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Aircraft Accident Investigation Bureau AAIB

Final Report No. 2051 by the Aircraft Accident Investigation Bureau

concerning the serious incident

involving the Cessna 550 Citation Bravo aircraft, registration LZ-ABV

operated by Air VB under flight number VBC 3004

on 24 January 2007

Samedan aerodrome, municipality of Samedan/GR

approx. 5 km north-east of St. Moritz

Ursachen

Der schwere Vorfall ist darauf zurückzuführen, dass die Besatzung nach einem unstabilierten Anflug das Flugzeug mit einer zu hohen Landemasse, mit zu hoher Geschwindigkeit zu spät aufsetzte und dieses auf der Piste nicht mehr zum Stillstand bringen konnte.

Zum schweren Vorfall beigetragen haben:

- Mangelhafte Flugvorbereitung durch die Besatzung.
- Keine adäquate Wetter- und Gefahrenanalyse für einen Anflug und eine Landung auf einem Gebirgsflugplatz.
- Fehlende Koordination, korrigierende Unterstützung und Reaktion innerhalb der Besatzung.

General information on this report

This report contains the AAIB's conclusions on the circumstances and causes of the serious incident which is the subject of the investigation.

In accordance with art 3.1 of the 9th edition, applicable from 1 November 2001, of Annex 13 to the Convention on International Civil Aviation (ICAO) of 7 December 1944 and article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the incident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

All times in this report, unless otherwise indicated, follow the coordinated universal time (UTC) format. At the time of the serious incident, Central European Time (CET) applied as local time in Switzerland. The relation between LT, CET and UTC is:

LT = CET = UTC + 1 hour.

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Final Report

Owner	AVB-2004 Ltd, 43 Moskovska Str., 1000 Sofia, Bulgaria
Operator	AVB-2004 Ltd, 43 Moskovska Str., 1000 Sofia, Bulgaria
Aircraft type	Cessna 550 Citation Bravo
Country of registration	Bulgaria
Registration	LZ-ABV
Location	Samedan aerodrome, municipality of Samedan/GR
Date and time	24 January 2007, 15:03 UTC

Synopsis

On 24 January 2007 the Cessna 550 Citation Bravo aircraft, under flight number VBC 3004, took off from Geneva (CH) at 14:21 UTC, on a private flight under instrument flight rules (IFR), under a Y flight plan, to Samedan (CH). Two crew members and six passengers were on board. At 14:54:26 UTC, after an uneventful flight, the crew of VBC 3004 confirmed to the Air Defense and Direction Center (ADDC) air traffic controller (ATCO) that they were now flying on under VFR conditions and at his request changed to the Samedan tower frequency. Two and a half minutes previously, the crew had already contacted the Flight Information Service Officer (FISO) in the Samedan tower and received from him the information that the runway was 75% covered with ice and the braking coefficient was "*poor*".

After a missed approach and a repeated frequency change to the ADDC ATCO, the crew reported back to the Samedan FISO at 15:01:09 UTC and said that they would report again on final approach to runway 03. On final approach the FISO gave the crew wind direction and wind speed and 20 seconds later informed them that there was ice on the runway. After an unstabilised approach the aircraft touched down just before the runway half-way point and a good 4 m to the right of the runway centre line. The aircraft then drifted slightly to the right and could not be brought to a standstill on the runway. At a speed of approximately 30 knots, the aircraft rolled over the runway end and came to a standstill in the snow after 20 metres.

The aircraft was not damaged. The crew and passengers were able to disembark the aircraft normally.

Investigation

The serious incident took place at 15:03 UTC. The Aircraft Accident Investigation Bureau (AAIB) opened an investigation at 18:30 UTC in cooperation with the Grisons cantonal police.

Causes

The serious incident is attributable to the fact that the crew, after an unstabilised approach, landed the aircraft with an excessively high landing mass, at an excessively high speed, too late and were no longer able to bring it to a standstill on the runway.

The following factors contributed to the serious incident:

- inadequate flight preparation by the crew
- inadequate weather and hazard analysis for an approach and landing on a mountain aerodrome.
- a lack of coordination, corrective support and reaction within the crew.

1 Factual information

1.1 Pre-flight history and history of the flight

1.1.1 General

For the following description of the pre-flight history and history of the flight, the recordings of the radio communication, conversations and sounds in the cockpit, radar data and the statements of the crew members were used. Throughout the whole flight the commander was pilot flying (PF) and the copilot was pilot not flying (PNF).

The World Economic Forum (WEF) was taking place in Davos at the time of the serious incident. For this reason, a flight restricted zone had been defined in the airspace above Davos; this extended over Samedan aerodrome. A military air traffic controller (ATCO) from the Air Defence and Direction Center (ADDC) was responsible for authorisation to fly through this restricted zone.

The flight took place under instrument flight rules (IFR) as far as the area of Samedan. The approach and landing in Samedan took place under visual flight rules (VFR).

1.1.2 Pre-flight history

On 23 January 2007 the operator AVB-2004 Ltd. applied to Samedan airport for support with processing a planned private flight with passengers under flight number VBC 3004 from Geneva (CH) to Samedan on 24 January 2007 and another under flight number VBC 3005 on 28 January 2007 from Samedan to Plovdiv (BG).

On 24 January 2007 the Cessna 550 Citation Bravo aircraft, registration LZ-ABV and flight number VBC 3003, took off from Sofia (BG) at 11:20 UTC on a commercial ferry flight under instrument flight rules to Geneva (CH). On board were the two crew members who were subsequently to fly from Geneva (CH) to Samedan (CH) with six passengers. At 12:53 UTC, the aircraft landed in Geneva after an uneventful flight.

According to the commander's statement, during this flight, when they were in the Samedan area, the crew informed themselves about the weather in Samedan. They listened to the 11:20 UTC ATIS report, which in his recollection forecast a cloud ceiling at 3000 ft for Samedan airport and reported the braking coefficient as "poor".

On arrival in Geneva, the commander contacted the responsible agency at Samedan aerodrome by telephone to find out about the current weather situation. According to his statement, since the 11:20 UTC report which he had listened to the weather had not changed and the braking coefficient was still reported to be "poor".

The commander then met his passengers and consulted the ATIS report for Samedan aerodrome for the last time, making a note of the following: *"RWY 03, Time 13:30, Wind 020/8, 10 km, OVC 3000, Temp -7, QNH 991, runway wet, braking action medium"*.

1.1.3 Flight preparations

Prior to their departure from Sofia, the crew received a so-called "Flight Documentation Folder" from the company. Among other things this folder contained a pre-printed flight plan (navigation log) from Geneva to Samedan (Jeppesen FliteStar), a fuel calculation for this flight and a corresponding weight and balance report. On these calculation sheets, a loaded block fuel of 2100 kg (4630 lb) was specified; this quantity was also used for the weight and balance calculation. Neither on these papers nor on other sheets were any notes found made by the crew, which would provide evidence of a calculation using the actual data for this flight.

Prior to departure from Geneva, 1783 litres of fuel were taken on board at 13:30 UTC. On the basis of the corresponding indication of fuel quantities after the serious incident, it can be calculated that an actual block fuel of 4800 lb was in the tanks for the flight to Samedan.

1.1.4 History of the flight

At 14:21 UTC on 24 January 2007, the Cessna 550 Citation Bravo aircraft, registration LZ-ABV and callsign VBC 3004, took off from runway 05 in Geneva on a private flight, initially under instrument flight rules and subsequently under visual flight rules for a landing in Samedan (Y flight plan). Two crew members and six passengers were on board. This was the first flight to Samedan for the two pilots.

At 14:46:34 UTC, after an uneventful flight, the crew of VBC 3004 received from the Air Defense and Direction Center (ADDC) air traffic controller (ATCO) the instruction to stop the descend at flight level (FL) 170 and a clearance to fly on a direct heading to the destination airport. In the cockpit, the two pilots then discussed the visual references and the possibility of penetrating the cloud cover over the aerodrome to establish sufficient visual contact for an approach and landing. To this end they tried twice, without success, to call the Samedan aerodrome Flight Information Service Officer (FISO) on the radio. At 14:49:10 UTC one of the pilots commented as follows, according to the CVR: *"So, when they take us down to one six zero the valley is visible. So more or less course to ... (unreadable) ... we use the map"*. At 14:50:10 UTC, the crew of VBC 3004 again tried, unsuccessfully, to establish radio contact with the Samedan tower FISO.

Immediately afterwards, at 14:50:34 UTC, the ADDC ATCO informed the crew that a continued descent would be possible only under visual flight rules (VFR). At that time the aircraft was approximately 20 NM west south-west of Samedan aerodrome (Annex 1). The crew of VBC 3004 immediately answered as follows: *"Copied three zero zero four we are cancelling IFR"*. The ATCO confirmed this at 14:50:52 UTC as follows: *"Victor Bravo Charlie three zero zero four copied IFR plan cancelled time five zero report below flight level one five zero and due to restricted area Davos overhead Samedan only right turn possible to remain south of Samedan for descend"*. The crew of VBC 3004 acknowledged this message and shortly afterwards the commander commented to the copilot that he would initially descend to FL 160. Five seconds later the ATCO informed the crew of the Samedan QNH, to which the crew replied at 14:51:28 UTC that they had received the information "I" [ATIS of 14:20 UTC] from Samedan.

At 14:51:49 UTC, the crew of VBC 3004 again tried, very probably using the second radio set, to make radio contact with Samedan tower. This time they were successful. The crew reported that they were now approximately 16 NM from the

aerodrome and that they would land in five to ten minutes. The Samedan FISO then informed the crew of the runway condition as follows: *"Victor zero four for your information the runway is seventy five percent covered with ice and the braking action is poor"*. The copilot gave the commander this information and the continuation of the flight was discussed in the cockpit. In view of the current visibility and the radar data, the crew decided to fly a heading of 110 degrees.

At 14:53:35 UTC the crew informed the ADDC ATCO that they had visual contact with the ground and requested a descent to FL 140 and to fly a heading of 110 degrees. The ATCO immediately answered as follows: *"Victor Bravo Charlie three zero zero four that's approved if possible remain south of Samedan and strictly VFR"*. The crew of VBC 3004 read back this clearance and confirmed that a descent under VFR conditions would be possible. The ATCO then instructed flight VBC 3004 to change to the Samedan tower frequency. At this time the aircraft was approximately 3 NM west of Samedan aerodrome, at FL 150 and on a heading of 077 degrees. The speed was 237 knots.

At 14:55:01 UTC the following comment was made in the cockpit: *"We are too high, aren't we?"*. Nine seconds later the crew of VBC 3004 reported on the Samedan aerodrome tower frequency as follows: *"Samedan tower good afternoon again Victor Bravo Charlie three zero zero four we have visual contact with airfield"*. When the FISO in the tower asked whether they were on their final approach the crew replied in the negative and said that they were over the aerodrome.

The FISO informed the crew that runway 03 was in use and requested them to report on final approach to runway 03. The continuation of the flight was now discussed in the cockpit. The question about visual contact was answered in the negative, with a comment that the mountain peaks would be visible. At 14:55:38 UTC the crew initiated a clockwise three sixty. At 14:56:07 UTC, according to the FDR recordings, the landing gear was extended. This action was not commented on in the cockpit. Seven seconds later, at 14:56:14 UTC, one of the crew members twice called out loudly *"climb!"* (Annex 1 and 2). At this time the aircraft was just south of the aerodrome, during the three sixty on a south-westerly heading at a pressure altitude of 13 912 feet. The speed was 222 knots. A shallow climb was initiated.

To the comment of one of the pilots at 14:56:42 UTC that they would be high enough at FL 150, the other pilot replied that they were already at FL 140 and were descending (Annex 2). During this discussion, the acoustic warning *"bank angle"* sounded in the cockpit at 14:57:36 UTC. The FDR recordings indicate a maximum bank angle of 58 degrees. Shortly afterwards, one of the pilots commented that they would be on final approach and the question at 14:58:16 UTC as to whether anything could be seen was answered in the negative. The following response was given to the comment that the runway would be in front of them: *"Yes we are exactly in the valley"*. According to the FDR recordings, shortly afterwards the speed brakes were deployed for four seconds.

A little later, at 14:58:57 UTC, the Samedan tower FISO asked the crew of VBC 3004 for their position. The crew had just completed the clockwise three sixty and answered repeatedly at 14:59:12 UTC as follows: *"We are overhead on heading zero three seven and we are turning back"*. The FISO acknowledged this message and instructed the crew to change once more to the ADDC frequency.

At 14:59:39 UTC flight VBC 3004 reported back to the ADDC ATCO and to his question about whether they would be flying to an alternate airport the crew said that they would attempt another approach in Samedan. At this time the aircraft had just initiated an anti-clockwise three sixty and was practically over Samedan aerodrome, at an altitude of 13 350 feet. The aircraft's speed was 180 knots.

A question from one of the pilots in the cockpit about visual contact was answered in the negative by the other pilot and during this discussion the acoustic warning *"bank angle"* again sounded. The FDR recordings indicate a maximum bank angle of 64 degrees (Annex 3). The speed brakes were then extended and immediately afterwards the crew reported to the ATCO at 15:00:33 UTC that they were now in a position to make contact with Samedan tower. The ATCO then instructed the crew to do so. At this time the aircraft was flying at a slowly increasing speed, which attained a maximum value of 269 knots. The maximum permitted speed of 260 knots with the landing gear extended was exceeded for 16 seconds.

At 15:00:56 UTC, the crew of flight VBC 3004 reported to Samedan tower as follows: *"Samedan Victor Bravo Charlie three zero zero four descending visually and we have contact with airfield. Call you turning final"*. When the Samedan tower FISO asked whether flight VBC 3004 was turning on its final approach the crew answered in the negative, with the comment that the aircraft was currently above the aerodrome.

At 15:01:24 UTC, the speed brakes were retracted again and at 15:01:37 UTC the commander commented to the copilot during the anti-clockwise three sixty on a west south-west heading: *"just now we are going to turn, a little more"*. Immediately afterwards, according to the FDR recordings, the flaps were extended to the approach position (APPR position – 15°). This action was not commented on in the cockpit. At 15:02:10 UTC the commander said: *"Flaps, we are going to land"*. According to the FDR recordings, the speed brakes were extended again ten seconds later and shortly before they were retracted, at 15:02:32 UTC, at a speed of 196 knots, the flaps were extended to the landing position (LAND position – 40°) (Annex 3). At this time the aircraft, on a heading of 359 degrees, had just completed the anti-clockwise three sixty and was passing a pressure altitude of 6732 feet in descent. Towards the end of this three sixty the FDR recordings indicate a bank angle of up to 49 degrees and a pitch angle of up to -12°. After ten seconds, the speed had reduced to 170 knots.

At 15:02:34 UTC, the crew reported to Samedan tower that flight VBC 3004 would now turn onto the final approach. The FISO replied: *"Victor zero four wind two zero degrees twelve knots runway zero three is free"*. Only two seconds later, the acoustic warning *"sink rate, pull up, pull up"* sounded in the cockpit. Six seconds later the commander said to the copilot: *"We are going to go around perhaps, no we are not going to do anything"*. The aircraft had just turned onto the runway centre line at a bank angle of up to 40 degrees when, after a brief increase in attitude from -2° to -8°, the acoustic warning *"sink rate, pull up, pull up"* sounded again at 15:02:51, followed by the acoustic warning: *"bank angle, bank angle"*. At the same time, only 130 feet above the ground, the speed brakes were again deployed for six seconds. At 15:02:58 UTC, the Samedan controller informed the crew as follows: *"Victor zero four ice on the runway"*.

Two seconds later, at 15:03:00 UTC, according to eye witnesses the aircraft touched down just before the runway half-way point and then drifted slightly to the right. According to the FDR recordings, the speed of the aircraft on touch-

down on the runway was 128 knots. According to the commander's statement, immediately after touchdown he had used the foot brakes to maximum effect, applied reverse thrust at maximum power and deployed the speed brakes. The FDR recordings show that reverse thrust was activated four seconds after touchdown. However, deployment of the speed brakes was not recorded. At a speed of 32 knots, the buckets for reverse thrust were retracted and then deployed again only two seconds later. The buckets then remained deployed until the aircraft had come to a standstill in the snow.

According to the commander's statement, shortly before the runway end he had brought reverse thrust power back to idle and eased up slightly on the foot brakes. When he realised that he was still approaching the runway end relatively quickly, he again applied the foot brakes to maximum effect. However, he was no longer able to bring the aircraft to a standstill on the runway.

At a speed of approximately 30 knots, the aircraft rolled over the runway end and came to a standstill in the snow after 20 metres.

At 15:03:43 UTC, the crew reported that they had rolled over the runway end, upon which the FISO in Samedan tower informed them that the rescue services were on the way.

The aircraft was not damaged. The crew and passengers were able to disembark the aircraft normally.

1.2 Injuries to persons

Injuries	Crew	Passengers	Total number of occupants	Others
Fatal	---	---	---	---
Serious	---	---	---	---
Minor	---	---	---	---
None	2	6	8	Not applicable
Total	2	6	8	

1.3 Damage to aircraft

The aircraft was not damaged.

1.4 Other damage

There was no other damage.

1.5 Personnel information

1.5.1 Commander

Person	Bulgarian citizen, born 1965
Licence	Air transport pilot licence aeroplane – ATPL(A) according to ICAO, first issued by the Directorate General Civil Aviation Administration of the Republic of Bulgaria on 25.09.2006.

	Ratings	Type rating C550 as pilot in command, valid till 16.09.2007 International radiotelephony for flights under visual and instrument flight rules RTI (VFR/IFR) Night flying NIT
	Instrument flying rating	Instrument flight aircraft IR(A) C550 category I instrument approaches, last extended on 16.09.2006, valid till 16.09.2007
	Last proficiency check	Last line check on 16.09.2006
	Medical fitness certificate	Class 1, without restrictions. valid from 05.09.2006 till 05.03.2007.
	Last medical examination	05.09.2006
1.5.1.1	Flying experience	
	Total	2283:09 hours
	of which as military pilot	600:00 hours
	on the type involved in the incident	476:32 hours
	of which as commander	309:24 hours
	during the last 90 days	173:55 hours
	of which on the type involved in the incident	173:55 hours
1.5.2	Copilot	
	Person	Bulgarian citizen, born 1971
	Licence	Air transport pilot licence aeroplane – ATPL(A) according to ICAO, first issued by the Directorate General Civil Aviation Administration of the Republic of Bulgaria on 25.09.2006.
	Ratings	Type rating C550 as copilot, valid till 22.09.2007. Type rating An12 as pilot in command, valid till 16.05.2007. International radiotelephony for flights under visual and instrument flight rules RTI (VFR/IFR) Night flying NIT
	Instrument flying rating	Instrument flight aircraft IR(A) C550 Category I instrument approaches, valid till 22.09.2007
	Last proficiency check	Last proficiency check on 22.09.2006

	Medical fitness certificate	Class 1, without restrictions. valid from 01.12.2006 till 30.11.2007.
	Last medical examination	01.12.2006
1.5.2.1	Flying experience	
	Total	2348:19 hours
	of which as military pilot	350:00 hours
	on the type involved in the incident	295:59 hours
	during the last 90 days	170:25 hours
	of which on the type involved in the incident	170:25 hours
1.5.3	Crew duty times	
	Since the two pilots had been working together as a crew since 22.01.2007, the same crew duty times apply to both pilots.	
	Start of duty on 22.01.2007	18:00 UTC
	End of duty on 22.01.2007	21:50 UTC
	Start of duty on 23.01.2007	04:30 UTC
	End of duty on 23.01.2007	20:50 UTC
	Rest time from 22. to 23.01.2007	6:40 hours
	Flight duty time on 23.01.2007	16:20 hours
	Start of duty on 24.01.2007	09:30 UTC
	Rest time	12:40 hours
	Flight duty time at the time of the serious incident	5:33 hours
	The above crew duty times take into account a preflight duty of 30 minutes but no postflight duty (cf. chapter 1.17.1.2).	
1.5.4	Passengers	
	Six persons, Bulgarian nationals, with no flying experience.	
1.6	Aircraft information	
1.6.1	General	
	Registration	LZ-ABV
	Aircraft type	Cessna 550 Citation Bravo
	Characteristics	Twin-jet business aircraft
	Manufacturer	Cessna Aircraft Company, Wichita, Kansas, USA
	Year of manufacture	2005
	Serial number	550-1103

Owner	AVB-2004 Ltd, 43 Moskovska Str., Sofia, Bulgaria
Operator	AVB-2004 Ltd, 43 Moskovska Str., Sofia, Bulgaria
Engine	PW530A Pratt & Whitney engines, S/N DA619 and S/N DA620
Operating hours, airframe and engines	Total hours since manufacture 861:13 hours, since last periodic inspection: 43:24 hours.
Max. permitted take-off mass	14 800 lb (6713 kg)
Max. permitted landing mass	13 500 lb (6123 kg)
Mass and centre of gravity	The mass of the aircraft at the time of the serious incident was 14 562lb (6604 kg). For take-off and landing, the mass was outside the permitted limits and the centre of gravity was within the permit- ted limits.
Maintenance	The last scheduled maintenance work took place at 817:49 hours (499 cycles) on 04.01.2007. The Phase Inspections B and 57 were carried out at the same time.
Fuel grade	JET A1 kerosene
Fuel remaining	According to calculations, the take-off fuel was 4700 lb. A minimum required fuel of 1234 kg (2720 lb) was included in the flight plan. The additional fuel of 1980 lb corre- sponds to a flying time of approxi- mately two hours.
Registration certificate	Issued by the Directorate General Civil Aviation Administration of the Republic of Bulgaria on 17.05.2005.
Airworthiness certificate	Issued by the Directorate General Civil Aviation Administration of the Republic of Bulgaria on 03.06.2005, valid till 30.05.2007.
Certification	IFR category I, B-RNAV, RVSM, RNP 5
1.6.2	Mass and centre of gravity
1.6.2.1	Calculations for take-off The bases of calculations are specified in the aircraft manufacturer's Operating Manual (OM), section VII "Flight Planning and Performance", in the chapter enti- tled "Weight and Balance". On the basis of these principles and of the informa-

tion provided in the aircraft manufacturer's corresponding forms (form number 1985 and form number 1988) dated 03.03.2005 for the aircraft with the serial number 550-1103, the "actual" figures are given in the table below. In the table, the weights of passengers and luggage correspond to the information contained in the weighing log of the Samedan airport manager, dated 06.02.2007.

The "planned" figures in the table correspond to the values published in the calculation sheets (Jeppesen, FliteStar) in the Flight Documentation Folder, which the crew received in Sofia. The information in kilograms has been converted to pounds.

For purposes of comparison, the limit values for take-off and landing specified in the aircraft manufacturer's airplane flight manual (AFM), Section II – Operating Limitations are shown.

	Actual	Planned	AFM limits
Aircraft Empty Mass	9 165 lb	8 800 lb	
Crew	291 lb	308 lb	
Passengers and luggage	1 246 lb	875 lb	
Zero Fuel Mass	10 702 lb	9 983 lb	
Fuel	4 800 lb	4 630 lb	
Taxi Fuel	100 lb	60 lb	
Take-off Mass	15 402 lb	14 554 lb	14 800 lb
Trip Fuel	940 lb	807 lb	
Landing Mass	14 462 lb	13 748 lb	13 500 lb

The actual take-off and landing mass were above the limits published by the aircraft manufacturer. The landing mass shown in the calculation sheets (Jeppesen, FliteStar) was also above the limit.

1.6.2.2 Calculations for landing

The full length of runway 03 was available for the landing in Samedan, i.e. an asphalt runway with dimensions 1800 x 40 metres. According to information from the Samedan FISO, the runway was 75% covered with ice and at the time of the landing (information "I", 14:20 UTC), the braking action was reported as "medium".

In the "DESCENT/APPROACH" section of the "Pilot's Abbreviated Checklist Model 550/551" for the "Citation Bravo" available on aircraft LZ-ABV, six tables are published from which the minimum required runway length can be determined for the corresponding conditions.

These six tables are extracts from Section IV of the aircraft manufacturer's airplane flight manual (AFM) recognised by the American Federal Aviation Administration (FAA) and cover aerodrome elevations from sea level to 5000 ft in one thousand foot steps. No correction factors are published for criteria of any kind. These tables cannot be used for calculating an actual landing distance under the conditions prevailing on Samedan aerodrome.

Figures for the landing distance must therefore be taken from the FAA approved AFM (cf. section 1.17.2.3).

For a maximum permitted landing mass of 13 500 lb and the weather conditions encountered at Samedan, these landing distance tables produce a landing distance of 3760 ft and a V_{REF} of 111 KIAS. A landing mass of 14 800 lb produces a landing distance of 4860 ft and a V_{REF} of 117 KIAS.

These two values apply to a runway with a dry surface. They are therefore above the maximum value of 2000 ft for which a landing distance is still published, if the runway surface is covered with ice.

If one applies the criteria published by the operator in section 8 of its OM A, the result is a landing distance of 7221 ft or 9334 ft respectively. The available landing distance in Samedan is 5906 ft.

1.6.3 Ground proximity warning system

The aircraft involved in the serious incident was equipped with a ground proximity warning system (GPWS). This system warns the crew visually and acoustically in the event of hazardous ground proximity. Appropriate flying states respectively movements and aircraft configurations (flight modes) are taken into account. In the aircraft manufacturer's operation manual, SECTION III INSTRUMENTATION AND AVIONICS six different flight modes are defined, which among other things are described as follows:

The flight modes and envelopes which will cause the system to activate are not linear for mode one, two and three, and vary considerably with airplane altitude, attitude, and airspeed.

Mode 1 – Excessive Sink Rate (SINK RATE envelope)

The sink rate is measured barometrically and registered in a flight envelope determined by the radio altimeter. If this flight envelope is entered, an aural warning SINK RATE will be announced. ...

Mode 1 – Excessive Sink Rate (PULL UP envelope)

A flight envelope, beginning at a preset barometric rate-of-descent at a radio altimeter altitude in the upper range of the radio altimeter envelope ranging down to slightly 200 feet above ground level, will produce a voice warning PULL UP and illumination of a red PULL UP annunciator. The PULL UP warning will continue until it is cleared by a positive pull up out of the danger area.

Mode 2 – Excessive Terrain Closure Rate

On the CVR recordings, at 15:02:39 UTC and at 15:02:53 UTC, i.e. 21 and 7 seconds respectively before landing, the acoustic warning "sink rate, pull up, pull up, pull up" is audible. At this time the FDR recordings indicate a pitch angle of max. 10° and 6° attitude nose down (AND) respectively.

In addition, this system generates the acoustic warning "bank angle" if the bank angle is excessive. SECTION III INSTRUMENTATION AND AVIONICS of the aircraft manufacturer's operation manual describes, among other things, the activation of this acoustic warning as follows:

A call out "BANK ANGLE" advises of excessive bank angle and occurs at 50 degrees of bank above 190 feet AGL, reducing progressively to 15 degrees of bank at zero altitude. The "BANK ANGLE" warning is active at any altitude above 190 ft AGL. It is repeated every three seconds until the bank angle is reduced below the warning threshold.

According to the CVR recordings, this acoustic warning sounded at 14:57:36 UTC, while a clockwise three sixty was being flown. The FDR recordings indicate a maximum bank angle of 58 degrees.

At 15:00:27 UTC, this acoustic warning sounded again while an anti-clockwise three sixty was being flown. The FDR recordings indicate a maximum bank angle of 64 degrees.

This acoustic warning is audible again at 15:02:58 UTC, only two seconds before touchdown on the runway.

1.7 Meteorological information

1.7.1 General

The information in chapters 1.7.2 to 1.7.5 was provided by MeteoSwiss. The information in chapter 1.7.6 originates from the Samedan aerodrome recordings.

1.7.2 General meteorological situation

A low-pressure area over northern Italy was causing cold arctic air to flow towards Switzerland and was accumulating over the Alps from the north.

1.7.3 Aviation weather forecasts

Among other things, the following aviation weather forecasts and warnings were published for 24.01.2007:

GAMET

Gamet valid 12 – 18 UTC for the Region Eastern Alpine Switzerland:

SFC GUSTS: 25KT

ICE: LOC MOD BLW FL100

AIRMET APPLICABLE:4

Wind/temperature at 13 000 ft AMSL 010/20kt MS23

Wind/temperature at 8000 ft AMSL 340/15kt MS18

0°: SFC

AIRMET

The following Airmet was active at the time of the serious incident:

AIRMET 4 VALID 241245 / 241500

SWITZERLAND FIR MOD ICE FCST BLW FL120 STNR NC

AIRMET 5 VALID 241500 / 241800

SWITZERLAND FIR MOD ICE FCST BLW FL120 NE PART OF SWITZERLAND STNR WKN=

Aviation weather forecast for Switzerland, valid from 12:00 to 18:00 UTC:

Under hazards, the following was stated:

In the north and south along the Alps, reduced visibilities in snowfall and low cloud. Alpine passes in clouds. Moderate icing from the ground to approximately 11 000 ft AMSL. In the south, north wind turbulence, in the Valais south-west wind turbulence at times.

1.7.4 Forecasts

At the time of the serious incident, the following terminal aerodrome forecast (TAF) applied:

LSZS 241221 03007KT 6000 BKN010

In clear text, this means: On 24.01.07, the following weather conditions were forecast for Samedan aerodrome between 12:00 UTC and 21:00 UTC:

Wind	From direction 030 degrees at 7 knots
Meteorological visibility	6 km
Cloud	5-7/8 at 1000 ft AAL

1.7.5 Meteorological conditions at the time and location of the serious incident

On the basis of the listed information, it is possible to conclude that the meteorological conditions at the time and location of the serious incident were as follows:

<i>Cloud</i>	<i>8/8 at 8000 ft AMSL</i>
<i>Weather</i>	<i>--</i>
<i>Visibility</i>	<i>about 10 km</i>
<i>Wind</i>	<i>North wind at 5 kt, gusting to 10 kt</i>
<i>Temp./Dewpt.</i>	<i>-09 °C / -11 °C</i>
<i>Atmospheric pressure</i>	<i>QNH LSZH 1005 hPa, LSZA 0994 hPa</i>
<i>Position of the sun</i>	<i>Azimuth 229°, elevation 9°</i>
<i>Hazards</i>	<i>Icing possible inside and just below cloud</i>

1.7.6 Aerodrome meteorological reports

No METAR was produced for Samedan aerodrome.

ATIS reports for Samedan aerodrome:

LSZS 241120Z 36012KT 9999 OVC030 M07 Q0989

Runway condition: 100% covered with ice, braking action *"poor"*

LSZS 241220Z 36012KT 9999 OVC030 M07 Q0990

Runway condition: 100% covered with ice, braking action *"poor"*

LSZS 241330Z 02008KT 9999 OVC030 M07 Q0991

Runway condition: snow clearing in progress, runway wet, braking action *"medium"*

LSZS 241420Z 02004KT 9999 OVC030 M08 Q0991

Runway condition: *runway wet*, braking action *"medium"*

Samedan aerodrome had published the following SNOWTAM:

VAA3165240650

GG LSAZAI ZL LSZH YOYX

240649 LSSN NYX

SWLS0029LSZS 01240640

(SNOWTAM 0029

A) LSZS

B) B) 01240640

C) C) 03 F) 7/7/7
 J) 100/4LR L) TOTAL/TOTAL P) YES
 T) RWY CONTAMINATION 100 PERCENT

In clear text, this means:

The following runway condition was measured on Samedan aerodrome for runway 03 on 24.01.2007 at 06:40 UTC:

- Ice present over the entire length of the runway (observed on each third of the runway).
- The average thickness of the ice on each third is 1 mm.
- Walls of snow 1 m high at a distance of 4 m to the left and right of the runway.
- Further clearing operations are envisaged.
- Clearing of snow walls higher than 60 cm on taxiways and apron is envisaged.
- Runway contamination is 100%.

1.8 Aids to navigation

It is only possible to approach Samedan aerodrome under visual flight rules (VFR).

1.9 Communications

Radio communication between the crew and the air traffic controllers involved took place normally and without difficulties up to the time of the serious incident.

1.10 Aerodrome information

1.10.1 General

On 1 January 2004 Samedan aerodrome was transferred from the Department of Defence, Civil Protection and Sport (VBS) to the Canton Grison financial assets. On 5 July 2004, Canton Grisons concluded a contract on the operation of Engadin Airport with the newly founded Engadin Airport AG (EA).

The regional airport operated by Engadin Airport AG is located in the municipality of Samedan. It is about 5 km from St. Moritz and is the highest airport in Europe.

The reference altitude of the airport is 5600 ft AMSL and the reference temperature is specified as 17.8 °C. The airport reference point (ARP) has the coordinates 46° 32' 04" N / 009° 53' 02" E.

The licensed aerodrome is used for public air transport and can be used throughout the year by aircraft of all categories up to aircraft of medium weight.

1.10.2 Runway equipment

It is only possible to approach the runway at Samedan aerodrome under visual flight rules (VFR). The runway dimensions are as follows:

Runway	Dimensions	Elevation of runway thresholds
03/21	1800 x 40 m	5600/5574 ft AMSL

At the time of the serious incident, runway 03 was available.

1.10.3 Rescue and fire-fighting services

Samedan aerodrome was equipped with Category 1 fire-fighting resources. A higher category, category 4, for commercial traffic is possible on request within 3 hours of the scheduled arrival/departure time. Such requests must be made 24 hours in advance.

1.11 Flight recorders

1.11.1 Flight data recorder

Type	Solid state memory flight data recorder - SSFDR
Manufacturer	Honeywell
Serial number	10557
Recording medium	Solid state memory

The recordings were complete and could be analysed.

1.11.2 Cockpit voice recorder

Type	L3
Manufacturer	FA 2100
Serial number	00 283 760
Recording medium	Solid state memory
Duration of recording	120 minutes

Some of the conversations and sounds recorded on the CVR could not be interpreted in their entirety, as the noise level inside the cockpit was relatively high and consequently the quality of the recordings was not entirely satisfactory. All communication with the corresponding air traffic control units took place in English. The conversations between the two pilots took place in Bulgarian, the mother tongue of both pilots. It was not always possible to distinguish between the voices of the commander and co-pilot. These conversations were translated into English and are published in the investigation report as "original quotations".

1.12 Wreckage and impact information

The aircraft rolled over the end of runway 03 at a speed of approximately 30 knots, and came to a standstill in the snow after 20 metres, about 5 metres east of the runway centre line. The aircraft was not damaged and it was possible to tow it back onto the runway using ropes secured to the main landing gear.

1.13 Medical and pathological information

There are no indications of the pilots suffering any health problems during the flight involved in the serious incident.

1.14 Fire

Fire did not break out.

1.15 Survival aspects

The crew and passengers survived this serious incident uninjured, as the crew managed to stabilise the aircraft, which was drifting to the right, on the runway centre line. This prevented a collision with the walls of snow along the runway (cf. chapter 1.7.6 SNOWTAM), with possibly serious consequences.

1.16 Tests and research

Not applicable.

1.17 Organisational and management information

1.17.1 The operator

1.17.1.1 General

The "Air VB" operator is a private company which has specialised in business flights. It operates two aircraft, a "Bombardier Learjet 60" and the "Cessna Citation Bravo 550" involved in the serious incident.

"Air VB" is a company based in Sofia, Bulgaria, and is in possession of the following licences:

- License for Air Carrier # BG 2407-17 since 18.01.2006 y.
- Air Operator Certificate # BG-25 since 03.06.2005 y.

1.17.1.2 Crew duty times

Among other things, section 7 FLIGHT TIME LIMITATIONS of the operator's operations manual A (OM A) contains the following concerning crew duty times, under 7.1.5 "Reporting Times":

The reporting time shall never be less than 30 minutes prior to the beginning of the planned block time for short range flights. For all other flights the Flight operator Operations Manager will define and publish the individual reporting times.

Furthermore, section 7.1.7 "Rest Requirements" contains the following, under 7.1.7.1:

Before the start of a flight a crew member shall have completed a rest period at least as long as the preceding duty period, or 11 hours, whichever is the greater.

This rest time was not complied with in the night from 22 to 23 January 2007.

1.17.1.3 Procedures

Within the operating company, the procedures relevant to the serious incident are laid down in the corresponding operations manuals A, B, C and D (OM A, OM B, OM C and OM D).

In this context, it should be noted that the OM B is a copy of the aircraft manufacturer's airplane flight manual (AFM). Only the title page and the respective footers refer to the operator. Relevant information from the OM B is therefore provided in chapter 1.17.2 of this investigation report.

1.17.1.3.1 Landing

Among other things, the operator's operations manual A (OM A), section 8 OPERATING PROCEDURES, 8.1 FLIGHT PREPARATIONS INSTRUCTIONS, 8.1.2.4 "Performance Considerations – Performance Class A Aircraft" states the following:

The performance regulations applicable for Performance Class "A" aircraft (all jets and all other aircrafts with more than 9 passenger seats or when above 5.7 tons) under JAR-OPS1 state.

LANDING – Operational rules require, that the actual (unfactored) landing distance is factored with 1.67 (60% factor for jets) or 1.43 (70% factor for prop aircraft). The 60%/70% factor applies for dry runways only.

When dispatching a flight to an aerodrome with a wet or contaminated runway, then the LDA must be such as to allow a landing with the estimated LW considering the 60%/70%-factor plus a 15% factor for a wet runway. When in flight and prior to commencing descent, the crew must consider the actual runway condition for the landing time.

For landing on a wet or contaminated runway and/or with system failures, the longer of the two distances must be used:

- prop a/c: dry unfactored distance x 1.43x1.15
- jet a/c: dry unfactored distance x1.67x1.15

OR:

- dry unfactored distance corrected for contamination and/or system failure x1.15

Note:

1. All type related performance data may be found in the AOM
2. Regardless of the AFM/AOM performance data a take off must not be made on runways with a reported braking action "poor" (or a braking coefficient less than 0.25). Same restriction applies to landings as well unless justified by an emergency.

1.17.1.3.2 Crew coordination

Regarding crew coordination, the OM A, section 1.4 AUTHORITY, DUTIES AND RESPONSIBILITIES OF THE COMMANDER, 1.4.2 "Flight" states the following, among other things:

In flight, the commander continues to coordinate the tasks/work of his cockpit team to obtain a maximum of good airmanship for the conduct of the flight. He ensures:

- ...
- *Observation of limitation, proper use and proper handling of the aircraft's systems, including strict use of check-lists,*
- ...

The OM C ROUTE AND AERODROME – INSTRUCTIONS AND INFORMATION, Section 11 "Aerodrome Categorization for Crew Competence", 11.3 "Aerodrome Competence" states the following, among other things:

Aerodrome competence for aerodromes category "A" and "B" is given once on each 12 months during the ground theoretical training for 2 practical hours in class.

....If a crewmember is going to perform flight to aerodrome category "A", not published in Part C, during the Preflight preparation he exams the schemes of the aerodrome and make a note in the "Flight Brief".

By judgement of the Chief pilot or by other means (repair, NOTAMS etc.) particular aerodrome category "A" is de-classified in category "B", or a crewmember must conduct a landing on aerodrome category "B" not published in OM- Part C, the dispatcher files "Flight Crew Notice Form" (reference OM-D Appendix No. 17) for preparation for this aerodrome, which must be noted in the "Flight Brief".

Moreover, by analogy with the above, 8.3.2.7 "Procedures" points out that there should be a division of tasks between the PF (pilot flying) and PNF (pilot not flying). A distinction is made between flying with and without the autopilot. Above

all it is emphasized how important reciprocal orientation by the two pilots is with regard to operations they carry out.

According to the definition in OM A, paragraph 8.1.2.3 "Airport Classification for the Commander's Competency", Samedan aerodrome is a category "B" aerodrome. It is not published in the list mentioned in the OM C.

1.17.1.3.3 Dealing with warnings

Furthermore, section 8.3 FLIGHT PROCEDURES, 8.3.5 "Proximity Warning System Procedure" states, among other things:

... As a general policy no GPWS warning signals/announcements shall be ignored, proper action shall be taken immediately! ...

1.17.2 The aircraft manufacturer, Cessna

1.17.2.1 General

The manufacturer of the Cessna aircraft, the "Cessna Aircraft Company", was founded in 1927 and has its headquarters in Wichita, Kansas. It builds small single-engined and twin-engined propeller aircraft and since 1965 has also built business aircraft, which are generally turboprop or jet aircraft. The Cessna company was purchased by General Electrics in 1985. In 1986, the building of jets continued, but production ceased for the single-engine reciprocating aircraft. In 1992, Textron Inc. purchased Cessna Aircraft Company and in 1996, production of the single-engine reciprocating aircraft resumed.

The main area of business of the current Cessna Aircraft Company is the Citation series of business jets, which are twin-jet business passenger aircraft. The development goals of the Citation included, among other things, the capability to take off from and land at aerodromes which are otherwise served only by twin-engined propeller aircraft. First deliveries of the Citation Model 500/501 started in August of 1971. The Citation I/SP was a production improvement to the Model 500/501, which began at unit 350. A total of 689 units of the Model 500/501 were delivered, with production ending in 1985.

Cessna introduced the Citation, Model 550/551 Citation II in 1979 and the Citation Classic in 1987. A total of 687 units of the Model 550/551 were delivered, with production ending in 1994. The Citation Bravo replaced the Model 550 and is still in production.

1.17.2.2 Limitations

The aircraft manufacturer's airplane flight manual (AFM), Section II – "Operating Limitations" publishes the following limitations, among others:

<i>Maximum Flap Extended Speed – V_{FE}</i>	
<i>Full Flaps – LAND Position (40°)</i>	<i>174 KIAS</i>
<i>Partial Flaps – T.O. & APPR Position (15°)</i>	<i>200 KIAS</i>
<i>Maximum Landing Gear Extended Speed – V_{LE}</i>	<i>260 KIAS</i>
<i>Maximum Landing Gear Operating Speed – V_{LO} (Extending)</i>	<i>250 KIAS</i>
<i>– V_{LO} (Retracting)</i>	<i>200 KIAS</i>

1.17.2.3 Operating procedures

The FAA-approved aircraft manufacturer's AFM, SECTION III – OPERATING PROCEDURES, NORMAL PROCEDURES contains no explicit instructions as to how the aircraft should be operated by two pilots (pilot flying – PF und pilot not flying – PNF). This section publishes the corresponding checklists for the individual flight phases; information in the sense of an expanded checklist is not provided.

Nor are there any explicit instructions in the aircraft manufacturer's OM (operating manual) on operating the aircraft with two pilots. The OM in SECTION I DESCRIPTION AND SPECIFICATIONS merely states that the minimum flight crew for all operations must consist of a pilot and a co-pilot. The checklists are identical to those in the FAA-approved AFM and contain additional explanations on the individual points in the form of an expanded checklist. Thus, for example, the following is stated for the APPROACH under point 6:

6. *Crew Briefing – COMPLETE.*

At this point brief the copilot/crew on the approach to be flown, procedures desired, and any unusual circumstances.

The remarks under the point BEFORE LANDING contain, among other things, the following under point 5:

5. *Airspeed – V_{REF}*

Consistently comfortable and safe landings are best achieved from a stabilized approach. The point at which the airplane should be stabilized with airspeed at V_{REF} to $V_{REF} + 10$, full flaps, and the desired descent rate is normally coincident with commencing the final descent to landing. ...

Speed control on final should be precise for optimum landing performance and this is best accomplished by establishing V_{REF} airspeed well before crossing the threshold. ...

Approaching within approximately 50 feet of airport elevation, power should be gradually reduced to counter the acceleration induced by ground effect. ... Retarding the throttles gradually in the final descent will normally result in idle thrust being reached just before touch down.

In SECTION IV PERFORMANCE GENERAL (STANDARD PERFORMANCE CONDITIONS) of the FAA approved AFM, the following criteria are published under LANDING (page 4-6):

- a. *Landing preceded by a steady three degree angle approach down to 50-foot height point with airspeed at V_{REF} in the landing configuration.*
- b. *Two engine thrust setting during approach was selected to maintain the three degree approach angle at V_{REF} .*
- c. *Idle thrust was established at the 50-foot height point and throttles remained in that setting until the airplane had stopped.*
- d. *Rotation to a three-point attitude after touchdown was accomplished at a normal rate.*
- e. *Hard wheel braking was initiated immediately on nose wheel contact and continued throughout the landing roll.*
- f. *The antiskid system was on during all tests.*
- g. *Speed brakes were not used.*
- h. *Thrust reversers were not used.*

CONDITIONS

<i>Wing flaps</i>	<i>Land</i>
<i>Engines</i>	<i>Two engines operating</i>
<i>Landing gear</i>	<i>Extended</i>
<i>Antiskid system</i>	<i>Operative</i>

In addition, the landing distance is defined as follows in the same section, under *DEFINITIONS*:

Landing Distance: The distance from a point 50 feet above the runway surface to the point at which the airplane would come to a full stop on the runway utilizing the techniques presented on page 4-6.

Landing distances are published in the same table for a landing mass of 14 800 lb. In this regard, the aircraft manufacturer comments:

For use in emergency that requires a landing at weight in excess of the maximum design landing weight of 13 500 pounds.

These calculations in the FAA-approved AFM SECTION IV are based on a dry runway. Additional information is contained in SECTION VII – ADVISORY INFORMATION. The following is stated therein under DATA FOR WET, SLUSH, SNOW AND ICE COVERED RUNWAYS, under PERFORMANCE:

The takeoff field length and landing distance tables presented in Section IV are based on a paved, dry runway. For takeoffs and landings on precipitation covered runways, use the following tables and correction factors. The performance data presented are based on weights up to the following weights:

<i>Takeoff Weight</i>	<i>14,800 Pounds</i>
<i>Landing Weight</i>	<i>13,500 Pounds</i>

WARNING

THESE DISTANCES AND CORRECTION FACTORS FOR WET AND ADVERSE RUNWAY CONDITIONS ARE APPROXIMATE AND ARE TO BE CONSIDERED MINIMUMS, AS ACTUAL RUNWAY CONDITIONS MAY REQUIRE DISTANCES GREATER THAN THOSE DETERMINED.

The following is also stated under *DEFINITIONS* (page 7-3):

Runway Contaminated *A runway surface condition where braking action is expected to be very low, due to presence of wet ice.*
by *Wet Ice*:

From the tables (Figure 7-7 and 7-8) it is apparent that for a landing distance (DRY RUNWAY WITHOUT THRUST REVERSE) of 2000 ft under WET ICE conditions, there results a landing distance of 16 300 ft. In the case of a V_{REF} over-speed of 10 knots, the result is a landing distance of 17 000 ft. Values for WET ICE conditions for landing distances in excess of 2000 ft on dry runways are not published.

Correction factors for corresponding braking coefficients or braking actions are not published.

1.18 Additional information

Not applicable.

1.19 Useful or effective investigation techniques

Not applicable.

2 Analysis

2.1 Technical aspects

There are no indications of any pre-existing technical defects which may have caused or contributed to the serious incident.

2.2 Human and operational aspects

2.2.1 Aircraft manufacturer

2.2.1.1 Procedures

SECTION VII – ADVISORY INFORMATION of the aircraft manufacturer's airplane flight manual (AFM) provides information on calculation of landing distance on contaminated runways. The landing distances for a dry runway surface published in SECTION IV – PERFORMANCE APPROACH AND LANDING – are used as a basis. A corresponding landing distance for adverse runway conditions is published in relation to a fixed landing distance for a dry runway surface. The following are listed under adverse runway conditions in tabular form: wet, water-covered runway-inches, slush covered runway-inches, snow-inches and wet ice. This information takes into account the two speeds V_{REF} and $V_{REF} + 10$ as described in chapter 1.17.2.3.

For a landing distance of 1200 ft on a dry runway surface, a landing distance of 6800 ft or 8000 ft respectively is required under "wet ice" conditions. For a landing distance of 2000 ft, a landing distance of as much as 16 300 or 17000 ft respectively is required under "wet ice" conditions. Figures in excess of these values are not published.

From this it can be easily concluded that on ice-covered runway surfaces operation with the Citation Bravo 550 is practically impossible. Runway surfaces which are only partially covered are not considered in the aircraft manufacturer's AFM. Furthermore, no correction factors for corresponding braking coefficients or braking actions are published. Thus, in practice the result is very conservative landing distances which greatly restrict operation in relation to contaminated runways.

In the aircraft manufacturer's operating manual OM there is only little information on the manner in which the aircraft is to be flown with two pilots. The division of tasks between the PF (pilot flying) and the PNF (pilot not flying) is not mentioned, even in relation to the use of checklists. Furthermore, no specific explanation is made of stabilised approaches; only the preconditions for calculating landing distances are specified. This leaves operators with a very great latitude of action. More precise information from the aircraft manufacturer on optimal operation of their aircraft would help to unify and improve conditions in training and in operation of the aircraft.

2.2.2 The operator

2.2.2.1 Crew duty times

Crew duty times are defined in the operator's operations manual (OM A) in chapter 7 FLIGHT LIMITATIONS. Paragraph 7.1.5 Reporting Times essentially allows 30 minutes for flight preparations (preflight duty).

There is no information on a time after the flight (postflight duty). This must be described as an error. The postflight duty must be known for calculation of rest times, otherwise these calculations are incorrect.

In the night preceding the serious incident on 24 January, from 22 to 23 January the minimum rest time was clearly not attained. It must remain open whether this violation had an effect on the serious incident.

2.2.2.2 Procedures

The procedures in the OM A and OM B published by the operator and relevant to the flight involved in the serious incident essentially conform to those contained in the aircraft manufacturer's AFM and OM. Some of them are described in greater detail and include additional limitations.

The conditions for calculation of landing distances are listed in the OM A in section 8.1.2.4 "Performance Considerations – Performance Class A Aircraft". It is mentioned that under JAR-OPS1 conditions the landing distance from the FAA-approved AFM must be multiplied by 1.67 to obtain the required landing distance. This corresponds to the JAR regulations as a safety factor of 40% is included and therefore the landing distance published in the AFM corresponds to 60% of the required runway length.

The operator further specifies that all landing distances for contamination and/or system failure must additionally be multiplied by a factor of 1.15. This additional safety margin may be described as appropriate. It provides a means of calculating the landing distance in all cases where the aircraft manufacturer does not publish landing distances.

The aircraft manufacturer's AFM does not include any information on possibilities of mathematical interpolation in the event that the tables are used for landing distance under adverse runway conditions. In this case the pilot would be able to apply the calculation formula according to the OM A section 8.1.2.4. In this regard, however, it must be stated that apart from the runway conditions "wet" and "compact snow" the method of calculation according to the OM A sometimes provides substantially shorter landing distances than those published by the aircraft manufacturer in its AFM. The operator should draw attention to this discrepancy in section 8.1.2.4 and should provide appropriate instructions.

The operator provides the following remark in the OM A, section 8.1.2.4:

AFM/AOM performance data at take off must not be made on runways with a reported braking action "poor" (or a braking coefficient less than 0.25). Same restriction applies to landings.

Since the aircraft manufacturer does not provide any information in this respect, this remark is meaningful to pilots.

Among other things, Section 11 "Aerodrome Categorization for Crew Competence", 11.3 "Aerodrome Competence" of the OM C, ROUTE AND AERODROME – INSTRUCTIONS AND INFORMATION, states that in the case of aerodromes such as Samedan aerodrome special regulations apply and must be included in the "Flight Brief". Neither of the pilots of the aircraft involved in the serious incident had complied with these special regulations. They were flying to Samedan for the first time. The operator should therefore not have allowed this flight to take place.

2.2.3 Flight crew

2.2.4 Calculations for take-off

The Flight Documentation Folder, which the crew received as preparation for the flight from Geneva to Samedan in Sofia, contained, among other things, a pre-printed flight plan (Jeppesen FliteStar, navigation log) from Geneva to Samedan, a fuel calculation for this flight and a corresponding weight and balance report. Since no information with the actual figures could be found either on this flight plan or on other notes, it must be assumed that the crew did not carry out any calculations using the latest actual figures.

Such a calculation would have indicated to the crew that they exceeded the maximum permitted take-off and landing mass for this flight. It must remain open whether they therefore deliberately refrained from making a calculation.

2.2.5 Calculations for landing

According to the take-off weight calculations based on the actual figures (cf. chapter 1.6.2.1), the resulting landing mass is 14 562 lb. This mass is above the maximum permitted landing mass of 13 500 lb.

It is not comprehensible why the crew took no notice of this circumstance. Landing masses in excess of 13 500 lb up to the maximum permitted take-off mass of 14 800 lb are, according to the aircraft manufacturer, permitted only in emergencies. The crew therefore exceeded also on landing the maximum certificated landing mass.

It must be assumed that the crew were not at all clear what length of runway they required in the prevailing weather and runway conditions or whether they were actually entitled to make a landing in Samedan.

According to the aircraft manufacturer's AFM, an unfactored landing distance of 3760 ft and a V_{REF} of 111 KIAS would have resulted for a dry runway and a maximum permitted landing mass of 13 500 lb under the Samedan weather conditions. A landing mass of 14 800 lb results in a landing distance of 4860 ft and a V_{REF} of 117 KIAS.

If one takes into account the operator's guidelines in the OM A, section 8.1.2.4, there results a required runway length of 6279 ft (3760x1.67) and 8116 ft (4860x1.67). The available runway length in Samedan was 5906 ft. Thus under JAR OPS regulations a landing should not have taken place even on a dry runway surface.

According to the commander's statement, during the flight from Sofia to Geneva, when they were in the Samedan area, the crew informed themselves about the weather in Samedan. They listened to the 11:20 UTC ATIS report, which in his recollection forecast a cloud ceiling at 3000 ft for Samedan airport and reported the braking action as "poor".

According to the operator's OM A, section 8.1.2.4, a landing in the event of a reported "poor" braking action is not allowed, except in emergencies. This condition did not change until the 13:30 UTC aerodrome weather report. Thus, the aerodrome was closed for the crew of VBC 3004 throughout the morning, until after the planning. It should be noted that the crew received the following report at 14:52:16 UTC from the Samedan FISO concerning the condition of the runway: *"Victor zero four for your information the runway is seventy five percent covered with ice and the braking action is poor"*. The copilot gave the com-

mander this information and the continuation of the flight was discussed in the cockpit. However, this discussion related to the visibility. The reported runway condition, which according to the operator's procedures should not have permitted a landing in Samedan at all, was not discussed by the crew.

In the 13:30 UTC aerodrome weather report the runway condition was described as follows: snow clearing in progress, runway wet, braking action "medium".

If this runway condition is used as a basis for calculation, according to the operator's OM A, section 8.1.2.4, for wet or contaminated runways there results a required runway length of 7221 ft (3760x1.67x1.15) and 9334 ft (4860x1.67x1.15).

According to the aircraft manufacturer's AFM, SECTION VII – ADVISORY INFORMATION Fig. 7-7 (adverse runway conditions), the interpolated values come to 5910 ft and 7698 ft. According to the operator's OM A, these unfactored landing distances still have to be multiplied by 1.15. This produces required runway lengths of 6797 ft and 8852 ft. Moreover, according to the operator's OM A, the longer of the two specified runway lengths must be used.

All calculated landing distances are longer than the 5906 ft available runway length in Samedan.

In summary it can be said that a landing of flight VBC 3004 should not have taken place in Samedan under the prevailing conditions.

2.2.6 Operation of the aircraft

Among other things, sections 1.4.2 and 8.3.2.7 of the operator's OM A provide some remarks on how the aircraft should be operated with two pilots. It is specified that the commander should coordinate the division of tasks in the cockpit and that when manipulations are carried out in the cockpit reciprocal orientation should take place.

The CVR (cockpit voice recorder) recordings during the last 30 minutes of the flight indicate no recognizable cooperation within the crew. Neither on extending the gear at 14:56:07 nor on setting the flaps in the two positions APPR and LAND is any corresponding order heard from the commander, acting on this flight as pilot flying (PF); nor is there any confirmation from the co-pilot in his assisting role as pilot not flying (PNF).

The question about visual contact was answered with the comment that the mountain peaks would be visible. It must be assumed that the visual contact reported to Samedan aerodrome at 14:55:10 UTC had been lost again. Subsequently, at 14:55:38 UTC, a clockwise three sixty was initiated. During this manoeuvre, "*climb*" was called out loudly twice at 14:56:14 UTC. It must be assumed that the topography in the area caused this call-out. A shallow climb was then initiated. The landing gear was not retracted. The pitch and bank angle recordings (Annex 2) indicate very nervous handling of the controls.

The crew replied to the question from the Samedan FISO at 14:59:12 UTC about their position as follows: "*We are overhead on heading zero three seven and we are turning back*". The choice of words: "*we are turning back*" caused the FISO to think that the crew no longer wished to fly to Samedan. He therefore instructed them to change back to the ADDC frequency. The ADDC ATCO also assumed that the crew would be flying to an alternate airport. Only in response to the corresponding question from the ADDC ATCO did the crew clarify the situation, stating that they would attempt another approach in Samedan. At this time the crew had again initiated a three sixty, this time counter-clockwise. Once

again, the pitch and bank angle recordings during this three sixty indicate very nervous handling of the controls. (Annex 3). The non-optimal choice of words by the crew and the resulting frequency change contributed eventually to this unclear situation.

When the crew reported to the ADDC ATCO at 15:00:33 UTC that they once again had visual contact with Samedan airport and could change to its frequency, the aircraft, still in the anti-clockwise three sixty, had increased its speed slightly up to maximal 269 knots. It exceeded the maximum permitted speed for flying with the gear down for 16 seconds. Shortly before, there was again a controversial discussion in the cockpit about possible visual contact. From this it can be concluded that the situational awareness was missing during this phase of the flight.

During this anti-clockwise three sixty, the aircraft crossed the centre line of runway 03, turned further onto a northerly heading and then corrected its heading in the direction of the runway centre line. In the process the runway centre line was again crossed. The recordings indicate massive pitch and bank angle corrections during this flight phase. Only 21 seconds before touchdown on the runway the acoustic warning *"sink rate, pull up, pull up"* sounded in the cockpit. The commander mentioned briefly that he might perhaps go around, but immediately decided to land. This decision corresponded neither to the guidelines applicable to the commander regarding "good airmanship" nor to the procedures laid down in the operator's OM A in section 8.3 FLIGHT PROCEDURES under 8.3.5 "Ground Proximity Warning System Procedure".

The course of events in the final approach phase, in which the flaps were extended to the LAND position at a speed which was 22 knots too high and the speed brakes were deployed and retracted three times, indicates that the crew were overburdened. No intervention from the copilot is audible during this phase.

In the crew's work, neither systematic dispositions or orientations by the pilot flying nor monitoring or intervening behaviour on the part of the pilot not flying were detectable.

The conditions as specified by the aircraft manufacturer in its AFM (cf. chapter 1.17.2.3) regarding aircraft configuration, speed and stability were not met.

When, according to eye witnesses and physical traces, the aircraft touched down just before the half-way point of the runway, its speed was 128 knots. This speed was 17 knots above the published speed for a maximum landing mass of 13 500 lb and 11 knots above that for a landing mass of 14 800 lb. This should be seen as a further indication of the crew being overburdened.

It is not comprehensible why the speed brakes were retracted just before touchdown. The aircraft is certified to land with the speed brakes deployed and this would have helped to reduce the excessive speed prior to landing and to shorten the landing distance after landing, as a result of their braking effect.

Reverse thrust was applied after touchdown. It is not comprehensible why the speed brakes were not deployed. According to the commander's statement, shortly before the runway end he had brought reverse thrust power back to idle and eased up slightly on the foot brakes. When he realised that he was still approaching the runway end relatively quickly, he again applied the foot brakes to maximum effect. This statement does not make sense as it must have been clear to the commander as soon as he touched down that it would be critical to bring the aircraft to a standstill on the runway.

It is much more likely that the aircraft's slight drift to the right caused the commander to retract the reverser buckets, reduce brake pressure and re-align the aircraft on the runway centre line. The one metre high walls of snow along the runway, only 4 metres from the runway edge line, may have reinforced this reaction. The fact that reverse thrust was re-applied only two seconds later may have been an instinctive reaction, as the buckets were still deployed after the aircraft came to a standstill in the snow.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The aircraft was licensed for VFR/IFR transport.
- The investigation produced no indications of any pre-existing technical defects which might have caused or influenced the serious incident.
- The last scheduled maintenance work took place at 817:49 hours (499 cycles) on 04.01.2007.

3.1.2 Crew

- The pilots were in possession of the necessary licences for the flight.
- There are no indications of the pilots suffering any health problems during the flight involved in the serious incident.
- The minimum rest time was clearly not attained by both pilots in the night preceding the serious incident.
- Both pilots were flying to Samedan for the first time.
- No adequate weather and hazard analysis was made for an approach and landing on a mountain aerodrome.
- Coordinated working by the commander, acting as pilot flying (PF) on this flight, and the copilot in an assisting role as pilot not flying (PNF), did not take place.
- In the crew's work, neither systematic dispositions or orientations by the pilot flying nor monitoring or intervening behaviour on the part of the pilot not flying are detectable.
- An appropriate reaction to the acoustic warnings from the ground proximity warning system did not take place.

3.1.3 History of the flight

- After the crew had received clearance at 14:46:34 UTC to fly direct to the destination airport, they subsequently discussed the visibility and the possibility of penetrating the cloud cover over the destination airport.
- At 14:53:35 UTC the crew informed the ADDC ATCO that they had ground contact, upon which the ATCO instructed them to fly strictly according to VFR.
- At 14:55:10 UTC, the crew reported to the Samedan airport "Flight Information Service Officer" (FISO) that they would see the airport.
- The crew subsequently discussed making the planned approach for about three minutes. The question about visual contact was answered in the negative, followed by the comment that the mountain peaks would be visible.
- At 14:56:14 UTC, one crew member gave the loud call-out "*climb!*" and a shallow climb was initiated.
- The maximum permitted speed with the landing gear extended was exceeded for 16 seconds.

- The maximum speed for extending the landing flaps to the LAND position was exceeded by 22 knots.
- The question in the cockpit about visual contact at 14:58:16 UTC was answered in the negative.
- At 15:00:56 UTC the crew informed the FISO that they had the aerodrome in sight and would descend.
- During both three sixties flown, the acoustic warning "*bank angle*" sounded. The FDR recordings indicate bank angles of 58 and 64 degrees respectively.
- The recordings indicate attitude changes from 12° AND (attitude nose down) up to 7° ANU (attitude nose up).
- Shortly before landing, the acoustic warning "*sink rate, pull up, pull up, pull up*" sounded twice in the cockpit followed by the warning "*bank angle, bank angle*".
- On final approach, the aircraft was never stabilised in terms of bank angle, pitch angle, aircraft configuration and speed and touched down on the runway too late and at too high a speed.
- According to the FDR recordings, immediately after landing the reverse thrust buckets were deployed. The speed brakes remained retracted.
- It was not possible to bring the aircraft to a standstill on the runway, it rolled over the runway end at a speed of approximately 30 knots and came to a standstill in the snow after 20 metres.

3.1.4 General conditions

- The procedures in the operator's OM A concerning calculation of landing distances on non-dry runway surfaces are not congruent with those in the aircraft manufacturer's FAA-approved AFM.
- The aircraft's maximum permitted take-off mass was exceeded during the planning and execution of the take-off.
- According to the operator's OM A, the runway condition reported by the Samedan FISO at 14:52:16 UTC should not have allowed a landing in Samedan.
- The procedures of the aircraft manufacturer and of the operator for a safe landing were not complied with.
- The meteorological conditions did not have any influence on the unstabilised approach.

3.2 Causes

The serious incident is attributable to the fact that the crew, after an unstabilised approach, landed the aircraft with an excessively high landing mass, at an excessively high speed, too late and were no longer able to bring it to a standstill on the runway.

The following factors contributed to the serious incident:

- inadequate flight preparation by the crew
- inadequate weather and hazard analysis for an approach and landing on a mountain aerodrome.
- a lack of coordination, corrective support and reaction within the crew.

4 Safety recommendations and measures taken since the serious incident

4.1 Safety recommendations

None.

4.2 Measures taken since the serious incident

4.2.1 By the Federal Office of Civil Aviation

By revision No. 08 dated 28 August 2008, the FOCA demanded, among other things, the following manual correction AREA 4/VAC 13:

AD im Gebirge: Einweisungsflug empfohlen

[AD in mountains: familiarisation flight recommended]

4.2.2 By the operator

The operator stated in a letter, dated 16 September 2009, among other things the following:

Please, kindly be informed for the measures taken after the aircraft flight back to Sofia, as follows:

- *According to Safety recommendations of the Bulgarian Civil Aviation Authorities our crew had the Ground School in our training center covering the landings at High Altitude Airports and flight operations in heavy winter conditions;*
- *The crew operated on Flight VBC 3004 had the Simulator session with the instructor from the CAA before to re-start their normal activities;*
- *The crew had the line check flight.*

Payerne, 20 October 2009

Aircraft Accident Investigation Bureau

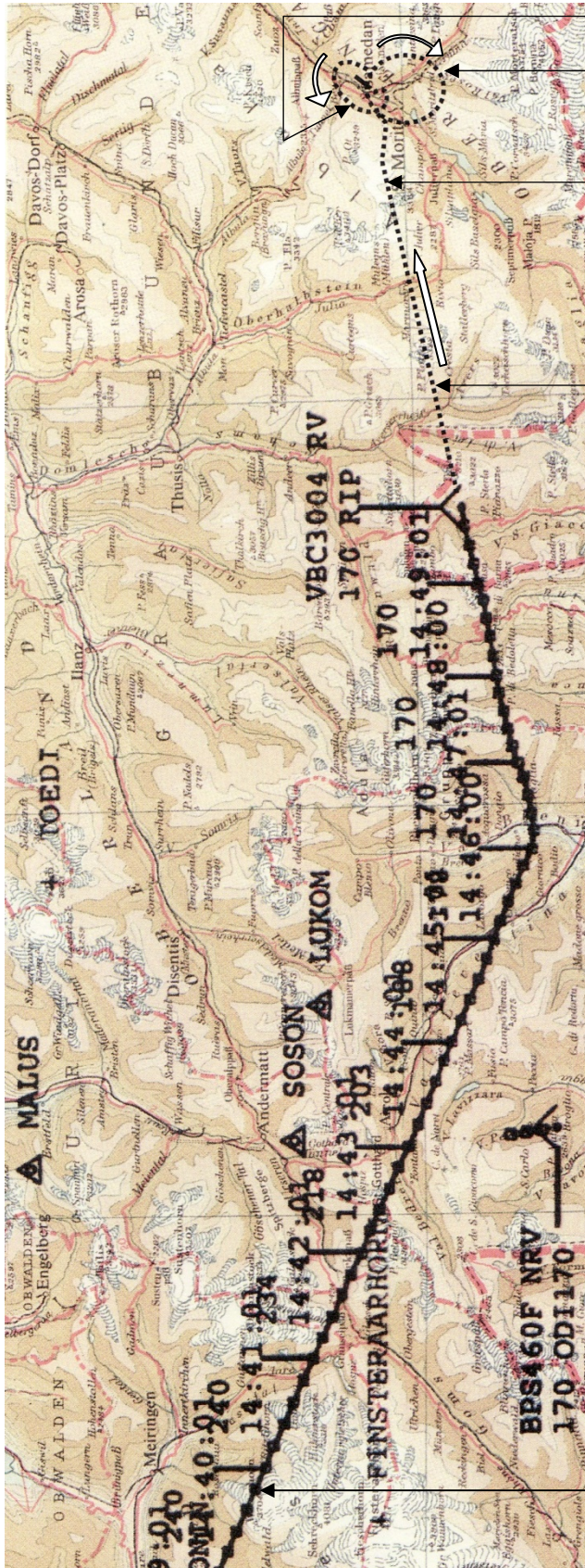
This report contains the AAIB's conclusions on the circumstances and causes of the serious incident which is the subject of the investigation.

In accordance with art 3.1 of the 9th edition, applicable from 1 November 2001, of Annex 13 to the Convention on International Civil Aviation (ICAO) of 7 December 1944 and article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the incident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

Annexes

Annex 1: Flight path of flight VBC 3004



14:50:45 UTC
 Crew cancels IFR flightplan
 PA: 17 000 ft CAS: 221 kt heading: 075°

14:53:35 UTC
 Crew informs ATCO that they have ground contact and requests a heading of 100° and a descent to FL 140
 PA: 14 712 ft CAS: 237 kt heading: 077°

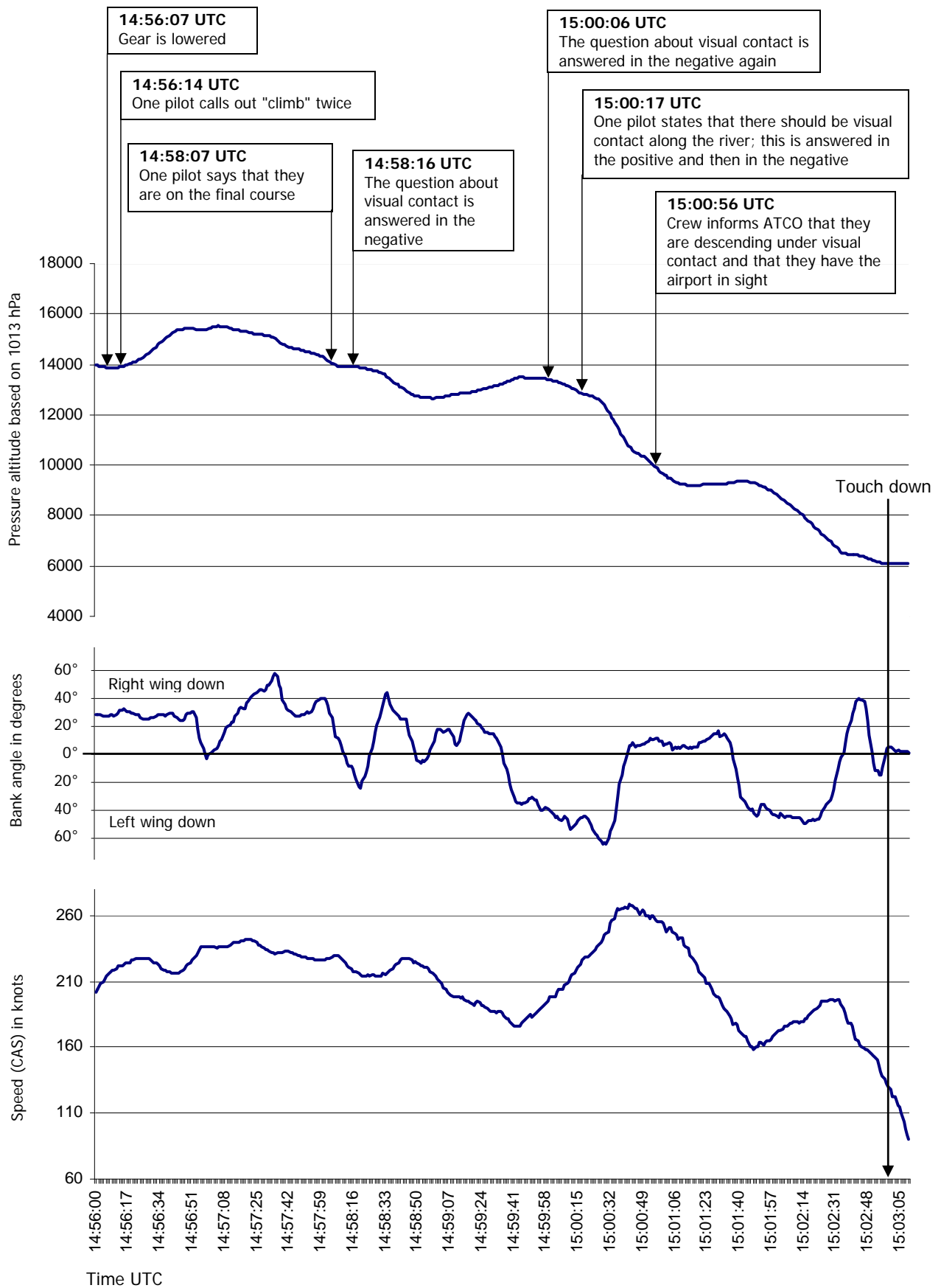
14:56:14 UTC
 One pilot calls out "climb" twice and a shallow climb is initiated
 PA: 13 912 ft CAS: 222 kt heading: 110°

15:00:56 UTC
 Crew informs ATCO that they are descending under visual contact and that they have the airport in sight
 PA: 9932 ft CAS: 256 kt heading: 212°

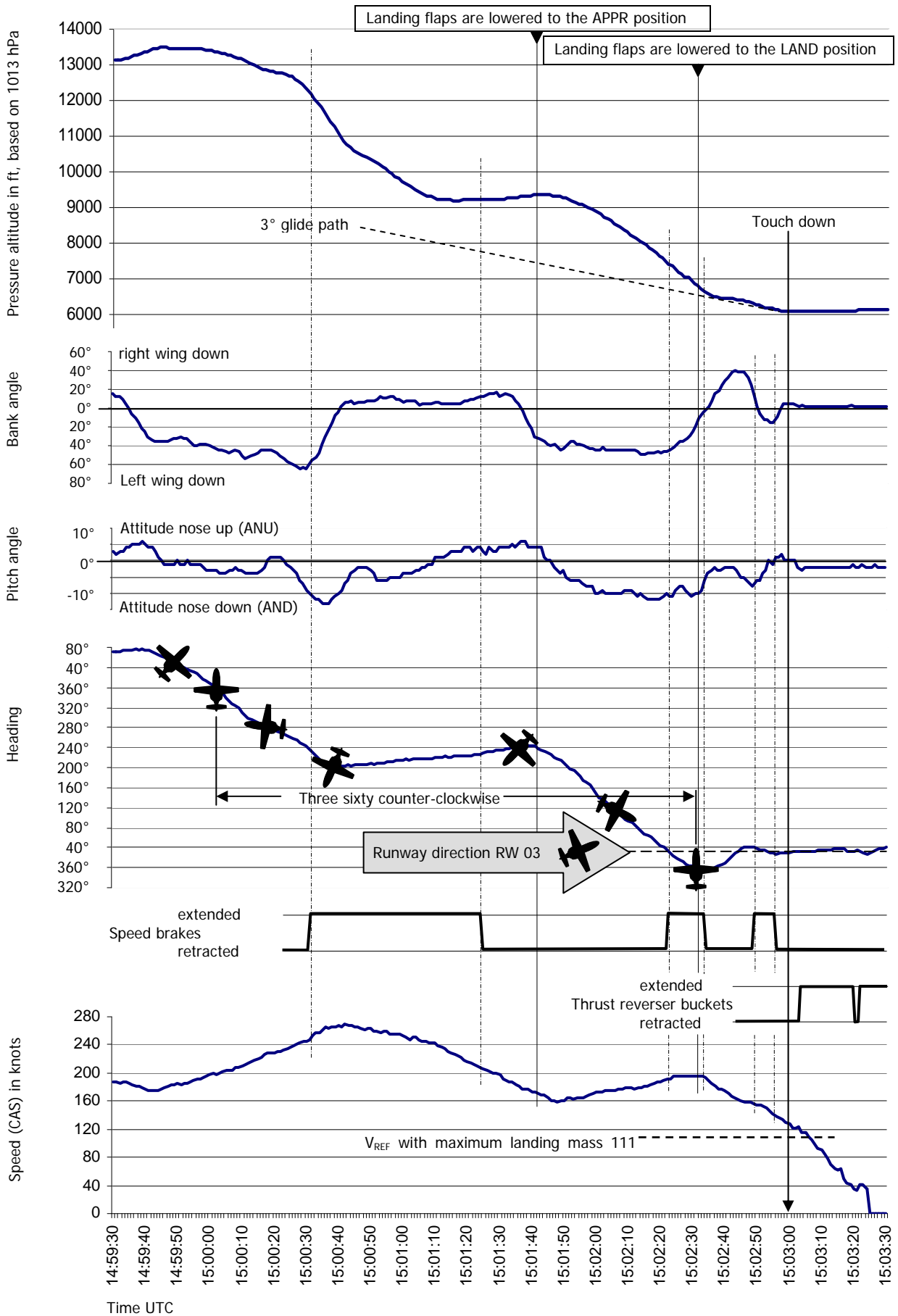
Flightpath according radar plot
 reconstructed flightpath

PA: Pressure altitude based on standard pressure of 1013 hPa
 CAS: Computed airspeed in knots

Annex 2: History of the flight during the last seven minutes



Annex 3: History of the flight from FL 130 to landing

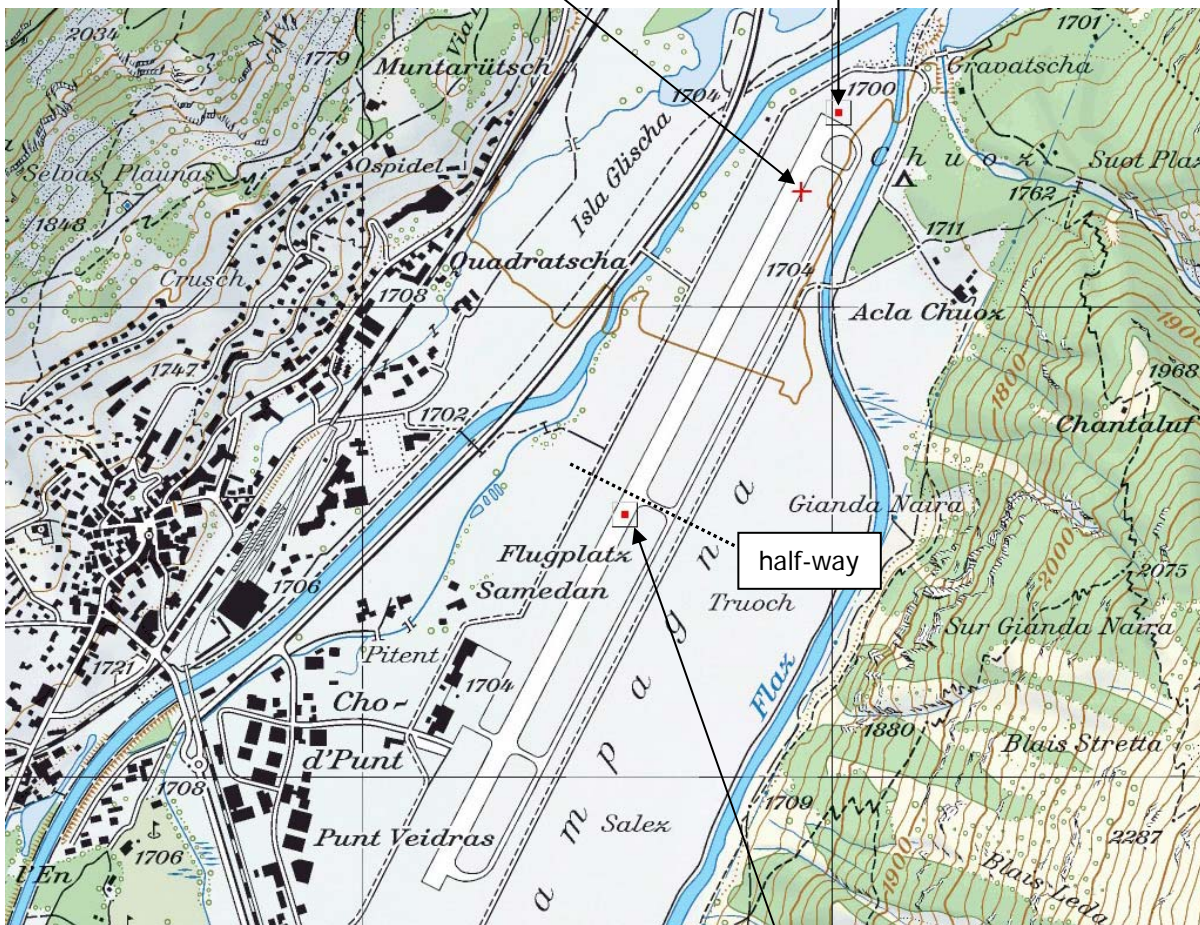


Annex 4: Marks on the runway in Samedan



Right main gear drifts 30 cm beyond the right runway edge line

End position of the aircraft (20 m after runway end)



half-way

Touch down point (915 m before runway end and 440 cm right of centerline)