigation and landing support, were available and serviceable at the time of accident, in accordance with the air navigation certificate of Sochi aerodrome. No radio aids were out of service.

Flight checks and maintenance of the radio and telecommunication aids of the items maintained by the Radio and Communication Aids Service were conducted fully and in a timely manner.

At the time of the accident there was no non-observance of the regulatory requirements for radio aids operation, nor any shortcomings in their functioning.

Air navigation support to flight RNV 967 was provided in compliance with ICAO Annex 10 requirements, the Russian Federation AIP, Federal Aviation Rules, the AOAR of the Russian Federation, 1992, Revision 3, as well as the effective Air Navigation Certificate issued to Sochi aerodrome.

## **1.9 Telecommunications**

The aerodrome's means of communication included the following:

- VHF and HF radio stations;
- loudspeaker communication;
- telephone and telegraph communication.

1.9.1. The main VHF radio stations were the "Sprut-1", "Yasen-50", "Baklan-RN" stations located in the radio transmission centre. The backup radio stations were located in the control tower and the runway control points 2 and 3. No VHF communication is provided for flight operations at an altitude below 600 m in the sector from 320° to 120° (the mountainous area).

1.9.2. The HF “Bereza” radio transmitters are located in the radio transmission centre, and the HF radio receivers are located in the radio office of the control tower. HF communication is provided via a radio operator from the radio bureau.

1.9.3. Direct telephone and loudspeaker communication is provided between the approach, holding and tower control points, runway control point 1 (the control tower), runway control points 2 and 3, the local control point and the Chief of state flight operations and the interacting services.

1.9.4. Direct loudspeaker communication is also provided between Sochi, Krasnodar (Pashkovsky) and Gelendzhik aerodromes, with the “Strela”. regional AATC centre

1.9.5. Departmental telephone communication is provided between Sochi and Rostov-on-Don aerodromes.

1.9.6. At Sochi aerodrome telegraph communication is provided via the Rostov-on-Don switching centre.

1.9.7. Radio communications between the ATC controllers and the crew of flight RNV 967 was conducted with the use of the radio aids in accordance with the Air Navigation Certificate of Sochi aerodrome.

Flight checks and maintenance of the telecommunication equipment at the sites maintained by the Radio and Communication Aids Service were conducted fully and in a timely manner.

At the time of the accident there was no non-observance of the regulation requirements for operation of the radio aids, nor any technical equipment malfunctions.

The air navigation support to flight RNV 967 was provided in compliance with ICAO Annex 10 requirements, the Russian Federation AIP, Federal Aviation Rules, the Russian Federation AOAR, 1992, Revision 3, as well as the effective Air Navigation Certificate issued to Sochi aerodrome.

## **1.10 Aerodrome Information**

1.10.1. Sochi aerodrome is of Class B and has two intersecting paved runways, a network of taxiways, a parking area and a ramp.

The primary runway is a Class B paved runway 1 2890 m x 50 m, with MH 60/240. It was built in 1956, then overhauled and extended in 1984 for the purpose of IL-86 airplane operation.

The secondary runway is a Class B paved runway, 2200 m x 50 m, with MH 24/204, built in 1972.

This is a “mountain” aerodrome, with the runways requiring take off towards the sea: MHto=240° and MHto=204° and approach from the sea: MHland=60° and MHland=24°.

According to the certificate issued by the IAC Aviation Register, the aerodrome is suitable for international flights and not restricted.

This is a mixed aerodrome shared with the Ministry of Defense of the Russian Federation.



RW-1 is of a rigid type, paved with two-ply concrete with 0.2+0.22 m thickness, the surface classification number is PCN 29 /R/A/W/T/.

RW-2 is also of a rigid type, paved with one-ply concrete, the surface classification number is PCN 29 /R/A/W/T/.

The aerodrome pavement has defects by way of jagged full-depth cracks, longitudinal and lateral cracks with rough edges, and the upper layer of the paving is flaking off. The surface would benefit from repair.

The aerodrome drain system, which provides collection and discharge of the surface water from the area, consists of rain-collecting wells and manifold mains that discharge the unfiltered waste water in the Pervinka river. Currently there is no waste water treatment facility.

The physical aerodrome characteristics are in compliance with the Civil Aerodrome Operational Regulations of the RF, 1994.

#### 1.10.2. Runway condition

Inspection of the aerodrome surface and the runways was carried out in accordance with the Civil Aerodrome Operation Guidance of the Russian Federation, 1994.

The inspection results was recorded in the Airfield Condition Logbook kept at the aerodrome control tower.

#### 1.10.3. Aerodrome support

Aerodrome support was provided in accordance with the ICAO Chicago Convention, Annex 14, AOAR, Revision 3, 1992, Appendices 1, 3 and 4 and the effective Civil Aerodrome Operation Guidance.

### **1.11 Flight Recorders (FDR and CVR)**

A320 EK-32009 was equipped with an Allied Signal 4700 FDR and a Sundstrand AV-557-C CVR, which were installed in the rear part of fuselage. When the airplane impacted the water and was destroyed, both recorders were torn out of their installations.

The recorders were equipped with radio beacons that were activated when they hit the water. Work was undertaken to locate the radio beacon signals. According to preliminary conclusion, the radio beacons were located within a triangle with 150-meter sides. With the use of high-precision measurement equipment, the precise radio-beacon coordinates were determined as: 43° 22.9812 N; 39° 51.6875 E and 43° 22.9777 N; 39° 51.6871 E at a depth of 496.5 m.

On 22.05.2006, in course of the search in the specified area, the Sundstrand AV-557-C CVR was found and recovered. The Allied Signal 4700 FDR was found 40 m away from the CVR and was recovered on 24.05.2006.

The both recorders had suffered only minor damage, and after external inspection they were packed in containers with water, sealed and sent for further inspection.

#### **Flight Data Recorder**

The Allied Signal 4700 FDR registers the flight data for the previous 25 hours.

The FDR casing had minor mechanical damage and bore no traces of thermal influence.

The opening of the FDR, assessment of its status and read out of the data from the damaged medium were conducted by BEA specialists in France. Further processing and analysis of the retrieved data was performed with the use of the computerized WinArm32™ system in the Commission on Scientific and Technical Support to Aviation Accident Investigation of the IAC.

The Allied Signal 4700 FDR was serviceable and recorded all parametric data on 2 May 2006 until 22:13:02:08, in accordance with the List of Parameters for A320 EK-32009. The recording quality was good. The system stopped recording due to a cut in electrical power supply, when the airplane was destroyed.

### **Cockpit Voice Recorder**

The Sundstrand AV-557-C CVR records audio information in three channels (the left cockpit seat, the right seat and the cockpit area microphone) and records the last 30 min of flight.

The CVR casing was mechanically damaged, but bore no traces of thermal influence.

The opening of the CVR, assessment of its status and read out of the data from the damaged medium was conducted by BEA specialists in France. Further processing, listening and analysis of the retrieved data was performed with the use of SIS 5.5 and WinSis software in the Commission on Scientific and Technical Support to Aviation Accident Investigation of the IAC.

The work on identification of the crewmembers' voices and translation from the Armenian language were conducted in the Commission on Scientific and Technical Support to Aviation Accident Investigation of the IAC with participation of flight personnel from Armavia airlines.

The data analysis showed that the CVR had registered the audio data during the last flight of A320 EK-32009 on 02.05.06 until 22:13:02:6. The system stopped recording due to a cut in electrical power supply, when the airplane was destroyed.

### **1.12 Wreckage and Impact Information**

Since the airplane was destroyed due to the impact with the water surface and sank, it was impossible to determine the exact point of the initial impact.

The airplane wreckage sank into a depth of about 500 m, so exhaustive investigation was also impossible. Only a small portion of the wreckage (less than 5%) was found and recovered from the water surface.

The largest recovered fragments were the following:

#### *Nose dome*

Looking from behind at the nose dome, it was noticeable that almost a half of it was missing (approximately a section between 4 and 10 o'clock). The type of damage made it possible to conclude that the airplane did not hit the water nose first.

#### *Landing gear*

The lower parts of the left and right main landing gears were found.

The recovered right main landing gear wreckage was a piece about 1 m long from the lower edge of the outer cylinder. The torque-link survived, though deformed. The recovered left main landing gear wreckage was a piece of the shock strut piston about 80 cm long (from the wheel axle) and a lower part of the torque-link. The tires of the main landing gear wheels were intact and inflated.

Based on the damage, it may be suggested that at the moment of the airplane impact with the water the landing gear was extended.

#### *Fin*

The fin with a fragment of the left rear fuselage survived. There are no corrosion traces on the primary structural elements and on the rupture faces. The anti-corrosion coating was present. The upper fin was ruptured. The fin section from rib No. 9 along the forward spar to rib No. 10 along the rear spar was absent. The rudder moved easily. The rest of the rudder kinematics (actuators, rods) had suffered no external damage. The lower part of the rudder was seriously damaged.

#### *Elevator*

The left surface of the elevator was almost completely reconstructed from the recovered fragments. A fragment of the right surface of the elevator about 1.1 m long also survived. The elevator hydraulic actuators (PN 31075-230) were also damaged (hydraulic actuator 34CE1 had minor damage, and only the cylinder of the hydraulic actuator 34CE3 was found). The measurements taken on the hydraulic actuator 34CE1 showed 440 mm between the flexible joints, which corresponds to the elevator deflection to 19 degrees nose up. However, it should be taken into account that at the time of the airplane impact with the water the elevator deflection might have been different.

#### *APU air intake duct*

The APU air intake duct was found as a whole, severely deformed, with the deformation growing from the leading edge to the rear flange of the attachment.

#### *Shock-absorbing frame of the FDR*

The shock-absorbing frame of the FDR was found severely damaged. The plug connectors appear not to be damaged.

#### *Fragments of the passenger cabin interior*

The identified interior fragments had been laid out, in order to inspect for any evidence or traces of fire:

- fragments of seats and seat and back cushions;
- fragments of internal panels;
- luggage bays and doors;
- forward attendant panel.

No traces of ignition or fire were found on the recovered fragments.

#### *Life-jackets*

The main purpose of the life-jacket inspection was to determine if they were used before the impact with the water. Some of the jackets were found still packed, the others without package and not inflated. The life-jackets' condition makes it possible to conclude that they were not used.

Apart from the above, they found some fragments of the lower side parts of the fan cowls, an engine fire extinguisher and the APU fire extinguisher.

The fire extinguishers were discharged, as their safety valves and check valves on the filling connections had been torn off.

None of the fragments bore any traces of fire.

In the base of the airplane's fin the remaining wiring, connectors and HF radio feeders were found.

On the surviving partition that had been installed next to the left forward passenger door, the forward attendant panel used for control of the light equipment and the loudspeaker in the cabin remained, as well as the programming and test panel of the cabin intercommunication data system (CIDS). The panels and the wiring were in satisfactory condition (with no visible damage).

Some fragments of wiring, electronic units for lighting control, decoder-encoder units, and the dynamic loudspeakers were found on the fragments of the passenger luggage bays.

Some fragments of wiring and pieces of the volume and channel control panels were found on the passenger seats.

A container with the emergency HF radio station "Aktinia", which was in serviceable condition, was also found.

There were no traces of burning or melting on the fragments of wiring, plug connectors found and the other avionics components that survived.

### **1.13 Medical and Pathological Information**

According to the conclusion of the medico-legal investigation of the bodies that were recovered, the cause of death of the passengers and crew was trauma injuries on impact incompatible with life and typical of an aviation accident.

### **1.14 Survival Aspects**

All the passengers and crew were killed in the accident. 52 bodies and numerous human body fragments were recovered from the water surface.

The cause of death of the passengers and crewmembers, whose bodies were recovered was multiple blunt trauma with multiple fractures and injured visceral organs.

### **1.15 Emergency Services Actions**

The search and rescue work was organized and carried out in accordance with the Instruction for organization and conduction of search and rescue work on the aerodrome and in the area of responsibility of JSC “Sochi Airport”.

The Chief of the Search and Rescue Service of JSC “Sochi Airport” was responsible for the organization of the search and rescue work.

- 02.13 – the airplane’s trace disappeared from the radar screen of the ATC controller. Initially, there had been 105 passengers and 5 crewmembers on board (6 children, 63 men and 36 women).
- 02.15 – The Chief of flight operations N.G. Savelyev alerted all the search-and-rescue teams, the search-and-rescue crew of Mi-8 helicopter No. 27162 and the search-and-landing team of the Regional Search-and-Rescue Base (RSRB), via conference calls.
- 02.19 – the controller of the Operations and Dispatch Service informed the Ministry of Emergencies (an operator on duty).
- 02.39 – the controller of the Operations and Dispatch Service informed Sochi Seaport (a controller in the seaport surveillance service)
- 02.45 – the Captain of search helicopter No. 27162 reported that they were ready to take off with the search-and-landing team consisting of 3 RSRB rescuers on board. (Emergency time 30 min)  
They were not cleared for takeoff due to the weather conditions being below the minima.

In accordance with the aviation legislation of the Russian Federation and based on the Flight Safety Information No. 28 Part 1 item 3 of 20.12.2005, forwarded from FTOA to the Southern Civil Aviation Department and the aviation enterprises reporting to it, implementation of item 2.1.9 of the Civil Flight Operations Guidance 85 was temporarily cancelled..

Item 2.1.9 of the Civil Flight Operations Guidance 85: “While organizing flights connected with people rescue or natural disasters, heads of Civil Aviation Departments and commanders (chiefs) of aviation enterprises have a right in case of emergency to waive the flight operation procedure and rules stipulated in this Guidance, as well as the standard flying and rest time periods”, being personally responsible for their decision.

In the case in question, Item 2.1.9 of the Civil Flight Operation Guidance 85 was not implemented, and the air forces and facilities of Sochi Airport were not sent to the accident location.

- 04.08 – the Ministry of Emergency’s boat «Valery Zamarayev» found the probable area of the airplane crash, with coordinates 43° 23. 843 N, 39° 51. 448 E.
- 4.30 – the first group of 7 people, consisting of the RSRB rescuers and Aviation Technical Base (ATB) personnel, went to Adler Wharf, in coordination with the seaport and in accordance with the Sochi Seaport interaction plan.
- 05.35 – the RSRB rescuers went to the search area by “Typhoon” boat, carrying with them the appropriate technical equipment.

- 07.30 to 12.30 – the RSRB rescuers found and took on board 9 bodies (fragments)

- 08.40 – the second group of RSRB rescuers went to Sochi Seaport to take and transport the bodies (fragments) and the airplane wreckage in co-operation with the Russian Ministry of Emergencies , Sochi Seaport and other departments.

The two teams worked until 18 h 30 min (Moscow time) jointly with the other ministries and departments.

- 04.05.2006 - 07.30 - a group of RSRB rescuers and ATB personnel was sent to Sochi seaport to continue the search-and-rescue work jointly with the Ministry of Emergency of Russia, Sochi seaport and the other departments, and to transport the bodies (fragments) and the airplane wreckage.

- 05.05.2006 - 08.30 – a group of RSRB rescuers and 4 ATB people were sent to Sochi seaport to continue the search-and-rescue work jointly with the Ministry of Emergency of Russia, Sochi seaport and the other departments, and to transport the bodies (fragments) and the airplane wreckage.

- 06.05.2006 - 08.30 – a group of RSRB rescuers and 3 ATB people were sent to Sochi seaport to continue the search-and-rescue work jointly with the Ministry of Emergency of Russia, Sochi seaport and the other departments, and to transport the bodies (fragments) and the airplane wreckage.

Airplanes of the Ministry of Emergency were also involved in the search-and-rescue work.

- Be-200ChS airplane, No. 3276, performed visual observation of the accident area and determined the borders and direction of propagation of the airplane fuel and wreckage. This information was used to direct the boats in the search area.

The airplane performed two flights:

- 04.05.06 takeoff at 11.07 landing at 12.32;
- 05.05.06 takeoff at 10.16 landing at 11.27.

- Ka-32 helicopter, No. 31088 – performed visual observation of the accident area and the area of wreckage drift to the North-West and directed the boats collecting the bodies (fragments) and the wreckage.

The helicopter performed four flights:

- 03.05.06 takeoff at 17.49, landing at 18.50;
- 04.05.06 takeoff at 07.31, landing at 09.50;
- 05.05.06 takeoff at 08.12, landing at 10.37;
- 06.05.06 takeoff at 09.32, landing at 11.42.

- Mi-8MTV helicopter No. 32755 performing a flight from Rostov to Sochi, worked in the accident area on 03.05.06 from 13:30 to 14:30.

## 1.16 Tests and Research

In the course of investigation of the accident to the A320 EK-23009, Airbus specialists performed mathematic simulations of the accident flight.

In the course of the mathematic simulation, the final stage of the accident flight was split into two segments: the autopilot flight segment (up to the moment when the autopilot was disengaged) and the manual flight segment.

The pilot control inputs, flight control surface deflections, power plant and autopilot modes were set in accordance with the values registered by the A320 EK-32009's FDR. The results obtained showed a high convergence in the mathematical simulation parameters with the values registered by the FDR in the accident flight (see Attachment 3).

Analysis of the results obtained showed that the autopilot was working in accordance with its established logic, and the airplane movement was completely determined by deflection of the control surfaces and the engine mode. The aerodynamic and propulsion performance characteristics of A320 EK-32009 conformed to those of the type. There was no external influence on the airplane.

In the period from 25.06.2006 to 07.07.2006 experiments on A320 flight simulators were conducted.

The research was performed on the following A320 simulators:

- Motion Full Flight Simulator (FFS) A-320, manufactured by CAE, MFR's PART No. 35-181-MA002RV1-01 SERIAL No. 2RV1-470 2003. FLIGHT COMP (UNIT FC) 35181-MA184900.38.2.845 AEROFLOT TRAINING CENTRE (Sheremetyevo);

- Motion Full Flight Simulator (FFS) FFS A-320, manufactured by CAE, MFR's PART No. 35-181-MA002RJJ-01 SERIAL No. 2RJJ-479 2003г. FLIGHT COMP (UNIT FC) MA184900.22.2.845 AIRBUS A320 FFS (Toulouse, France);

- Research Fixed Simulator (FS) «ENGINEERING SIMULATOR Airbus» (Toulouse, France);

- Research Fixed Simulator (FS) «IRON BIRD», fitted with an actual flight control system, including its mechanical parts (Toulouse, France).

In total the research took the following time:

- on FFS – 12 hours

- on FS – 18 hours.

The following people were involved in the research: Airbus test pilots, a test pilot from the Flight Research Institute, Armavia and Aeroflot pilots, as well as pilot-inspectors from the CAA RA and FTOA of Russia.

There were two video cameras installed in the simulator cabins shooting all the experiments. In addition, the necessary parameters were recorded on a flight data storage unit for further analysis of the performed modes («ENGINEERING SIMULATOR»). The on board computer software and the indication and warning system of the «ENGINEERING SIMULATOR» conformed to those installed on A320 EK-32009 that crashed on 03.05.06. In course of the research, the

simulated weather conditions were close to the actual weather in Sochi airport on 03.05.06 to the maximum possible extent.

At the initial stage of the research, the flight weight and balance of EK-32009 at the time of the accident were verified based on the observed horizontal stabilizer balance values and the angle of attack. In further experiments the verified flight data was used, which allowed to reproduce the parameters and the airplane path on the simulator with the maximum accuracy. The most accurate results were obtained on the FS «ENGINEERING SIMULATOR». Taking into account the possibility of analyzing the recorded flight data, the research was mostly conducted on this simulator.

Experiments on the FFS with the use of the motion system were performed mostly to obtain a general picture of the accident, as well as to develop versions explaining crew actions during manual flight, and especially when the abnormal situation developed.

The research consisted of the following stages:

- simulation of the crew actions based on the actigram of the final stage of the flight on the motion (FS) and fixed (FFS) simulators;
- performance of standard procedures «GO AROUND» and «GO AROUND FROM AN INTERMEDIATE APPROACH ALTITUDE» («MISSED APP»);
- assessment of the airplane behaviour induced by simulated crew actions with the autopilot engaged, and with and without activation of TOGA mode at various stages of go-around;
- performance of the «MISSED APP» manoeuvre with retraction of flaps in configuration 3 and retraction of landing gear;
- assessment of the rudder deflection effect in the process of development of the abnormal situation;
- assessment of the possibility of recovering the airplane from the abnormal situation in its various stages;
- investigation of the longitudinal acceleration effect on misperception of pitch orientation.

The following conclusions were made based on the work undertaken:

- If the standard «GO AROUND» and «MISSED APP» procedures prescribed in the FCOM are followed, the airplane performs the go-around manoeuvre in both the autopilot and flight director modes with no difficulties.
- For actions similar to those of the crew of flight RNV 967, the parameters obtained on the airplane's movement were very close to the parameters of the crashed airplane, which proves high convergence of the results and adequacy of the applied mathematic model.
- In the case where the autopilot was not disengaged, while performing a maneuver similar to that in the accident flight, the autopilot successfully completed the go-around procedure with activation of warning «SPEED SPEED SPEED», and without the  $\alpha$  – FLOOR function engaged.
- If after activation of the «PULL UP» warning the FCOM recommendations were followed, for parameters similar to those in the accident flight, the loss of altitude during airplane recovery from descent was about 200 to 230 ft.



- The limited capabilities of the FFS motion system did not make it possible to check the version of misperception of pitch orientation under conditions of longitudinal acceleration. Most probably, the “pitch-up effect” might be a contributory factor, but not the prime reason explaining the inappropriate nose-down input on the side stick made by the Captain.
- Development of the abnormal situation into the catastrophic one during the final stage of the flight was made possible due to a partial loss of spatial orientation by the Captain and the co-pilot, which the crew could not regain because of their inadequate skill and training with the background of the fast-developing process and the lack of time.
- It was not possible to determine the actual cause of the inadequate pilot inputs after the segment of stabilized flight, nor the cause of the lack of monitoring of the value and direction of roll, pitch, altitude and the vertical speed.

Criminal aspects of the accident were investigated in the framework of criminal proceedings. According to the complex forensic report, there was no evidence of in-flight explosion or fire.

### **1.17 Information on Organizations and Management**

1.17.1. The airplane was registered in the state civil airplane register of the Republic of Armenia and operated by the limited liability company “Armavia Airlines”.

Certificate of Operator No. 008 was issued by the CAA RA on 08.01.2006 and was valid for a year.

The legal address: 375042, Yerevan, Zvartnots airport.

1.17.2. Operation of the radio and telecommunication aids at Sochi aerodrome is ensured by the Radio and Communication Aids Service, which is a division of the Black Sea Air Traffic Management Centre of the “Air Navigation of the South” branch of the federal state unitary enterprise “State Corporation on Air Traffic Management” and acts on the basis of license GSDM No. 000004 and Certificate of Compliance No. FAVT C.0006 issued by the Air Traffic Management Department of the Federal Air Transport Agency on 10 October 2005. Under this Certificate, which is valid until 10 October 2007, the following work is undertaken:

- flight operations support with radio and communication aids;
- providing companies and their contractors with telecommunication aids;
- maintenance of the radio and telecommunication aids.

1.17.3. The Air Traffic Service was provided by the Black Sea Air Traffic Management Centre of the “Air Navigation of the South” branch of the federal state unitary enterprise “State Corporation on Air Traffic Management” on the basis of license GSDN No. 005171, issued on 01.04.04 and valid till 01.04.09, and Certificate of Compliance No. FAVT.00089 issued 08.12.05 and valid till 08.12.08, both issued by the Federal Air Transport Agency, and in accordance with the ICAO Chicago Convention, Annex 11 “Air Traffic Service”, Document 4444 “Flight Operation Rules and Air Traffic Service”, the Russian Federation AIP, Federal Rules For Use of Air Space of the Russian Federation, Civil Flight Operations Guidance 85, ATC Controllers’ Operation Manual, the Rules and Phraseology for In-flight Radio Communications and ATC, and the Air Navigation Certificate of Sochi aerodrome.

1.17.4. The meteorological support to flight RNV-967 was provided by a shift on duty from the Sochi Civil Aviation Meteorological Station, which formed a part of the Specialized Black Sea and Sea of Azov Hydrometeorology and Environment Monitoring Centre (license No. B 420592, registration No. R/2002/0126/100/L, issued by Roshydromet on 25 December 2002, valid till 25 December 2007).

1.17.5. The airport services to flight RNV-967 were provided by the federal state unitary enterprise “Sochi Airport”, based on Certificate FAVT A.00236 valid until 15.02.06 and the License GS OA No. 004792 of 18.03.04 valid until 18.03.07 issued by the State Service of Civil Aviation.

## **1.18 Additional information**

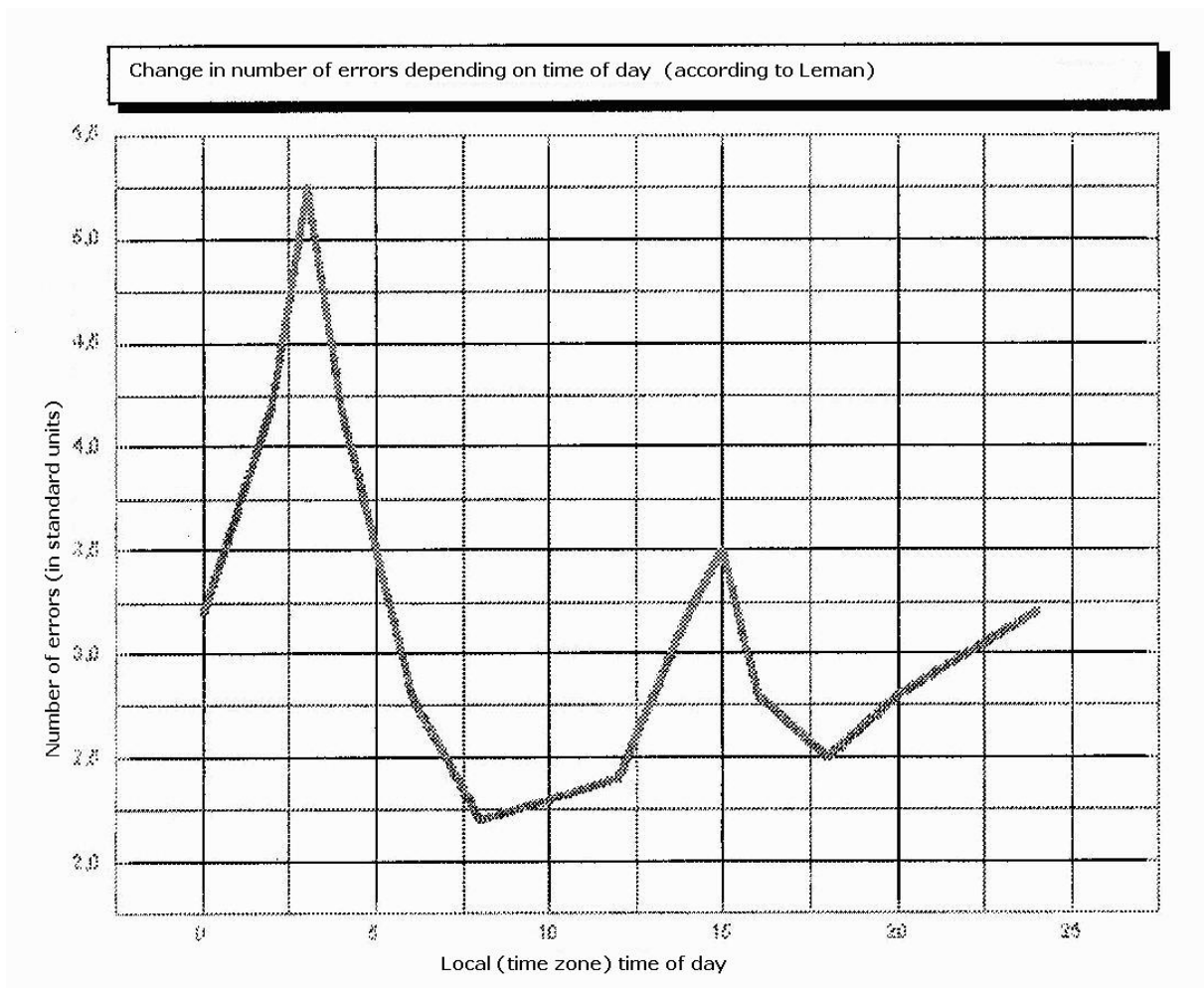
1.18.1 The expert assessment of the inadequate crew actions during development of the abnormal situation performed by a test-pilot.

The actual reason for the inadequate actions of the Captain (the nose-down movement of the side stick and holding it there for a long time after a segment of stabilized flight with the roll angle of 200) could not be determined.

Nevertheless, based on flying experience and the available data, the most probable means of explaining the development of the abnormal situation into the catastrophic one can be suggested.

The abnormal situation developed against the following background:

- early in the morning (local time 02:12), when the probability of mistakes is especially high;



- crew fatigue, which is shown by the co-pilot's phrase during descent: "*(expl., is it possible to perform such a nerve-racking flight in such a lack-of-sleep state?*)".
- changeable weather conditions at Sochi airport;
- the crew being annoyed with the changes in the flight plan (return to Yerevan, and then back to Sochi again);
- uncertainty that the controller would give a clearance for landing, which caused a negative reaction by the crew.

Quite a number of psychological factors contributed to the development from an abnormal situation into the catastrophic one:

**1. Excessive mental set** for landing at Sochi airport.

Probably, at some stage this contributory factor became dominant. This might lead the crew to fail to evaluate the situation adequately and make the right decision during the approach to Sochi airport, or to get prepared for alternate actions. Such a strong mental determination to perform the flight is indicated by the turn back to Sochi, even though before that the crew had decided to return to the departure airport, by in-cockpit conversations and the expletives addressed to the controller, who constantly informed the crew of the bad weather (as was his usual job), and by

the crew's decision to land the airplane, though they were not completely sure that the weather was above the minima.

It may also be supposed that the crew experienced "*a conflict of motives*", when equally important motives are addressing opposing goals.

In the situation, there was both a group of motives relating to landing at Sochi airport and a motive (or a group of motives) to carry out the controller's instructions (a wish to avoid a conflict with the Air Traffic Service). Such a psychological situation decreases the reliability of a professional pilot and may result in erroneous or unfulfilled actions. As a result, it may be supposed that the crew was in *a dominant psychological state*, the dominant element of which was to land in Sochi airport, combined with "*a conflict of motives*". Therefore, when the controller instructed the crew to abort descent and perform a right climbing turn, the crew fulfilled the instruction "literally", not analyzing the situation, though it apparently was an instruction to go around. Most likely, because of this the crew did not retract the landing gear and did not set the high-lift devices in the appropriate configuration. The crew showed low mental readiness to undertake any other task apart from landing at Sochi airport.

## **2. Low mental readiness of the Captain** to switch to the manual mode.

Firstly, the unexpectedness of the instruction to go around at an altitude of about 390 m that was above the expected decision altitude at which this manoeuvre is usually performed during training.

Secondly, the dynamics and attitude of the airplane in the process of this manoeuvre were unexpected by the Captain: pitch angle +21°, roll angle +25°, decrease in speed, activation of the "SPEED SPEED SPEED" warning and impossibility to evaluate further changes in these parameters.

It should be noted that while performing the go-around manoeuvre on a simulator in accordance with the FCOM, the Captain remembered that the maximum pitch angle did not exceed 15° with zero roll, and there was no decrease in speed.

In spite of the fact that after disengagement of the autopilot the Captain recovered the airplane to stable flight with a roll angle of 20° and a small positive vertical speed (about 2 m/s), he probably still felt startled and stressed. Possibly, the Captain tried to analyze the cause of such airplane behaviour or his own mistakes.

Such a situation could result in *mental torpor* (stupor). In this state people may be numb and passive or, on the contrary, overactive, when the actions being taken and their expediency become chaotic. In such cases we may talk about the pilot being perplexed. This state can explain inadequate, but still quite active actions by the pilot to increase the airplane roll and decrease the pitch angle, and at the same time his very poor response to the GPWS warning (the PULL UP warning).

In this state the pilot can concentrate on perception and analysis of only one, two or more flight parameters, being incapable of perceiving and evaluating the situation as a whole. As a result, the attention, perception and thoughts of the Captain and partially of the Co-pilot were concentrated on **monitoring of the flight speed**. This is demonstrated by the crew's (mostly Captain's) actions aimed at activation of the autopilot (setting of the altitude, though the autopilot was disengaged) and the autothrust (pulling the thrust control levers back to IDLE and then pushing them forward

to CLIMB, i.e. moving them too far), as well as flaps retraction at a speed exceeding the limits. Their concentration on one or several flight parameters might have made the crew unable to adequately perceive and analyze the situation as a whole, and also might have contributed to partial loss of spatial orientation. During the last 40 seconds of the flight the crew might very well have been in a state of mental torpor (judging by the Captain's inputs and taking into account the preceding factors). Being in this state, the crew failed to adequately and comprehensively evaluate the situation and make the right decision. It is quite possible that the co-pilot was out of the control loop during the go-around manoeuvre, being in contact with controllers and only carrying out the Captain's orders.

In the final stage of the flight, the crew apparently lost their spatial orientation, this being shown by the lack of monitoring of the pitch, altitude, vertical speed and roll parameters by the Captain. When the Co-pilot intervened in the control loop, he evaluated the roll and speed parameters correctly, but did not monitor the descent parameters (pitch angle, altitude, descent rate) and did not react to the "PULL UP" warning.

#### **1.19 New methods used in investigation**

No new methods were applied to this investigation. The investigation was conducted in accordance with the standard procedures.

## 2. Analysis

On 3 July 2006 the Armavia crew, consisting of Captain G.S. Grigoryan and co-pilot A.D. Davtyan, was performing international passenger flight RNV-967 from Zvartnotz airport (Yerevan) to Sochi airport on the A-320 registered EK-32009. There were 105 passengers and 8 crew on board (2 pilots, 5 flight attendants and 1 engineer from the Engineering Service as a non-paying passenger).

The crew had valid pilot's licenses and medical certificates. Their qualifications and state of health corresponded to the character of the mission performed and allowed the safe execution of the flight. According to the documents presented, professional

skill levels of the flight crew members corresponded to the Armenian CAA regulations.

*Note: Armavia airline does not undertake operational supervision of the A-320 aircraft crews' flights via the use of flight recorder information, which made it impossible to completely evaluate the professional skill levels of the flight crew members.*

The crew passed preliminary training on 23.03.2006 as a part of the seasonal training under the guidance of the airline's Flight Director .

At 19:30 all the crew passed the pre-flight medical examination. After that they proceeded to flight preparation under the guidance of the Captain.

According to the weight and balance chart submitted, the aircraft takeoff weight was 62,712 kg, and the center of gravity was 29.9%, which was within the limits defined in the A320 FCOM. The calculated flight time for the route from Yerevan to Sochi was about 1 hour. The aircraft had 10,000 kg of fuel on board, which was adequate for a flight to the destination airport with a possibility to divert to the alternate aerodrome (Rostov) or return to Yerevan.

Aircraft maintenance was provided by Sabena Technics (Belgium), in accordance with the contract with Armavia airline. Auxiliary work was performed by Armavia technical personnel. No deficiencies in the maintenance service were brought to light that could have influenced the outcome of the accident flight.

At the time of departure from Yerevan, the aircraft, its systems and engines were serviceable. The Investigation Commission did not reveal any evidence of failure in the aircraft systems or engines in the accident flight. The crew did not report any malfunctions on the aircraft, its systems or engines.

The Captain made his decision to depart based on the weather forecast for the period from 18:00 to 03:00 issued at 16:55 and transmitted from the Vienna data bank. The forecast and observed weather in Sochi airport conformed to one of the decision-for-departure variants provided in Armavia's Flight Operations Guidance.

*Note: For an unknown reason, the weather forecast was not provided after 21:00.*

The engines were started at 20:39:30, engine No. 2 first, and then engine No. 1. The crew received the controller's clearance and lined up. Takeoff was performed with flaps at 18°, the thrust control levers in the FLX position, with the autothrust engaged. The aircraft took off from Zvartnots airport (Yerevan) at 20:47:10. The aircraft lifted off at an indicated airspeed of about 160 kt (290 km/h). At an altitude of 55 ft (17 m) the landing gear began to retract. At 20:47:13 the NAV mode was selected (see Attachment 2, Fig. 2)

*Note: In the description of the takeoff and approach flight stages the radio altitude recorded by the Allied Signal 4700 system was used.*

At 20:47:56 at an altitude of 1,840 ft (560 m), the thrust control levers were set on the CL position (CLIMB is the maximum continuous power mode). After that, autothrust was activated. During the climb autothrust was set on N1 mode (fixed RPM). At 20:48:08, at a radio altitude of 2,370 ft (720 m) the autopilot was engaged.

During the climb the crew received the controller's instruction for a correction to the left to bypass an atomic power station, as well as information on thunderstorm cells: "967, for information, azimuth 300, distance 50, upper 7, a thunderstorm cell", CREW: "Information received, thank you". At 20:50:14 the selected heading was changed to 250°, a left turn was performed in a mode to reach a course with roll up to -13° for about 14 seconds. At 20:51:02 the navigation mode was selected (Attachment 2, Fig. 2 and 3). The crew continued climbing, bypassing the thunderstorm cells (Attachment 2, Fig. 1).

At 20:51:03, having obtained the controller's permission, the crew commenced a right turn to fly to the en-route TIBLO fix.

At 20:51:40, upon request from the crew, the controller gave permission to fly to the en-route TUNIS fix.

At 20:52:09 the approach controller instructed the crew of A320 EK-32009 to climb to FL 200 and get in touch with the regional control centre "Yerevan-Control".

At 20:52:23 the crew was instructed to climb to FL 300. At 20:52:41 setting of an altitude of 9,130 m was recorded, and after that the aircraft continued climbing in the CLIMB mode.

At 20:54:17 the crew requested permission to head the aircraft towards the en-route BARUS fix and obtained the controller's permission to change the flight route.

According to the radar data provided by the Yerevan Regional Control Centre, A320 EK-32009 twice crossed the Turkish frontier, at 20:58:00 and 21:01:00 (Attachment 2, Fig. 11-12). Based on the communications between the crew of flight RNV-967 and the Yerevan Regional Control Centre controller, it was established that crossing of the state frontier was not envisaged. However, due to the turbulence, according to Flight RNV-967 radar tracking data, the path of the aircraft track on the radar screen was in the vicinity of the state frontier. The Turkish ATC agencies did not raise any claims in connection with unauthorized crossing of the state frontier.

At 20:59:51 the crew reported: “Control, Armavia 967 approaching abeam TUNIS FL 300”, and received instruction from the controller: “Armavia 967, contact Tbilisi-Control 134.6, goodbye”.

At 21:00:07 the crew contacted the controller of the Tbilisi Regional Centre “North”: “Tbilisi-Control, RNV-967, good night, 300, abeam TUNIS, signed FL 340” and were instructed: “RNV-967, good night, monitoring you on the radar, climb to 340, heading to BANUT”. The crew confirmed in compliance with the instruction.

At 21:01:49 the controller of Tbilisi Regional Centre “North” instructed: “967, head to BARUS at present, you are going to cross the frontier. The frontier is very close, heading to BARUS at present”. The crew obeyed.

At 21:04:34 the controller of the Tbilisi Regional Centre “North” instructed: “Sochi, weather 2000 by 170 runway 06 and 02”. This weather was below the established minima for the landing aerodrome. The minima at Sochi aerodrome were 170 x 2500 for runway 06 and 220 x 3000 for runway 02.

At 21:05:49 the controller cleared the aircraft on a heading to the compulsory reporting point BANUT: “RNV-967, you may head to BANUT and work with Tbilisi-control 133.4”.

The target flight level 340 was reached at about 21:07:00.

The cruise altitude was ~33900 ft (~10300 m), at an indicated airspeed of ~265 kt (~490 km/h) in the NAV mode, with the autothrust in the V/M MODE (the airspeed hold mode), and with the ALT MODE (the altitude hold mode) selected. At 21:08:35 the Allied Signal 4700 recorded disengagement of Autopilot 1 and engagement of Autopilot 2.

At 21:10:21, in the area of Tbilisi Regional Centre responsibility, the crew contacted the controller of Sochi approach control and asked him to clarify if the weather could be expected to improve. At 21:10:46 the controller of Sochi approach control passed on the following information: “RNV-967, well, now the weather is below the minima here, that is on RW 06: the cloud ceiling at 170 m, visibility 2000. And the minima is 170 by 2500. And on the RW 02 the cloud ceiling is 170 m, visibility 2000. 220 is required there”. In response the crew informed: “Well, I’ve got the fuel, yes, for an hour of flight. Is 2500 expected within an hour?”, and later, at 21:11:43, they requested: “Clarify further. Within an hour, if there is 2500, then we will hold and land”.

At 21:16:07, having consulted with a forecaster, the controller of Sochi approach control advised: “RNV-967, so, the forecast for two hours: 150 by 1500”. This forecast weather was below the established aerodrome minima for landing.

*Note: The Sochi approach controller reported the weather forecast for Sochi aerodrome to the crew, but did not give the trend*



*“AT TIMES”. Inaccuracies by the controller while reporting the weather to the crew were not directly connected with the cause of the aircraft accident, but they influenced the initial decision of the crew to return to the departure aerodrome.*

At 21:16:14 the Captain contacted the Tbilisi Regional Centre “West” controller and advised him of their decision to return to the Zvartnots departure aerodrome (Yerevan). At that moment the aircraft was in the area of compulsory reporting point ALIKA, at a distance of 180 km from Sochi airport, the flight altitude was 33,900 ft (10300 m), and the indicated airspeed was 265 kt (490 km/h).

At 21:16:34 the Tbilisi Regional Centre “West” controller cleared the crew for turnaround: “RNV-967, make a left turn and head to BARUS”. At 21:17:00, in response to a question from the Sochi approach control point: “Say your decision, RNV-967”, the Captain said: “Yes, what, decision, we’re returning to Yerevan”.

At 21:26:31 the crew, being in the area of responsibility of the Tbilisi Regional Centre “West”, contacted the controller at Sochi approach control again and asked for a measurement of the observed weather. While waiting for the results, the crew told the Sochi controller that they had Deputies onboard. This information was not true. Analysis of the crew conversations for 21:43 shows that the crew intentionally misinformed the controller, in order to obtain a positive weather forecast. At 21:30:49 the Sochi approach controller informed the crew: “Armavia 967, visibility 3600, cloud ceiling 170, for 30 minutes. The weather is around the limit, but OK so far”.

After getting the weather information, the Captain decided to fly back towards Sochi, and at 21:31:04 he reported to the Tbilisi Regional Centre “North” controller: “967, we are on heading, request the heading to BANUT, Sochi is open again now”. The controller gave permission to change the flight route: “967, Roger, cleared for heading to BANUT”. At 21:31:17 the crew reported their decision to the Sochi approach controller: “967, we are coming back, that means flying to Sochi”.

At 21:37:20 the crew contacted the Regional Centre “West” controller: “Tbilisi-control, RNV-967, good night again, heading to BANUT, flight level 340”; “RNV-967, hold 340, monitoring you on the radar”. The flight was continuing with a heading to the en-route BANUT fix, to the left of the UL850 route, gradually getting closer to it (Attachment 2, Fig. 1). At 21:40:29 the Tbilisi Regional Centre “West” controller advised the crew: “Visibility in Sochi 3600, the cloud ceiling 170”.

**Note:** *For the purposes of the description of the flight, from 21:40:06 onwards, the transcript of the cockpit communications recorded by the Sundstrand AV-557-C CVR was used.*

At 21:40:44 the Regional Centre “West” controller asked the crew: “Advise once again endurance and alternate”. The crew responded: “Endurance 2.5 hours, alternate Rostov and Yerevan”.

In the time from 21:41:00 to 21:42:00, the Sundstrand AV-557-C CVR recorded the audio information showing the crew preparations for a possible go-around in case of unfavourable conditions:

Crew: Right turn heading 240 (*unintelligible*).

Captain: Heading for a missed approach ....

Captain: Right turn onto heading 240, yes?

Crew: Maximum 200 knots at a minimum bank of 20 degrees in take-off configuration. Climb 2100 at maximum rate 2060. Missed approach altitude 2100.

Co-pilot: That’s for runway 06, and for runway 02 it’s the same but on heading 204, missed approach on heading 204, yes, it’s 240 there and 204 here.

*Note: Analysis of internal communications from 21:44:00 to 21:45:00 shows that the situation in the cockpit was getting complicated. The crew (especially the Captain) appeared to be eager to land in Sochi, and nowhere else. Further conversations show that the crew did not even wish to bother the Sochi approach controller once more, so as not to get an unfavourable weather forecast from him.*

At 21:47:28, during the briefing before descent and approach, the Captain gave the co-pilot information on the approach:

Captain: In LOW configuration we’ll approach with flaps FULL, after landing maximum reverse thrust, SAFE ALTITUDE 1600, we have reviewed missed approach procedure.

Co-pilot: Yes.

Captain: Right turn at a bank of 20, maximum 200.

During the briefing the crew showed that they were not sure if VOR was available at Sochi aerodrome. Analysis of internal communications shows that before the flight the air navigation data on the landing airport was not fully reviewed by the crew.

At 21:52:32 the target altitude was set at 21,950 ft (6,690 m). The initial descent was performed in the DESCENT mode (MANAGED mode), with the average descent rate of ~ -5 m/s, with the autothrust set in the speed hold mode (V/M MODE). At

21:54:20 the CVR recorded the Captain's phrase: "*This one here is also crazy, she's not descending, brother, I don't understand, you descend, (\*\*\*\*) your mother.*", and 6 seconds later the OPEN DESCENT mode was selected, and the autothrust switched to the N1 mode, with the navigation mode (NAV MODE) selected. The descent rate increased to about -10...-12 m/s.

*Note: In the quotations from the internal communications provided here the words translated from the Armenian language are shown in **italics**.*

The co-pilot's phrase recorded by the CVR: "\*\*\*\* it, *who operates such flights with the jitters and not enough sleep?*" could be evidence of crew fatigue. At 21:55:31 the Captain's phrase was recorded: "*This one doesn't want to keep in the MANAGE, does it brother? Now have a look here. It doesn't want to, you can't make it.*" and the co-pilot's answer: "*Engage your autopilot if you want. Yours is better in descent (laugh)*". At 21:55:48 autopilot 2 was disengaged and autopilot 1 engaged, and at the same time the autothrust switched to the speed hold mode (V/M MODE) for a short while. After that the aircraft was descending in DESCENT mode, with autothrust set in N1 mode, the indicated airspeed of 260 kt (480 km/h), and the mean descent rate of ~ 10 m/s (Attachment 2, Fig. 2 and 3).

*Note: Analysis of the internal communications at this stage of the flight shows that the Captain was annoyed by the fact that in DESCENT mode (MANAGED MODE) the descent rate was not as high as he expected. It should be noted that in this mode the descent rate is calculated automatically, depending on a number of parameters describing the descent, e.g. the aircraft attitude in relation to the preset profile and so on. This fact shows that either the Captain did not fully understand the autopilot work algorithm in the DESCENT mode, or was in a state of high psycho-emotional strain with an imperative to land at Sochi as soon as possible.*

At 21:58:40 the crew contacted the controller at the regional control centre "Strela": "Rostov Control, Armavia 967, good night, BANUT, flight level 220." and was cleared for continued descent: "Armavia 967, Rostov Control, good night, continue descent, 4800", and 38 seconds later: "Armavia 967, continue descent, 3600". The flight was performed along route A277 (Attachment 2, Fig. 1).

At 22:00:35 the controller at the regional control centre "Strela" instructed the crew: "Armavia 967, contact Sochi Approach 124.6".

The crew contacted the Sochi approach controller at 22:00:46: "Sochi Approach, Armavia 967, good evening once again. Descending to 3600 to GUKIN."

The controller took over the control: “Armavia 967, Sochi Approach, good evening. Continue descent to GUKIN, magnetic 190, distance 43”. From this time on, the aircraft was controlled by Sochi controllers.

Having received the controller’s permission, the crew selected an altitude of 5,888 ft (1,795 m) and continued descent in the OPEN DESCENT mode (Attachment 2, Fig. 3 and 9).

After 22:00 the weather at Sochi aerodrome was as follows:

22:00 Visibility 4000 m, wind 100°, 1 m/s, light rain showers, mist, considerable clouds 5-7 octants with cloud ceiling at 180 m, overcast cumulonimbus 8 octants with cloud ceiling at 820 m; air temperature 11°C, dew point 11°C, pressure 1016 hPa; the two-hour forecast for landing: at times visibility 1500 m, mist, vertical visibility 150 m, the mountains partially in clouds, the friction coefficient 0.5.

22:07 A check measurement upon request of the controller of the tower control point: visibility 4000 m, light rain showers, mist, considerable clouds 5-7 octants with cloud ceiling at 160 m, overcast cumulonimbus 8 octants with cloud ceiling at 820 m.

22:09 A check measurement upon request of the holding controller: visibility 4000 m, light rain showers, mist, considerable clouds 5-7 octants with cloud ceiling at 190 m, overcast cumulonimbus 8 octants with cloud ceiling at 820 m.

During descent and approach the crew of flight RNV-967 was kept informed of the observed weather conditions.

At Sochi aerodrome, weather observation was conducted with the use of the Automatic Meteorological Information and Measurement System (AMIS), type certificate No. 89. The meteorological equipment of Sochi aerodrome had passed a metrological check, possessed the appropriate certificates, and at the time of the accident was serviceable.

The weather observation point is located near the end of RW 06. At the time of landing the cloud ceiling was observed from the non-directional radio beacon facility located at a distance of 1,454 m from the end of RW 06, and the data obtained were representative and valid. The printout of the cloud-ceiling data recorded by AMIS shows the values recorded every 15 seconds as follows:

22.10.23 ceilormeter/non-directional radio beacon: 185 m;

22.10.38 ceilormeter /non-directional radio beacon: 125 m;

22.10.53 ceilormeter /non-directional radio beacon: 115 m;

22.11.08 ceilormeter/non-directional radio beacon: 100 m.

At 22:01:25, during the aircraft descent, the controller advised the crew that the flight altitude was too high and informed them of the weather conditions in Sochi: “Armavia 967, you’re still flying too high. Continue descent to 1800 to GUKIN. And

copy current Sochi weather at 00 UTC”; “Runway 06, wind 130 degrees 2 meters per second, visibility 4 kilometres, broken 1800, QFE 762 or 1016 hectopascals, light rain shower, mist, overcast cumulonimbus at height 800 visually, plus 11, dew point plus 11, mountains partly obscured, exit point 5, runway is wet. And at times, for two hours, visibility 1500, mist at 150.”. The observed weather passed on to the crew was above the aerodrome minima. The crew confirmed receipt of the information from the controller and entered all the necessary data into the FMGS.

At 22:02:19 the controller again pointed out to the crew that the flight altitude was still too high to enter the takeoff and landing area: “Armavia 967, copied. Passing TABAN. If able expedite descent or you’ll overshoot the final turn.”, and at 22:03:13 he handed over the aircraft to the controller of the Sochi holding control point: “Armavia 967, magnetic 220, distance 43, contact Radar 119.7.”.

At 22:03:05, at an altitude of 12,660 ft (3,860 m) the crew set the aerodrome pressure.

At 22:03:29 the crew contacted the holding controller: “Sochi Radar, Armavia 967, good evening, descending 1800 to GUKIN, we have information for landing, QFE 1016”. The holding controller cleared them for descent to 600 m, as per the aerodrome pressure 1016 hPa, by the turn to final. At that moment the aircraft was at a distance of about 45 km from the end of RW 06. The crew confirmed the turn to final: “QFE 1016, descending 600 meters, turning final, Armavia 967”.

The aircraft entered the turn to final at 22:03:56. The turn was performed in the HDG mode, with the maximum roll angle up to 24°. At that time, when the aircraft entered the turn, the flight altitude was 10,260 ft (3,120 m), and the indicated airspeed was 280 kt (520 km/h). At 22:04:18 the CVR recorded the Captain’s order: “Put on landing lights.” and 15 seconds later a question from the co-pilot: “*Is this snow or rain? What the \*\*\*\*!*”, which indicated precipitation at this stage of the flight. (Fig. 9, Supplement 2)

During the turn on final the crew set the descent rate at -13 m/s and changed the descent mode from OPEN to VS. The autothrust mode changed as well, from N1 to V/M. The descent rate increased to -10...-12 m/s. At 22:05:04 the FDR recorded a short period (14 seconds), during which the autopilot was disengaged. While turning to final the aircraft overshoot the runway heading, and to eliminate the deviation the crew set heading 90. At 22:05:50 the holding controller informed the crew that they were to the left from the runway heading: “Armavia 967, you’ve appeared left of the landing course, you can turn onto heading 090 to intercept”. The crew responded: “ Armavia 967 we have turned already heading 090. Thanks”.

At 22:06:34, after the aircraft turned to heading 90°, the OPEN DESCENT mode was selected again, with selected altitude 2,048 ft (620 m). At 22:07:02 the crew activated the APPROACH CONTROL mode. In the pitch channel the autopilot switched to the altitude-hold mode with preset altitude 620 m. The autothrust mode changed to the V/M MODE (the speed-hold mode). At that time the crew proceeded to the approach check list.

**Note:** Throughout the entire approach the preset speed values were determined by the FMGS, as the speed was controlled in the MANAGED mode. The autothrust was working in accordance with the established work logic, maintaining speed VS in configuration 1, speed VF in configurations 2 and 3, and speed VAPP in configuration FULL.

At 22:07:35 the controller informed the crew of the weather: “Armavia 967, we’ve been given: cloud base 160 meters, visibility 4000. Proceed at 600 meters without descent”. The crew confirmed: “Without descent 600 meters, Armavia 967”. The information about the deteriorated weather conditions caused a negative overreaction by the crew, with the use of expletives. The crew had been discussing the issue for **three** minutes, swearing about the controller’s actions even between the items of the check list. Such behaviour by the crew inevitably must have resulted in an increase of their psycho-emotional strain.

At 22:07:48 the LOC CAPT (localizer capture) mode was selected, and the aircraft entered a left-hand bank turn with a roll angle up to 22°. At 22:08:14 the mode changed from LOC CAPT to LOC TRACK, which means that the sideward deviation from the RW heading that had developed during the turn on final was eliminated before the glide slope entry point and the aircraft was established on the localizer (Attachment 2 Fig.9). The flight altitude was 600 m, the altitude-hold mode was on, the indicated airspeed was 205 kt (380 km/h), and the autothrust was in the V/M mode (speed-hold mode).

During level flight, at 22:08:31, the Captain decided to extend the flaps: “Let’s *extend* FLAPS 1, \*\*\*\* him”. At 22:08:50 the slats were extended in 18° position. 30 seconds later the high-lift devices were extended further in configuration 2. Extension of the high-lift devices was initiated at the holding-pattern altitude of about 2,100 ft (~600 m), at a distance of ~22 km from the end of RW-06 and at the indicated airspeed of 184 kt (340 km/h).

According to the FDR data, at 22:08:42 the selected speed decreased from 134 kt to 133 kt.

At 22:09:33 the holding controller advised: “RNV 967, contact Tower, 4000 by 190, 121.1”. The reported weather was above the established minima at the landing airport. At 22:09:46 the crew extended the landing gear, and at 22:09:54 autopilot 2 was engaged and after that the flight was performed with the both autopilots engaged (Attachment 2, Fig. 5 and 7).

At 22:09:59 the final controller took over control of the aircraft: “Sochi Tower, Armavia 967, good evening, on final runway 06”; “Good evening, Armavia 967, Sochi Tower, distance 14, on track. Now 13 kilometres, approaching the glide path”. At that moment the aircraft was at the holding-pattern altitude, the indicated airspeed was about 143 kt (265 km/h), flaps in configuration 2, landing gear extended. The flight was performed in the autopilot altitude-hold mode, the LOC TRACK mode was on, and the autothrust was in the V/M mode (Attachment 2, Fig. 4 and 5). The Captain’s and the co-pilot’s weather radar displays were in the W/S AND TURBULENCE mode, and their navigation displays were in the ARC mode, with the Captain’s display scale 20NM and the co-pilot’s display scale 10NM, and the ECAM was displaying the WHEEL page (see Attachment 2, Fig. 6).

*Note: During the continuation of the flight the modes and scales of the above instruments remained unchanged, except for the automatic change of ECAM pages after the engines were set in takeoff mode.*

For the purpose of analysis, the final stage of the flight was split into several segments.

**The segment of automatic descent on the glide slope with two autopilots engaged and the autothrust in the speed-hold mode.**

At 22:10:27 the GLIDESLOPE CAPTURE mode was activated, the altitude-hold mode (ALT MODE) was switched off and the aircraft started approaching the glide slope. 15 seconds later the GLIDESLOPE CAPTURE mode changed to the GLIDESLOPE TRACK mode, which means that the aircraft had captured the glide path. At that moment the aircraft was at a distance of ~11 km from the RW 06 threshold, and its indicated airspeed was 144 kt (267 km/h). At 22:10:46 the crew reported to the controller that they were on the glide slope, with the landing gear extended, and ready for landing. In response they received information on their distance, 10 km, visibility 4000x190, as well as clearance for landing. The aircraft was descending on the glide slope with a mean descent rate of -3...-4 m/s, and the indicated airspeed was about 140 kt (260 km/h) (see Attachment 2, Fig. 5, 7 and 10). According to the available data, at the time of the accident the aircraft weight was 59,000 kg, with centre of gravity at 30%, and the amount of fuel onboard was 6,300 kg, which was within the limitations stipulated in the A320 FCOM.

*Note: In the course of experiments on the engineering simulator in Toulouse it was determined that the trim position of the horizontal stabilizer recorded during the aircraft approach corresponded to a landing weight of 60 tons and centre of gravity of 33%, which is within the precision limits for calculation of these parameters.*

At 22:11:08, at an altitude of 1675 ft (510 m) and an indicated airspeed of 142 kt (263 km/h), flaps extension in configuration 3 was initiated. After extension was completed, at 22:11:11, the CVR recorded a phrase by the co-pilot: "Add a bit, it's almost sitting on the VLS". Five seconds later the selected speed was increased by 4 kt (to 137 kt). At 22:11:21, at an altitude of 1,525 ft (465 m) and an indicated airspeed of 143 kt (264 km/h), they initiated flaps extension to configuration 4 (Full). After the flaps were extended to configuration 4, the aircraft descended on the glide slope in the landing configuration with the localizer and glide-slope beams captured. The speed was controlled by the autothrust. The target speed of 137 kt was equal to the actual speed.

Therefore, the aircraft was stabilized on the glide-slope, in the landing configuration and was completely ready for landing.

At 22:11:25 the crew proceeded to the landing check list (Attachment 2, Fig. 4).

**The segment of the automatic flight from controller's instruction to stop descent to the moment when the autopilot was disengaged.**

At 22:11:40 the controller instructed: "RNV 967, stop descent, cloud 100 meters, turn right, climb 600". The crew confirmed: "Turn right, climb 600, 967". At that moment the aircraft was

at a distance of 7 km from the end of RW 06, the flight altitude was 1,280 ft (390 m), and the indicated airspeed was 139 kt (257 km/h). The thrust control levers were in the CL position (Attachment 2, Fig.2). It should be noted that the controller did not give a direct instruction to the crew to go around.

The standard go-around procedure described in the A320 FCOM provides for the following order of actions:

*-Carry out following three actions simultaneously:*

**- THRUST CONTROL LEVER**

**TOGA (takeoff)**

**COMMAND**

**GO AROUND – FLAPS**

**AIRCRAFT PITCHING**

**CARRY OUT**

• Set aircraft to climb to achieve positive vertical speed and set required yaw as in director command panels

• activate audio indication on FMA: MAN TOGA, SRS, GA TRK

**- MECHANIZATION HANDLE**

**BACK ONE STAGE**

*activate sound for this*

**ACTIVATE SOUND**

**POSITIVE VERTICAL SPEED**

**COMMAND**

**RETRACT LANDING GEAR**

**LEVER TO RETRACT POSITION**

**MOVE**

**ACTIVATE SOUND**

**LANDING GEAR RETRACTED – FLAPS**

*N.B. If TOGA (takeoff) mode is not required - set CL mode*

**mode NAV or HDG**

**DESELECT**

*Reselect NAV or HDG mode as required (minimum height 100 ft).*

*N.B. Go-around can be carried out with two autopilots switched on. When any other mode is selected, the second autopilot is switched off.*

• At throttling height when turning to go around (LVR CLB blinks on FMA)

**THRUST CONTROL LEVER**

*To CL position*

• At acceleration altitude when turning to go around:

*- Make sure the set speed is increased to the green dot (GREEN DOT);*

• If not:

**FCU ALT**

**CHECK AND TIGHTEN**

*- retract flaps under standard procedure*



### **TURNING TO GO AROUND FROM INTERMEDIATE APPROACH ALTITUDE**

*To interrupt an approach or to turn to second course from intermediate approach altitude, and if TOGA is not required, follow this procedure:*

*- **MOVE THRUST CONTROL LEVERS** to TOGA stop and then throttle back as necessary*

*This enables the turn to go around mode to be activated along with the associated autopilot and director modes.*

***SELECT** required modes for **AUTOPILOT/DIRECTOR AND AUTOMATIC THRUST** on FCU*

*Further on, this section contains a warning about the possibility of reducing speed below VLS when interrupting fulfilment of a landing approach on autopilot and automatic throttle, if modes V/S or OP CLB are subsequently switched on.*

The go-around procedure for RW 06 in Sochi airport provides for a coupled right-hand climbing turn at heading 240° in the take-off configuration, with the roll angle at least 20 degrees and at a speed not exceeding 200 kt, with climb to 600 m (2,060 ft) at the maximum possible vertical speed.

After the controller's instruction, at 22:11:48:5, the PTLO (PUSH TO LEVEL OFF) button was pushed to bring the aircraft to level flight immediately. As a result, the autopilot pitch mode changed to the VS MODE (the preset vertical speed was 0 m/s). The pitch angle increased to 6°. Autopilot 2 disengaged automatically, since two autopilots can work simultaneously only during approach. An audible signal advised the crew of the aircraft's capability of performing ICAO Category 2 and 3 approaches as downgraded (ILS CAPABILITY DOWNGRADE). The autopilot lateral-directional mode automatically changed to HDG, with the preset heading equal to the current aircraft heading of 62°.

At the same time as the VS MODE was activated, the pedals were moved to the -1.4° position (the minimum pedal force required to move the pedals from the neutral position is ~10 kg). It should be noted that the A320 does not require the use of the pedals in a normal flight. During a turn the aircraft co-ordinates its movements automatically.

At 22:11:52 a heading of 172° was set with the use of the selector on FCU. As a result, the aircraft entered a turn to the right with a roll angle up to 25°, maintaining an altitude of 1,114 ft (340 m). During the turn the rudder moved to the 2.3° position, i.e. against the pedal travel direction, and the lateral G was 0.05.

***Note:** In the course of experiments on the simulator undertaken in Toulouse, it was determined that when the aircraft is in landing configuration, the turn coordination function works with rather significant errors. The Airbus representatives admitted this and explained that this aircraft type was not intended for manoeuvring with high bank angles in the landing configuration.*

At 22:11:53 the controller repeated his instruction to go around: “RNV 967, turn right, climb 600, contact Radar 119.7”. The crew confirmed: “Turn right, climb 600, 119.7, 967”. At that moment the aircraft was at a distance of 5.8 km from the RW 06 threshold (Attachment 2, Fig. 4 and 10).

At 22:11:57 on the control panel the altitude was selected to be 3,200 ft (975 m), and after that the OPEN CLIMB mode was activated, with the thrust control levers in the CL position, flaps and slats fully extended, the landing gear extended, the autothrust in the V/M mode, and the preset speed at 137 kt. It should be noted that previously the preset altitude was 2,048 ft (600 m), which corresponded to the go-around altitude. Apparently, the crew unintentionally increased the preset altitude during the process of mode activation. However, this fundamentally influenced the flight, due to specific features of activation of the OPEN CLIMB mode due to a variety of differences between the target and current flight altitudes. The integration of the aircraft pitch control and engine thrust control, as well as the logical sequence of the OPEN CLB mode are described below.

\*\*\*

### **The logic of integration of the autopilot/flight director (AP/FD) pitch control and the autothrust control**

- . If AP/FD pitch mode controls a vertical trajectory (e.g. V/S, ALT), then AT controls speed.
- . If AP/FD pitch mode controls a speed (e.g. OP CLB), then AT controls thrust.
- . If no AP/FD pitch mode is engaged, then AT controls speed.

### **Logic sequence of the OPEN CLB mode**

- . for level change more than 1200 ft:
  - . at OPEN CLB mode engagement by the pilot, V/S control with V/S target = + 8000 ft/min (40 m/s) is applied for AP/FD, and SPEED/MACH mode is engaged for AT
  - . when engine N1 reaches 95% N1CLB mode, AP/FD switches to SPEED/MACH control law, whereas AT switches to the THRUST mode
  - . Throughout this time the FMA displays THR CLB for AT and OP CLB for AP/FD

The given scheme of engagement for the OPEN CLB mode ensures the uniformity of the aircraft response in all configurations and within the whole range of the flight altitudes and speeds.

- . For level change less than 1200 ft:
  - . at OPEN CLB mode engagement by the pilot, V/S control with V/S target = + 1000 ft/min (5 m/s) is applied for AP/FD, and SPEED/MACH mode is engaged for AT
  - . Throughout this time FMA displays THR CLB for AT and OP CLB for AP/FD

In this case the climb is in fact performed in the vertical speed control mode.

\*\*\*

It should also be noted that if the OPEN CLB mode is engaged less than 30 seconds after the aircraft level off function is activated, the autopilot is authorized to

use the vertical acceleration at the maximum value of 0.3g, whereas usually it is only 0.15g.

In the automatic flight, when the OPEN CLIMB mode was engaged, the aircraft started climbing rapidly, at a vertical speed up to 12 m/s, with pitch angle increased to 21° by 22:12:06, maximum vertical acceleration 1.27g, maximum angle of attack 10.7°, and the indicated airspeed reduced to 129 kt (240 km/h), which is 8 kt lower than the target speed. Engine r.p.m. were increased to the maximum possible value for the given position of the thrust control levers (Attachment 2, Fig.4).

At 22:12:04 the aural warning «SPEED, SPEED, SPEED» (LOW ENERGY WARNING) was recorded. This warning advises the crew that “the aircraft energy is decreasing to the limit, below which the engine thrust must be increased to regain a positive angle on the flight path”. At the moment when the aural warning sounded, the aircraft altitude was 1,150 ft (350 m). The correct crew response to this warning would be to increase engine thrust. These actions are described in QRH Section “ABNORMAL PROCEDURE”.

It should be noted that at the same time as the warning sounded, the engines switched to the CLIMB mode, and, in accordance with the logic described above, the autopilot switched to the speed-hold mode in the pitch channel and deflected the elevator in a nose-down direction, in order to decrease the climb rate and to increase speed.

After the warning sounded, the thrust control levers were set in the TOGA position, therefore the crew response was fully in accordance with the QRH recommendations. The control input on the thrust control levers resulted in activation of the go-around modes (PITCH GO and ROLL GO), the autothrust was deactivated (AT engaged, but not active), and the ECAM page changed from WHEEL to ENGINE (Attachment 2, Fig. 4, 5 and 6). At 22:12:06:5 disengagement of autopilot 1 was recorded, and the rest of the flight was performed in director mode, with the Captain’s and co-pilot’s flight directors engaged. Judging from the single annunciation of the autopilot disengagement, the autopilot was disengaged normally, with the push-button on the side stick. At the moment when the autopilot was disengaged, the flight altitude was 1232 ft (370 m), indicated airspeed 130 kt (240 km/h), roll angle +25°, pitch angle +21°, angle of attack 10.2°, and the rate of climb about 11 m/s.

Analysis of the given flight segment shows that the crew carried out the controller’s instruction literally, meaning that they stopped descent and started performing a right-hand turn and then climb. Not a single action of those required in the go-around procedure (setting takeoff power, flaps retraction from the landing configuration, landing gear retraction) was performed by the crew. This fact shows that the crew’s work was far from optimal, and that they were unable to evaluate the current situation adequately. It can also be suggested that the aircraft behaviour while manoeuvring and activation of the LOW ENERGY WARNING were unexpected for the crew. Most probably, the autopilot was disengaged intentionally, because of doubts about whether it was functioning correctly.

Simulation of the given segment of the automatic flight on the engineering simulator, which fully reproduces the control laws and indications of the accident aircraft, showed perfect convergence of the results. During the manoeuvre the autopilot worked in accordance with the established logic. Based on the FDR readout and the results of mathematical simulation, it was determined that there was no external influence on the aircraft. It should be noted that the A320 FCOM does not describe this mode (climbing turn in the landing configuration).

In the course of experiments on the simulator the following was also established:

- Provided that the FCOM procedures are followed, the aircraft performs the go-around manoeuvre with no difficulties, with a maximum pitch angle of 15-16°, the aircraft speed not less than  $V_{APP}$ , and the LOW ENERGY WARNING «SPEED SPEED SPEED» not sounding. In the case where the autopilot is disengaged during go-around, the procedure can still be completed safely and does not induce any specific stress on the pilot, provided that he follows the command bars.

- In the case where the pilot moves the thrust control levers to the TOGA position at the beginning of the manoeuvre (after the OPEN CLIMB mode is engaged, with a pitch angle of +5°...+10°), in FULL configuration, with the landing gear extended, then the aircraft in fact performs a standard go-around manoeuvre, with  $\theta_{max} = 16-17^\circ$  and no decrease in speed. This, therefore proves the correctness of the FCOM recommendations provided in the GO AROUND and MISSED APPROACH procedures, which require setting the thrust control lever in the TOGA position first. This action ensures a safe go-around manoeuvre, even with the landing gear extended or if the aircraft configuration is not changed by one step.

- In case the autopilot remains engaged, while the aircraft is performing a manoeuvre similar to that in the accident flight, the autopilot normally completes the go-around procedure, with the maximum pitch angle not exceeding 21.5°, the short-time decrease of speed not exceeding 10-12 kt, with activation of the «SPEED SPEED SPEED» warning, and without activation of the  $\alpha - FLOOR$  function.

**The flight segment from the moment when the autopilot was disengaged to the moment, when right-and-forward control input on the Captain's side stick was recorded after the segment of stabilized turn**

For the purpose of analysis of the this and the next segments, it should be noted that the crew was probably in a state of psycho-emotional strain caused by a combination of the following factors:

- The necessity to carry out the go-around procedure, which is quite rarely encountered in actual flight conditions;
- The night flight and the lack-of-sleep state of the crew (at least, of the co-pilot);
- The unstable weather conditions at the destination airport during the whole flight and the crew being uncertain that they would land there in Sochi;
- The unexpected aircraft behaviour during automatic flight on the segment described above.

The change in the crew's intonation during their further conversations indicates that their stress levels were increasing.

After the autopilot was disengaged, the Captain made a control input on the side stick forward to 9.7° (the maximum deflection angle is 16°), which resulted in decrease of the pitch angle to +4° (while the angle of attack decreased to 2.2°...2.7°), and sideward to 17° (the maximum deflection angle is 20°), which decreased the aircraft roll angle to 7°...8°. At the same time the indicated airspeed increased to 140 kt (260 km/h), and the rate of climb decreased to 1...2 m/s. At the same time as the autopilot was disengaged, a short input on the pedals was recorded. As a result, they moved to a -2.3° position and then came back close to the neutral position. At 22:12:19 the side stick was moved to a position of -9° (increasing the right bank) and then returned to the neutral position (Attachment 2, Fig. 4, 7 and 8). As a result, the aircraft was stabilized on a right-hand turn with a roll angle of about 20° (which corresponds to the minimum roll angle in the go-around

procedure) and a rate of climb of 2-3 m/s (the pitch angle of 2.5-3.5°). Experiments on the simulator showed that the pitch command bar on the pilots' PFD was considerably above the aircraft symbol and set a desirable pitch up attitude of about 8°. The FDR readout shows that side sticks of the both pilots were fully released for 7-8 seconds, and the right pedal was pushed forward a bit (the pedal force was at least 10-11 kg). As previously mentioned, the aircraft type in question does not require pedal inputs to coordinate a turn. The continuous force applied to the pedals, while the side sticks were released, may be a sign that the crew's mental state was far from optimal.

*Note: It could not be determined, based on the FDR readout, which of the pilots made the pedal inputs. Presumably, it was the Captain who acted on the pedals, as he was pilot flying the aircraft at this stage of flight.*

*Based on the character of the pedal inputs during the whole abnormal event, it could be suggested that the Captain's actions were inadequate. The forces applied to the right pedal were at least 12-15 kg. In a normal situation they could not remain unnoticed by the pilot. During development of the abnormal situation there was no necessity to deflect the rudder, therefore it could be suggested that the pedal inputs were uncontrolled (the Captain perhaps did not even realize the considerable forces applied to the right pedal) and might have been caused by transfer of his knowledge of flying another previous aircraft type, while under stress.*

Starting from 22:12:20, by means of the selector on the control panel, the preset altitude of 3,200 ft (975 m) was gradually (in 5 sec) decreased to 2,048 ft (620 m). This crew action was accompanied by intensive discussions for 10 seconds, which shows that the crew knew the altitude that should be reached. However, since the autopilot was disengaged, the aircraft could not climb to the given altitude automatically. The change of the preset altitude resulted in the fact that the pitch command bar on the PDF came down, and now the required pitch angle was about 4°. The command bar coming down could have produced the illusion for the crew of pitching up.

At 22:12:24, during the change of the preset altitude, the thrust control levers were moved from TOGA position first to the FLX position and then to the CL position. The altitude at which these inputs were made corresponded to the default value of thrust reduction altitude (1500 ft + 40 ft aerodrome elevation). Therefore, it may be suggested that the crew was monitoring the activated flashing light LVR CLB on the FMA. Most probably, in this case the thrust reduction altitude coincided with the acceleration altitude, which resulted in automatic engagement of the OPEN CLIMB mode and the target speed change to the GREEN DOT (202 kt). After the engines were set in the CL mode, the autothrust was activated in the N1 mode (ensuring the maximum thrust for CL throttle levers position) (Attachment 2, Fig.4 and 5). By the time the engine thrust was decreased, the side sticks were in the neutral position, the pedals were in 1.30...-1.70 position, the aircraft altitude was 1,576 ft (480 m), and the indicated airspeed had increased to 163 kt (303 km/h). The aircraft was performing a right-hand turn, with a constant roll angle of about 20°, and

a pitch angle stabilized at +3°. The vertical climb rate was 2...3 m/s (Attachment 2, Fig. 4, 5 and 10).

At 22:12:28 the controller repeated to the crew: “Arm, Armavia 967, contact Radar 119.7”. The crew confirmed: “967, roger”.

At 22:12:30 a short control input on the side stick forward to 5.2° was recorded, and 3 seconds later – a control input sideways -9.3°. These Captain’s actions resulted in a decrease of pitch to 1.4° and an increase of roll angle to 30°. At 22:12:34 the Captain started moving the side stick forward and thereby pushed the aircraft nose down. The actual reason for such actions by the Captain could not be determined. However, it can be stated that such inadequate piloting was caused by a lack of monitoring of flight parameters, in particular pitch and roll angles.

In the course of the investigation the commission considered the following probable causes of such piloting, though neither of them could be fully substantiated:

- Influence of somatogravic illusions, in particular the illusion of pitching up experienced by the pilot flying, with a lack of monitoring of the flight indicators and longitudinal acceleration of the aircraft, at night, with no visible references. This interpretation is substantiated by the inadequate actions of the Captain that were recorded at the moment when the aircraft deviation from the runway heading was more than 90 degrees. That means that the shore and the ground lights that could be seen through the broken clouds disappeared at that moment, although aircraft acceleration continued. On the other hand, there is evidence that shows that the Captain monitored the PFD and read it correctly, at least the speed and FMA indication.

- Specific features of speed indication on the PFD, especially speed limitations for the given aircraft configuration that are shown as the red bars at the top of the speed indication strip. One may imagine the influence of the reflex acquired in training, for example, in response to a TCAS warning when the pilot is anxious to avoid the displayed red part of the instrument scale, which may result in the instinctive forward movement of the side stick, especially when the pilot is in a state of psycho-emotional strain. This version is substantiated by the fact that the pilot was monitoring the flight speed and its limitations (VFE) that depended on the aircraft configuration and retracted the high-lift devices in a timely manner, and the control inputs on the side stick coincided with the moments when the current speed was getting close to the limit value.

At 22:12:36 the last crew communication with the ground was recorded: “Sochi Radar, Armavia 967...”. The phrase was not completed, since the Captain ordered the co-pilot, who was communicating with the controller, to retract the flaps.

### **Segment where the aircraft started its final descent**

The maximum altitude attained by the aircraft during the go-around manoeuvre was 510 m (Attachment 2, Fig. 4).

The Captain’s actions described above resulted in a decrease of the pitch angle, the onset of descent and continued acceleration at maximum continuous power. If the crew, who did not follow the FD indications anyway, had switched off the FDs in accordance with the FCOM recommendations, the autothrust would have switched to the speed-hold mode with the preset speed 202 kt (GREEN DOT SPEED).

The table below provides the maximum allowable speed values for various configurations.

Configuration	Slats/Flaps		VFE (kt)
1	18/0	230	Intermediate approach, take-off
	18/10	215	
2	22/15	200	Take-off and approach
3	22/20	185	Take-off, approach and landing
FULL	27/35	177	Landing

By 22:12:37 the indicated airspeed reached the VFE value established for the FULL configuration. At that moment the Captain ordered flap retraction, and the wing high-lift devices started retracting from the FULL configuration to configuration 2 at once. During retraction, at 22:12:41 activation of the MASTER WARNING accompanied with the aural CRC warning was recorded, which means that the maximum allowable flight speed for the given aircraft configuration had been exceeded. This warning continued on all the time until the end of the flight, except for some short breaks. At this time the flight altitude had decreased to 1,626 ft (495 m), the indicated airspeed increased to 186 kt (344 km/h), the aircraft pitch angle was  $-5^\circ$  (nose down), with roll angle  $+33.5^\circ$ .

At 22:12:45 the high-lift devices were retracted further to configuration 1. Though configuration 1F provides for flaps extension to  $10^\circ$ , the flaps were fully retracted automatically, as the flight speed 210 kt was exceeded. At this moment the Captain made a control input on the side stick forward to  $11^\circ$ , which resulted in further increase in the nose-down pitch, the descent rate and the indicated airspeed. A control input on the side stick that resulted in an increase in right bank was also recorded. Simultaneously with the control inputs on the side stick, the pedals were moved to a position of  $-3.4^\circ \dots -4^\circ$ , and the lateral G went up 0.02...0.04.

At 22:12:47 the GPWS Alarm sounded, and at the same time the co-pilot's phrase: "*Level off*" was recorded. Altitude decreased to 1358 ft (414 m), the indicated airspeed increased to 211 kt (392 km/h), the pitch angle decreased to  $11 \dots 12^\circ$  nose down, and the roll angle increased to  $37 \dots 39^\circ$ . The aircraft descent rate was  $-20 \dots -22$  m/s. At this moment the co-pilot intervened and moved the side stick to the left stop position ( $20^\circ$ ) to counter the increasing right bank, while the Captain continued making control inputs to increase the right bank. Apparently the co-pilot was trying to counter the bank only. However, while moving the side stick sideways to the stop position, he had made forward control inputs on it as well (a "parasitic" input produced by high sideward forces applied to the side stick in the stop position) (Attachment 2, Fig. 4,7 and 8). While intervening, the co-pilot had not pressed the take-over pushbutton, therefore both pilots' control inputs were added and averaged. Such dual piloting is prohibited by the A320 FCOM. At that time the actions of the two pilots were not coordinated. The Captain twice moved the side stick half-way backwards, possibly, reacting to the EGPWS, but at the same time the co-pilot was inadvertently making nose-down inputs, which might have led the Captain to believe that the aircraft response to the control inputs in the pitch channel was not adequate.

*Note: During the onset and development of the abnormal situation the co-pilot did not comply with the duties of non-flying pilot during a go-around phase as stipulated in the FCOM. In particular, he did not inform the Captain of the pitch angle values below 10 degrees pitch up and of the descent rate, when it developed.*

*Note: The DUAL INPUT warning was not activated because of its lower priority compared to the EGPWS warning.*

*Note: As was shown by outcomes of experiments on the flight simulators and by the results of mathematical simulations provided by Airbus specialists, after autopilot disengagement and change-over to manual control, aircraft movement was entirely determined by deflection of the control surfaces and the engine modes. Aerodynamic and thrust performance of the aircraft corresponded to the characteristics of the aircraft type. There were no external influences on the aircraft (wind shear, etc.)*

The backward movement of the Captain's side stick to  $-11^\circ$  was accompanied by its sideways movement to the right to  $-16^\circ$ . At the same time the pedals were moved to  $-4.8^\circ$ , and the lateral G went up 0.1...0.11.

Neither of the pilots fully fulfilled the FCOM requirements for crew actions in case of EGPWS activation stipulated in the QRH "EMERGENCY PROCEDURE" Section. Flying at night or in difficult weather conditions requires an immediate response to this warning, in particular to move the side stick backward and hold it in this position, as well as to set the take-off power mode. The crew's attention might also have been distracted by a long 20-second message from the controller regarding a change in the approach procedure, which was recorded by the CVR along with the EGPWS and CRC warnings sounding in the background. The controller sent the message in accordance with the controller's operational manual, after the crew contacted him.

It should be noted that in the course of the investigation of the accident to the A320 A40-EK that occurred during go-around at Bahrain airport on 23 August 2000, the Investigation Commission also noted inadequate actions by the Captain, who moved the side stick forward and held it there, despite the EGPWS warning sounding for a long time. In that case the crew response to the CRC warning that was sounding at the same time was also correct (flaps retraction).

At 22:12:49 the preset vertical speed became equal to 25.4 m/s. The change in the preset value was connected with automatic activation of the VS MODE, with the autothrust switched to the speed-hold mode. In the case where the autopilot is disengaged, the manual control disagrees with the command bars and the aircraft speed reaches the VFE value plus 4 kt, the mode is changed automatically in order to prevent



exceeding the speed limitations and stabilize the speed by means of a thrust reduction, while maintaining the flight path (FCOM 1.22.30). However, at 22:12:51:5 one of the pilots abruptly moved the thrust control levers to the idle position and then moved them back, which resulted in disengagement of the autothrust (Attachment 1, Fig. 4). At that time the aircraft descent rate became -28...-30 m/s, and the flight altitude decreased to 933 ft (284 m). At 22:13:01 the FDR recorded retraction of the high-lift devices to zero configuration (slats retracted). By then the pedals were in -7.2...-5.5 position, and the lateral G increased to 0.18...0.25. The combined control actions of the Captain and the co-pilot resulted in decrease of the roll angle almost to zero, insignificant increase of the pitch angle to -6°...-7° and decrease of the descent rate to -22 m/s.

Despite the actions undertaken by both pilots at the last seconds of flight to deflect the elevator to the nose-up position, at 22:13:03 the aircraft impacted the water at an indicated airspeed of 285 kt (528 km/h), a vertical speed of about -22 m/s, a pitch angle of -4°...-5° nose down and a roll angle of 9°...10° to the right. At the moment of the impact the flaps were retracted, the slats were in a position of about 18° retracted, and the landing gear was extended.

The experiments on the simulator showed that the aircraft could have been recovered at any stage of the flight until 22:12:58, provided the crew acted properly. The simulator experiment allowed data to be obtained regarding the decrease in altitude during recovery of the aircraft in a configuration 18/0 at V =260-270kt, with pitch angles -4,5...-6,5° and various roll angles from 0 to 39°, and with the side stick in various back positions, including the fully back position. For the parameters similar to those in the accident flight (V=270kt, pitch angle -5,3°, roll angle about zero), the minimum altitude, at which the aircraft could be recovered and controlled to climb, was 200-230 ft. Allowing 2 seconds for the crew response to the EGPWS warning, the crew had 9 seconds spare to recover the aircraft.

## **Findings**

1. The A-320 EK-32009 aircraft was owned by the FUNNEL company (Cayman Islands) and was operated by Armavia. The aircraft had valid registration and airworthiness certificates issued by the Aviation Administration of the Republic of Armenia.

2. Aircraft maintenance was carried out by Sabena Technics (Belgium) specialists in accordance with the agreement with Armavia. Additional work was carried out by Armavia maintenance personnel. No deficiencies in the maintenance service were revealed that could have influenced the outcome of the last flight.

3. The aircraft, its systems and engines were serviceable on departure from Yerevan. The Investigation Commission did not bring to light any evidence of any aircraft system or engine failure during the last flight.

4. The aircraft's movements were completely determined by changes in the control surfaces and the engine modes. The autopilot was working according to the established work logic. Aerodynamic and thrust performance of the aircraft corresponded to the characteristics of the aircraft type. There were no external influences on the aircraft (wind shear, etc.).

5. The aircraft had a sufficient amount of the correct fuel for safe completion of the flight. The take-off, landing weight and balance of the aircraft did not exceed the limitations specified in the A320 FCOM.

6. There was no disintegration of the aircraft in the air. All aircraft structural damage resulted from the impact with the water.

7. The crew had valid pilot's licenses and medical certificates. Their qualifications and state of health corresponded to the character of the mission performed and allowed safe execution of the flight. According to the documents presented, the professional skill level of the flight crew members was in accordance with Armenian CAA regulations.

8. Armavia does not exercise operational supervision of the A320 aircraft crews' flights by using flight recorder information, which made it impossible to fully evaluate the professional skill level of the flight crew members.

9. According to the data presented, the pre-flight rest of the crew prior to the departure to the Sochi airport consisted of over 24 hours at home. However, the crew's cockpit conversations indicated their fatigue, which could have influenced the outcome of the flight. The flight was performed at night, when the probability of mistakes is especially high.

10. The meteorological and air navigation support for the flight met the requirements of the existing regulatory documents. Air traffic control service personnel, including personnel from the areas of responsibility in Sochi, Yerevan, Tbilisi and Rostov, had valid licenses as civil aviation specialists with the required ratings.

11. At the time of the accident the meteorological conditions were complicated and did not correspond to the meteorological minima of the runway 06 of the Sochi airport due to the «cloud ceiling» parameter. In the time before the accident, the weather conditions at Sochi airport were unstable. The crew was informed of the weather changes by the air traffic controller in a timely manner. Inaccuracies committed by the air traffic controller while reporting the weather were not directly connected with the cause of the aircraft accident, but they influenced the initial decision of the crew to return to the departure aerodrome .

12. The emotional reaction of the crew to the air traffic controller's information about the actual weather changes below the established meteorological minima was negative and could have led to an increase in the psycho-emotional strain of the crew members during the final stage of flight.

13. The approach for a landing on runway 06 was made with the use of ILS in an automatic mode. There was no deviation of the aircraft from the established glide slope profile. All the radio navigation aids at Sochi airport were fully serviceable.

14. The tower controller's instruction to abort the descent and perform a right-hand climbing turn to 600 m that was given to the crew after the cloud ceiling decreased below the established minima for RW 06, did not fully comply with the provisions of the controller's operational manual, though it did not directly influence the outcome of the flight. According to the AIP of Russia the controller had a right to refuse the landing. It should be noted that a number of AIP items contradict each other and are ambiguous.

15. According to the Armavia Operations Manual, the crew must initiate the go-around manoeuvre on receiving weather information below the minima, even if the reliable visual contact is established with the runway or with landmarks.

16. At the beginning of the aborted-approach manoeuvre the crew did not comply with the standard go-around procedure stipulated by the FCOM, regarding applying takeoff thrust, retracting flaps by one step and retracting landing gear. The climb in the OPEN CLIMB mode and the right-hand turn in the HDG mode were carried out under autopilot control in the landing configuration with the autothrust working in the speed-hold mode. The landing gear was extended until the end of the flight. The mode in question is not described in the A320 AFM.

17. During flight under autopilot control, the LOW ENERGY WARNING signal was activated. The crew had properly reacted to this warning by setting the thrust levers in the takeoff position in full compliance with the AFM. It must be noted that the crew actions on activation of this warning are specified in the ABNORMAL PROCEDURE section of the A320 QRH.

18. Simultaneously with an increase in engine power the crew (the Captain) switched off the autopilot in the normal manner using the take-over pushbutton on the side stick. Most probably, the cause of the autopilot disengagement was the fact that the aircraft dynamics and attitude during this manoeuvre were unexpected by the Captain: pitch angle +21°, roll angle +25°, decrease in speed, the activated «SPEED SPEED SPEED», warning as well as the fact that he could not predict further changes in these parameters. Throughout the rest of the flight the airplane was controlled manually, with the both FDs switched on.

19. After disengagement of the autopilot the Captain was pilot flying. His actions, originally, led to the plane making a stabilized turn to the right with a roll of about 20 degrees, climbing at a rate of 2-3 m/s and accelerating. The stabilized turn proceeded until the magnetic heading attained the value differing from the runway heading by 90 degrees. Subsequently the Captain controlled the plane to descend with a pitch angle up to 12 degrees pitch down and a roll angle up to 40 degrees to the right, which at maximum continuous power resulted in a substantial increase in IAS and the vertical rate of descent, as well as in activation of EGPWS and CRC warnings (excessive speed in flight with high-lift devices extended). The actual reason of such actions by the Captain could not be determined. Probably, such inadequate piloting was caused by the lack of monitoring of such flight parameters as pitch, altitude and roll, at night in difficult weather conditions with a background of fatigue and psycho-emotional stress.

20. After the activation of the EGPWS warning, both pilots made control inputs simultaneously. The take-over button was not pressed by either of the pilots. The control inputs by the Captain and the co-pilot, both in roll and pitch were not coordinated and made in opposite directions. The DUAL INPUT warning was not activated because of its lower priority compared to the EGPWS warning. Before the airplane collided with the water the crew had almost completed retraction of the wing high-lift devices in several steps (the slats were still moving). Neither of the pilots was monitoring the aircraft descent parameters or fulfilled the FCOM requirements for crew actions after EGPWS warning activation, which are stated in the "EMERGENCY PROCEDURE" Section of the A320 QRH.

The crew's attention might have been distracted by a long 20-second controller's message regarding a change in the approach procedure, which was recorded by the CVR along with the EGPWS and CRC warnings that were sounding in the background. The controller issued the message in accordance with the controller's operational manual, after the crew contacted him.

21. Experiments on the simulators showed:

- Provided that the standard «GO AROUND» and «MISSED APP» procedures prescribed by the FCOM are followed, the aircraft performs the go-around manoeuvre with no difficulties, in both the automatic and director modes.

- In the case where the autopilot remains engaged, while the aircraft is performing a manoeuvre similar to that in the accident flight, the autopilot normally completes the go-around procedure, with a maximum pitch angle not exceeding 21.5°, the short-time decrease of speed not exceeding 10-12 kt, with activation of the «SPEED SPEED SPEED» warning, and without activation of the  $\alpha$  – FLOOR function.

- If after activation of the «PULL UP» warning the FCOM recommendations are implemented, for the parameters similar to those in the accident flight (indicated airspeed 270...280 kt, pitch angle -5.5°...-6.5°, roll angle about zero and the wing high-lift devices in the 18°/0° position), the decrease in altitude during aircraft recovery from descent is about 200...230 ft.

### **3. Conclusion**

The fatal crash of the “Armavia” A-320 EK-32009 was a CFIT accident that happened due to collision with the water while carrying-out a climbing manoeuvre after an aborted approach to Sochi airport at night with weather conditions below the established minima for runway 06.

While performing the climb with the autopilot disengaged, the Captain, being in a psycho-emotional stress condition, made nose down control inputs due to the loss of pitch and roll awareness. This started the abnormal situation.

Subsequently the Captain's inputs in the pitch channel were insufficient to prevent development of the abnormal situation into the catastrophic one.

Along with the inadequate control inputs of the Captain, the contributing factors to development of the abnormal situation into the catastrophic one were also the lack of necessary monitoring of the aircraft descent parameters (pitch attitude, altitude, vertical speed) by the co-pilot and the absence of proper reaction by the crew to the EGPWS warning.

### **4. Shortcomings found during investigation**

4.1. During descent and approach the crew constantly had irrelevant conversations that had nothing to do with the crew operations manual, and therefore violated the requirements of ROLRGA RA-2000, Section 8.3.4.

4.2. The A320 FCTM, which was approved by the Civil Aviation Administration of the Republic of Armenia and according to which Captain G.S. Grigoryan passed his training before starting solo flights with the airline, does not contain the requirement for passing the Upgrade to Captain programme. Captain G.S. Grigoryan did not pass this training. This training programme was made mandatory in the next revision of the FCTM.

4.3. The Flight Operations Department of Armavia does not comply with the provisions of ROLRGA RA Section 11.2 and ICAO Annex 6 Part 1 Chapter 3, which require airlines to analyze

fight operations with the use of the FDR and CVR recordings for aircraft with the certified MTOW exceeding 27 000 kg.

4.4. In violation of ROLRGA RA-2000 Sections 4.5.33 and 6.1.5, Armavia airline does not keep records on the approaches and landings in complicated weather conditions performed by their Captains.

4.5. The following deficiencies were identified in air traffic management:

- At 21:16 the approach controller of the Sochi aerodrome advised the crew of the trend weather forecast for landing as 150 by 1500 and did not identify the trend as "AT TIMES". This inaccuracy committed by the controller while reporting the weather to the crew was not directly connected with the cause of the aircraft accident, but it influenced the initial decision of the crew to return to the departure aerodrome.

- At 22:01:37 the approach controller advised the crew of the observed weather at Sochi aerodrome as at 22:00 and by mistake said the cloud ceiling was "considerable 1800", instead of 180 m, however this did not influence the Captain's decision.

- At 22:03:29 the crew did not report, and the holding controller did not request the crew to report the selected system and mode of approach, which does not meet the requirements of the Holding Controller's Operation Manual, Section 4, item 4.2.1, of Sochi aerodrome.

- At 22:11:38 the final controller at Sochi aerodrome was informed by the weather observer on the actual weather at Sochi aerodrome with the cloud ceiling at 100 m, which was below the established minima (cloud ceiling 170 m, visibility 2500 m). Based on this information, the final controller instructed the crew: "Abort descent, clouds at 100 m, right-hand climbing turn to 600 meters". The controller's actions did not comply with the requirements of the Civil Flight Operations Guidance 85 Section 6.5.16 and the Final Controller's Operation Manual, items 4.3 and 4.3.1.

However, according to the AIP of Russia the controller had a right to forbid the landing. It should be noted that a number of AIP items contradict each other and are ambiguous.

4.6. Meteorological support:

- The weather forecast for the Sochi aerodrome for the period from 18:00 to 03:00 was not verified with regard to visibility in the "At times" group;

- In violation of the Guidance for Meteorological Support in Civil Aviation 95, Sections 4.3.1 and 4.4.1 d) and the Instruction for meteorological support at Sochi aerodrome, the observer did not complete the special weather report at 22:11, when the cloud ceiling descended to 100 m, i.e. to a value stipulated in Annex 8 of the Criteria For Issuance of a Special Weather Report;

- The recommendation for ATIS broadcast content stipulated in the joint Order No. 62/41 "On approval and implementation of Instruction for ATIS broadcast content in English and Russian languages" of 20.03.2000 issued by the Federal Air Transport Administration and Hydrometeorology and Environment Monitoring Service was not entirely fulfilled.

4.7. A320 aircraft:

- In course of reading out the FDR data, a number of discrepancies were found in the documentation describing the logic of binary signal recordings;

- While performing manoeuvres in the landing configuration with the autopilot and autothrust engaged, the LOW ENERGY WARNING may sound, which Airbus considers as an abnormal situation.

## **5. SAFETY RECOMMENDATIONS**

### 5.1 To aviation administrations of the CIS countries:

- To conduct briefings with the flight crews, controllers and technical and engineering personnel to review the circumstances and the causes of the accident.
- To ensure fulfilment of the requirements of ICAO Annex 6 Part 1 Chapter 3 for mandatory analysis of performed flight operations based on the CVR and FDR recordings for the aircraft with a certified MTOW exceeding 27000 kg.
- To draw the attention of A320 crews to the necessity of immediate response to activation of the EGPWS warning (even if other warnings are on at the same time) in the case of instrument flight, or flight in difficult weather conditions, or flight in the mountains. To introduce the relevant exercises in the simulator training programmes to practice these actions. To consider the advisability of extending these recommendations to other aircraft types.
- To review the necessity of enhancing crew simulator training in the section on flying in Flight Director mode, especially during approach and go-around.
- To bring the content of the AIP, as well as the ATC controllers' job descriptions and operations manuals, into compliance with the standards and practices recommended by ICAO, with regard to clearance for approach and landing.

### 5.2 To aviation administrations of CIS countries jointly with the industrial and scientific and research organizations:

- To organize and conduct research into the conditions under which a crew may lose spatial orientation and/or upset aircraft attitude may develop, and to issue practical recommendations to enhance flight safety. In particular, to evaluate the effect of in-flight acceleration illusions. Based on the research, to develop and introduce a specialized course for recurrent training of crews that should contain both classroom and flying training.

### 5.3 To the Civil Aviation Administration of the Republic of Armenia and Armavia airline administration:

- To include in the A320 FCTM the mandatory requirement for trainee Captains to pass the Upgrade to Captain programme.
- To keep records on approaches performed in difficult weather conditions by A320 crews, in accordance with the regulatory documents relating to the organization of flight operations in civil aviation of the Republic of Armenia.
- To organize FDR and CVR readouts for analysis of A320 flight operations, in order to reveal any errors and deficiencies in crews' piloting technique, and to develop measures for their prevention.
- To point out to aircraft crews that irrelevant conversations in the cockpit, especially during the climb and descent phases, are prohibited.

- To consider the necessity of enhanced simulator training for A320 crews.
- To develop a procedure for storage of A320 operational documentation that would regulate the conditions of keeping the originals and copies of the documents by both Sabena Technics and Armavia airline.

5.4. To the Federal Air Navigation Service of the Russian Federation:

- To review the possibility of updating of AIP of the RF and other regulatory documents for the purpose of unification of ATC procedures for issuing instructions for go-arounds to aircraft operated by domestic and foreign airlines, and to incorporate the relevant amendments into the Rules and Phraseology for In-flight Radio Communications and ATC.
- To review the possibility of incorporation of the Air Traffic Service procedures in the aerodrome services provided in accordance with ICAO recommendations (Document 4444, Attachment 11) and the Order No. 103/DV-116 of 26.10.95 issued by Department of Air Transport.

5.5. To the Federal Service for Hydrometeorology and Environmental Monitoring:

- To review the possibility of purchasing and installing of a new Doppler weather radar at the civil aviation meteorological station in Sochi.
- To undertake measures to eliminate the shortcomings in the meteorological support to civil flight operations at Sochi aerodrome brought to light in the course of the investigation.

5.6. To the federal state unitary enterprise “State Corporation for Air Traffic Management»:

- To restore complete ATIS broadcasting for Sochi aerodrome, including weather data.
- To clarify to controllers of the Sochi Air Traffic Support of the groups of BECMG and TEMPO changes in the weather forecasts for the aerodrome and of the two-hour “trend” weather forecasts.

5.7. To Airbus:

- To eliminate the discrepancies in the documentation describing the logic of the binary signals recorded by the FDR.
- To introduce in the A320 FCOM information clarifying specific features of activation of the OPEN CLIMB mode in various flight conditions.
- To introduce in the A320 FCOM a warning about possible activation of the LOW ENERGY WARNING, when the aircraft performs manoeuvres in the landing configuration with considerable changes in pitch and roll angles.
- To review the expediency of alteration of the type and/or priority of the EGPWS warning to ensure more reliable pilots’ response to its activation.

5.8. To eliminate the shortcomings revealed during investigation of the aviation accident.

Chairman of the Investigation Commission	L.A Kashirsky
Deputy chairmen	G.M. Galstyan
	A.N. Morozov

Commission members :

N.F. Zobov

Y.V. Fedyushin

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E.P. Glukhovskaya

N.N.Chubarov

INTERSTATE AVIATION COMMITTEE



## ACCIDENT TO FLIGHT RNV967

### BEA COMMENTS ON THE DRAFT FINAL REPORT

The BEA agrees overall with the facts and conclusions in the Draft Report. The comments that are presented here, with the aim of improving aviation safety, focus on the flight crew's work during the flight, on the airline's conditions for technical operations and the application of oversight by the Authority, as well as on some aspects of air traffic control.

#### **Flight Crew**

a) The report should underline the absence, during that part of the flight that it was possible to reconstitute, of the application of Standard Operating Procedures (SOP), as described in the Operator's FCOM documentation, as well as on the critical inadequacies in Crew Resource Management (CRM). As analyzed in the appendix to this document, this failure to follow Standard Operating Procedures and teamwork led to the pilots losing situational awareness and made it impossible for them to regain control of the airplane in time.

Thus, the crew did not make systematic callouts during the changes in AP/FD and ATHR.

The Captain almost never made the callouts on the selections that he was making, which prevented the Co-pilot from carrying out his task of monitoring the parameters and surprised him on two occasions. During the A320 type rating training that the Captain had undertaken at SAS Training, several remarks were made on the absence or inadequacy of his callouts.

The Co-pilot, PNF, did not push the takeover button when he started to use his sidestick and made no call out for this action. This dual input (in pitch and roll) may have led Captain, who was unaware of the Co-pilot's actions, to believe that the airplane was behaving abnormally.

More generally, apart from during the phases of arrival briefing and airplane configuration when they were cleared to land, the two pilots had no common strategy on the conduct of the flight.

b) The CVR transcript throws very clear light on the event. It would therefore be very useful for it to be appended to the report, in accordance with Annex 13 - paragraph 5.12.1.

## **Technical Operations within Armavia**

The dysfunctions noted in the crew's performance are too significant for them to be merely circumstantial. With regard to this point, it would be desirable to widen the scope of the report to include the structure of operations. In the context of the investigation that has been undertaken on this point, the BEA did not have access to the elements relating to the airline's technical operations (ICAO - Annex 6), but the BEA recommends clarifying the following:

- details on the accident prevention and flight safety programmes;
- details of the flight crew training programme;
- application of the standard operating procedures for each phase of flight;
- instructions relating to clarification and acceptance of ATC clearances;
- conditions required to start or continue an instrument approach;
- instructions relating to performing standard approaches and precision instrument approaches;
- training and instructions relating to the Ground Proximity Warning System (GPWS) ;
- operator's operational minima for Sochi aerodrome and crew training for this specific aerodrome;
- checks on the pilots' skills in performing emergency procedures;
- information on the operator's training programme aimed at developing knowledge and aptitude in human performance and crew resource management.

## **Oversight Authority**

In relation to the national oversight authority, a certain number of points could usefully be added to the report, in support of the recommendations formulated, in particular:

- the requirements and procedures for approving foreign training centres that carry out training for those possessing Armenian Pilots' licenses;
- the programme of inspection of the airline's operations by the oversight authority;
- the programme of maintenance follow-up for airplanes not manufactured in the Commonwealth of Independent States.

In fact, the ICAO Summary Report (April 2004) on the follow-up to the Safety Oversight Audit of the GDCA of the Republic of Armenia carried out in 2003 does not provide any answers to these questions.

## ATC

The controller treats flight RNV967 as a domestic Russian flight, for which he could intervene in the Captain's decision to continue or abort an approach. This flight was, however, an international flight governed by different regulations, which specifically allow the Captain to descend to the minima before deciding on a go-around.

In addition when the controller aborted the final approach, he gave a series of instructions that appear to be piloting instructions rather than a clear instruction for a missed approach. In doing this, the controller transformed himself into a decision-maker for airplane manoeuvring and it should be noted that, in fact, the pilot performs the instructions received in a sequential manner. Questions should be asked concerning this "dual piloting" by the controller and the crew where those involved do not perceive the airplane's situation with the same precision. Thus, it would be desirable for the Russian Civil Aviation Authority to clarify its doctrine on interventions by ATC in relation to the responsibilities that normally fall on the Captain.

In conclusion, we propose to remove the phrase "however it did not render the direct influence on the outcome of the flight." from the first sentence in Finding 14. The preceding, clarified by the elements that are included in the attached analysis, in fact show that aspects linked to air traffic control contributed to the accident occurrence.

## APPENDIX

### Study of CRM performance during Flight RNV967

#### Technical Operations within Armavia

- Standard Operating Procedures (SOP)

The Captain practically never made any callouts on the mode changes or inputs that he made, which prevented the Co-pilot from accomplishing his role of checking the information displayed on the FMA. Further, this even surprised him on two occasions - vertical mode V/S having been engaged for two minutes when the Co-pilot noticed it and selection, for no apparent reason, of an altitude of 3,200 feet on the FCU for no particular reason. It is notable that, during the A320 training that was undertaken at SAS Training, several remarks had already been made to the Captain concerning the absence or the poor quality of his callouts.

For his part, the Co-pilot, though he was Pilot Not Flying (PNF), did not press the takeover button and did not make the callout when he started using his sidestick, which is in contradiction with the SOP. This may have led the Captain, who was unaware of his Co-pilot's inputs (both in pitch and roll), to believe that the airplane was behaving abnormally, and thus increase his difficulties in recovering control of the trajectory.

**Note:** fatigue resulting from the very late hour of the flight likely contributed to a reduction in the crew's attention to the conduct of the flight and respect for the SOP's.

- Pilots' Objectives

The meteorological information available at departure made it possible to plan the flight. Around thirty minutes after takeoff, the forecast provided by the Sochi controller led the Captain to turn back towards Yerevan. Fifteen minutes later, after having stated that they had some Deputies on board, the crew received meteorological information that allowed them to return towards Sochi. Exchanges between the pilots and the chief flight attendant show that the Captain seemed satisfied at having achieved his objective of landing at Sochi. The Co-pilot seemed less focused on the destination airport and on several occasions considered a diversion (to Rostov).

It was only in the last few minutes that the situation was reversed, with the Captain scrupulously following the controller's instructions, despite his increasing anger, and the Co-pilot who was ready to "go and see". In fact, this switch in the two pilots' objectives was only superficial, resulting as it did from the marginal meteorological situation and from their obviously divergent concept of the crew's responsibilities with

regard to the decision to land (see following). In this context, the Captain accepted the authority of the controller while the Co-pilot seemed to refer to international procedures.

- **Relations between crew members**

**Note:** No available documents made it possible to determine that the crew followed any Crew Resource Management training (CRM). Furthermore, the Captain seems never to have followed an adaptation course relating to the change in environment from three- or four-man crew operations to two man-crew operations.

The Captain and the Co-pilot carried out the arrival briefing together. Subsequently, however, due to divergences in strategy (focus on the landing against acceptance of a possible diversion) the two pilots were more or less no longer working in phase.

Several comments by the Co-pilot remained unanswered despite their significance for the flight. For example, the Co-pilot proposed erasing the LAMET point, inserted by the Captain in the flight plan. In fact the published approach, which passes through BANUT, is then followed by flying towards GUKIN, located on the runway extended centreline, and not towards LAMET, located beyond, which corresponds to another arrival. The Captain stated that the controller might possibly send them through that point<sup>1</sup>. The conversation was then interrupted and was not continued subsequently. Later, the Co-pilot prepared the arrival by presenting the structure of the exit taxiways while the Captain was concentrating on getting back on to the descent path.

From the time they were established on the centreline and the descent path, when they were cleared to land, the pilots shared a plan (they were then sure that they were going to land). The configuration of the airplane and pre-landing actions were coordinated. The controller's order to stop the descent surprised both of them and, from that moment on, verbal comments were made almost exclusively by the Co-pilot. The Captain hardly communicated any more, not announcing the go-around, for example, and no comments were made on the various alarms and warnings. No task-sharing was performed; neither of the pilots any longer had a real overall vision of the situation or any anticipatory capacities.

This lack of adherence to SOP's and lack of teamwork contributed to the pilots' losing situational awareness and made it impossible for them to regain control of the airplane. Experience in aviation has clearly shown how important call-outs are to ensure that both crew members

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<sup>1</sup> This shows a lack of knowledge of the airplane flight modes as managed by the FMGS: the unjustified presence of the LAMET point in the flight plan calculated by the FMGC resulted in prolonging the flight path, thus delaying the start of descent point. This initiative by the Captain led to an increase in the workload during the descent in order to correct the glide slope and during interception of the localiser. Without this point in the flight plan, this work overload would not have occurred.

are fully in the information loop regarding the various Auto Flight System modes. It is therefore clear that the crew did not possess an adequate level of performance to undertake the flight in the optimum safety conditions.

### **Relations with ATC**

Even though this was an international flight, the Sochi controller managed the flight as if it were a domestic flight, with the tacit agreement of the Captain, which led him to intervene in the latter's decisions.

**Note:** The air traffic control regulations in Russia depend on the nature of the flight. If it is a domestic flight, the controller can decide to abort the approach according to the evolution of the meteorological conditions (ceiling and visibility). If it is an international flight, the approach, once initiated, can be continued down to the minima, whatever the evolution of the ceiling and visibility may be.

In this context, the Captain was clearly looking to influence the controller by telling him that they had a delegation of Deputies on board and by asking him to "come on board" during the stopover. For the crew, the « negotiation » with the controller in fact appeared to have worked, as indicated by remarks made on several occasions, which clarifies their subsequent incomprehension of events and their surprise when the tower controller ordered them to stop the descent.

During the approach, the relationship between the crew and ATC was characterised by a continuous and progressive increase in irritation and stress, due to the controller's regular updates on the height of the cloud base around the value of the minima, as well as the power struggle with the controller that may have been engendered in the minds of the crew. The Captain, in particular, no longer seemed to view the controller as an ally but rather as an overseer, became more and more annoyed as they received information and even became positively angry at the time the crew was cleared to contact the tower for landing.

The slight difference between the meteorological conditions received on several occasions and the minima surprised the crew, who became convinced that this was a deliberate technique by the controller, whose motivation they were trying to understand. Further, the Captain decided to put the airplane into "Approach" configuration despite the information available that made it impossible to land. He was persuaded that the controller was giving them limit values on the cloud base to cover himself but that he would clear them to land whatever the real conditions might be. In fact, that is what effectively happened, the airplane being cleared to land at 8.5 kilometres from the SO beacon, the go-around point. The crew, now sure that they were going to land, did not expect any more disturbances. The order to stop the descent, which arrived forty-six seconds later, was thus completely unexpected

and ran counter to the pilots' mental representation of the situation. This destabilised the crew, already annoyed and against the controller, in particular the Captain, who reacted to this instruction rapidly and, it appears, without developing any strategy. Further, the nature of the instructions, oriented on piloting actions instead of consisting of an explicit order to abort the approach, may have contributed to the pilot's disorientation. The pilot carried out the instructions received in succession, but did not appear to have immediately adopted the missed approach procedure. This did not allow trained reflexes to cut in and probably contributed to his forgetting to retract the flaps, for example.

Finally, during the missed approach, the Co-pilot's attention was partially distracted from following the manoeuvre by the long message from the controller that gave new instructions for the go-around and a new approach. Thus, he only intervened tardily to draw the Captain's attention to the airplane's attitude.

## COMMENTS BY THE INTERSTATE AVIATION COMMITTEE ON THE BEA'S COMMENTS

In accordance with Section 6.3 of ICAO Annex 13 and Point 2.4.15 of the Rules for the Investigation of Aviation Accidents and Incidents involving Civil Aircraft in the Russian Federation, the Commission of Inquiry into the disaster involving the "Armavia" Airlines A-320 aircraft EK-32009, which occurred on 3 May 2006 in the vicinity of Sochi Airport, has considered the comments by the BEA (France), the official representative of the State of Design and Manufacture of the aircraft, on the draft of the Final report, which was signed by all the members of the Commission without comments or separate opinions.

The section of the comments touching on matters of aircrew training and actions during the disaster flight, as well as back-up for the operation of the aircraft as a whole and its oversight by the aviation authorities of the Republic of Armenia, does not contradict the findings set out in the Final Report, and contains detailed accounts of aspects of these matters, and will not be commented on.

The section of the comments devoted to matters relating to air traffic control and cooperation between the crew and the ATC services does not contradict the findings in the Final Report either, which reflects all of the shortcomings in the actions of the ATC service specialists involved in the control of the accident flight. The Final Report also analyses the air traffic controller's instruction to the crew to stop the approach, which, as things actually turned out in the accident flight, along with other factors, was the initial step in the chain of events that led to the accident. The Report also analyses contradictions in the regulatory documents that determine the procedures for handling air traffic in the Russian Federation. The Commission has made recommendations for the elimination of the failings that were brought to light.

It should be noted that the part of the air traffic controller's instruction which determined the sequence of actions that stopped the approach was in accordance with the established procedure for a go-around, published in the aviation navigation information handbooks.

Taking the above into account, as well as the fact that overall the BEA agrees with the findings of the Report, and that the comments that it has submitted do not affect the conclusion on the reason for the accident, the Commission has not amended Point 14 of the Conclusions section of the Final Report, and attaches the BEA material with these comments.