

Investigation Report

Identification

Type of Occurrence:	Accident
Date:	21 March 2013
Location:	Berlin
Type of aircraft:	Helicopter
Manufacturer / Model:	1. Eurocopter / EC155 B 2. Eurocopter / AS 332 L1
Injuries to Persons:	One person fatally, four people severely injured and five people with minor injuries
Damage:	Both aircraft seriously damaged
Other Damage:	Damages to fields and vehicles
Information Source:	Investigation by BFU
State File Number:	BFU 3X010-13

This investigation was conducted in accordance with the regulation (EU) No. 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and the Federal German Law relating to the investigation of accidents and incidents associated with the operation of civil aircraft (*Flugunfall-Untersuchungs-Gesetz - FIUUG*) of 26 August 1998.

The sole objective of the investigation is to prevent future accidents and incidents. The investigation does not seek to ascertain blame or apportion legal liability for any claims that may arise.

This document is a translation of the German Investigation Report. Although every effort was made for the translation to be accurate, in the event of any discrepancies the original German document is the authentic version.

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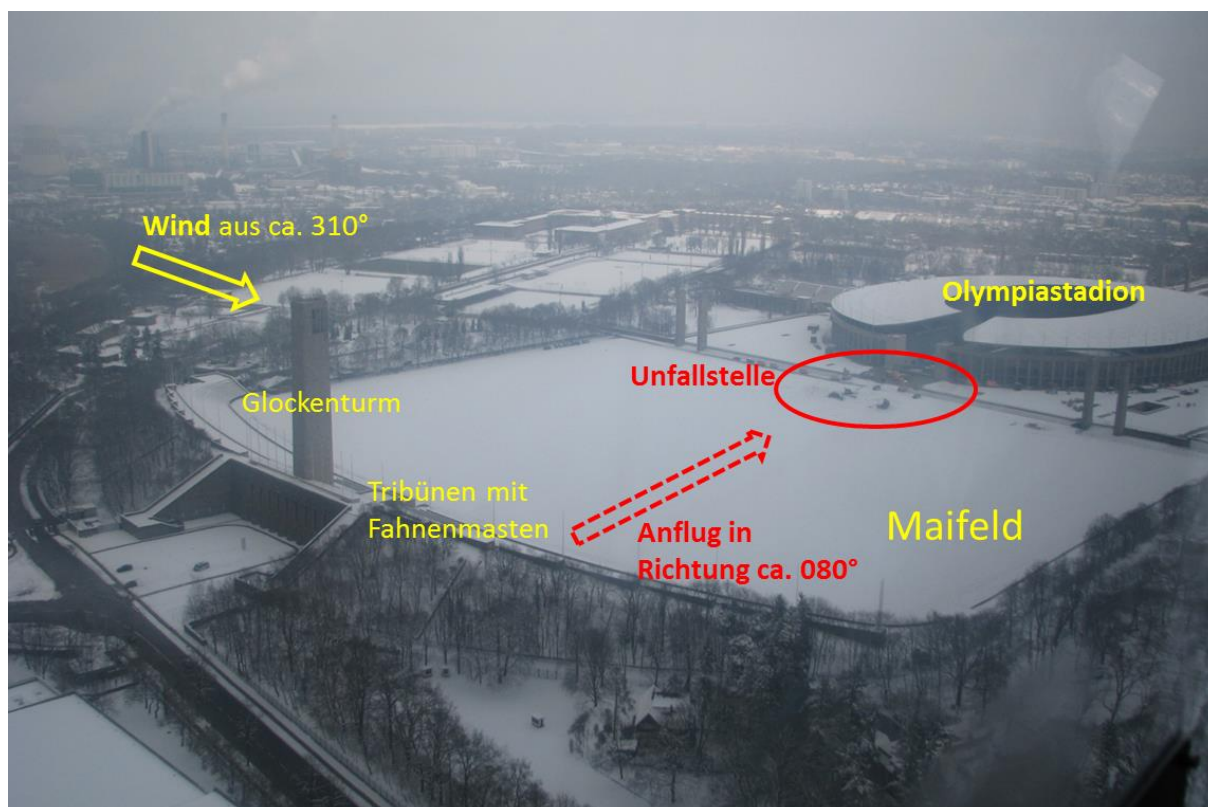
Abbreviations

AOM	Aircraft Operation Manual
AOP	Aircraft Operation Procedure
ARC	Airworthiness Review Certificate
ATPL(H)	Airline Transport Pilot Licence (Helicopter)
BFU	German Federal Bureau of Aircraft Accident Investigation
BIV	Night Vision Goggle
CCC	Crew Coordination Concept
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
DWD	German Meteorological Service
EASA	European Aviation Safety Agency
EHEST	European Helicopter Safety Team
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FOH	Flight Operations Handbook
FDR	Flight Data Recorder
FSF	Flight Safety Foundation
GPS	Global Positioning System
HCM	HEMS Crew Member
HEMS	Helicopter Emergency Medical Services
JAR	Joint Aviation Requirements
LBA	Luftfahrt-Bundesamt
LuftPersV	Regulation on Personnel Licensing
LuftVG	Federal Aviation Act
MCC	Multi Crew Cooperation
METAR	Meteorological Aerodrome Report

MTH	Medium Transport Helicopter
NM	Nautical Mile
PDV	Police Service Regulation
PF	Pilot Flying
PIC	Pilot in Command
PNF	Pilot Non Flying
QNH	Barometric air pressure

Synopsis

Three helicopters had to transport German Federal Police Forces to the Olympia Stadium in Berlin for exercise purposes. At about 1029 hrs¹ two helicopters collided on the ground during the landing. One pilot was killed and several other people suffered severe or minor injuries by wreckage parts flying through the air.



Overview Maifeld, Olympia Stadium and accident site

Photo: BFU

The loss of orientation and the resulting loss of control of the helicopter landing last and the subsequent collision of two helicopters on the ground under whiteout conditions were caused by:

Immediate Causes:

- Insufficient crew communication during the approach and landing
- The chosen approach procedure resulted in re-circulating snow which engulfed the helicopter even before it touched down
- Loss of visual contact with the reference point (marshaller) in the re-circulating snow

¹ All times local, unless otherwise stated.

- Loss of visual contact with the ground due to snow crust underneath the powder snow
- After the visual contact with the reference point was lost the landing was not aborted immediately
- The distances between the buses and the marshallers in front of them, as landing markers for the helicopters, were short

Systemic Causes:

- Missing and partially contra-productive instructions concerning crew communication
- Insufficiently described procedures and training of the crews regarding snow landings
- Non-binding procedures for minimum distances between helicopters on the ground

1. Factual Information

1.1 History of the Flight

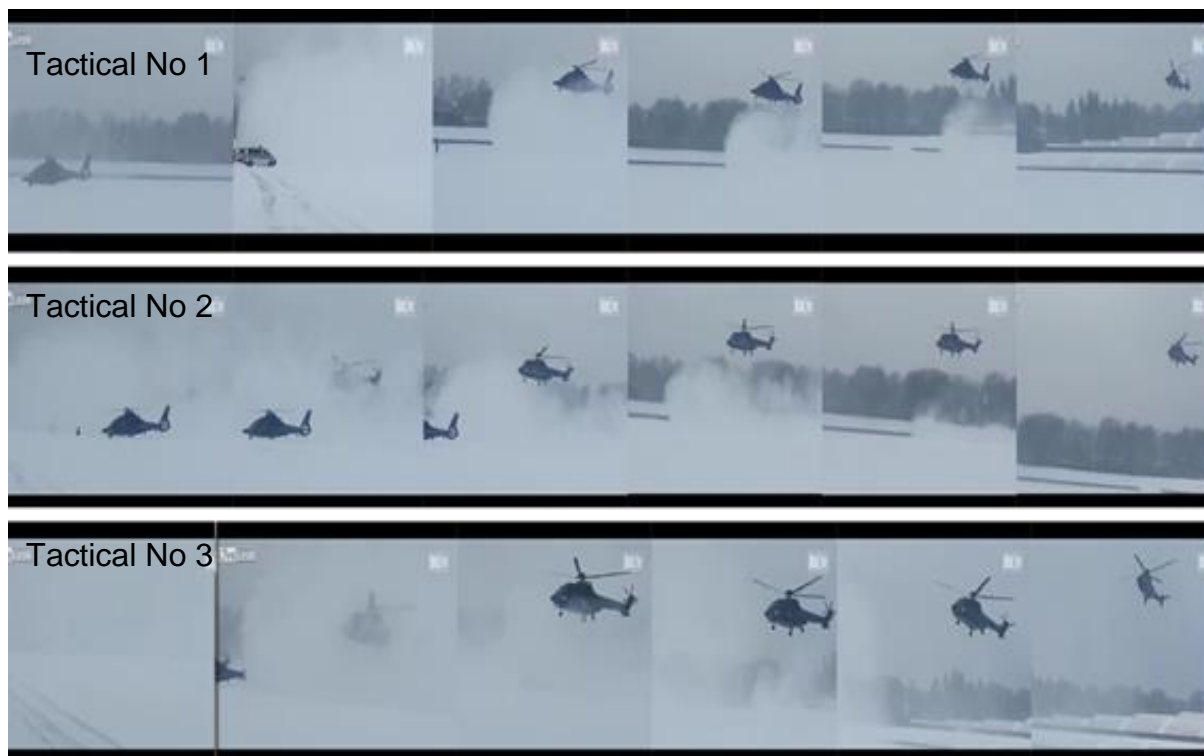
At about 1012 hrs three helicopters of the German Federal Police Flying Squadron at Blumberg took off to fly to the commuter railway station at the Olympia Stadium in Berlin. The helicopters carried the identifiers Tactical No 1 to Tactical No 3. According to the Cockpit Voice Recorders (CVR), the formation flew two full circles above the Olympia Stadium due to instructions from the ground crew, because top-ranking police representatives had not yet arrived. After the ground crew had issued the landing clearance the approach was begun. The pilot of Tactical No 1, flying in front, signed off the formation for landing with Tegel Tower. The pilot of Tactical No 3, flying in the last position, confirmed that all landing gears were extended. The pilot of Tactical No 2 instructed to increase the distance between the helicopters for the approach to the snow-covered Maifeld. On the eastern edge of the Maifeld three buses with flashing blue lights were positioned as landing markers for the helicopters. Approximately 15 m in front of each bus, one marshaller was positioned on the snow-covered Maifeld as additional reference point. The marshalls wore yellow reflective vests and safety helmets.

According to video recordings, which were made available to the BFU, showing the course of the accident, and the CVRs, Tactical No 1 landed first. Tactical No 1 was an EC155 B occupied by one pilot, one flight engineer, seven tactical forces and one journalist. During the approach the flight engineer referred via intercom to the extended landing gear, the visual contact with the marshaller and the individual flagpoles. After the flagpoles had been passed, he reported the developing re-circulating snow and the visual contact he still had. The pilot acknowledged all reports with a short "Ja" (Yes) or "Okay". The video recordings show that at about 1028 hrs with the decrease of speed during the approach and landing the rotor downwash caused re-circulating snow. From approximately 10 m AGL until touch-down the helicopter was engulfed by snow. On enquiry by the BFU the flight engineer stated that he had been surprised by the snow depth and the re-circulating snow because the crew had assumed slush or wet snow. But the re-circulating snow had not been a problem; he had had sufficient visual contact with the reference points at all times. The pilot's control of the helicopter and the parameters had been normal. That is why he had not given the pilot any further information or indications.

The second helicopter to land was Tactical No 2, an AS 332 L1, occupied by one pilot, one flight engineer and fourteen tactical forces. Tactical No 2 approached right of Tactical No 1 which was contradictory to the landing position agreed on prior to take-off. The crew stated the decision had been made because of the observed re-circulating snow and the drift of it. Because Tactical No 2 had changed their landing position, Tactical No 3 enquired and received the instruction to land left of Tactical No 1. The video recordings show that the approach of Tactical No 2 was rather steep with slow forward speed. Already during the descent the helicopter caused snow to recirculate and was engulfed by it. The crew stated that they had had visual contact with the marshaller or Tactical No 1 at all times. Prior to the final touch-down the helicopter hovered for about 30 seconds forward and backward and caused snow to re-circulate the entire time. The pilot stated that hovering was prolonged a little in order to achieve better positioning and alignment with Tactical No 1. The re-circulating snow engulfed Tactical No 1. The pilot of Tactical No 1 observed the slow touch-down of Tactical No 2 and commented: "Er hat zu früh die Fahrt herausgenommen (he decelerated too soon). Na ja, ihr seht jetzt was das für ein Problem ist, man hat keine Referenz mehr" (Now you can see what problem this is, one has no reference point any more). And: "Er geht jetzt nach hinten mit der Maschine (He now goes backward with the machine). Das ist sehr gefährlich" (This is very dangerous).

At that time Tactical No 3, also an AS 332 L1, was on approach already. It was occupied with one pilot, one flight engineer and thirteen tactical forces. According to the agreed change the helicopter approached left of Tactical No 1. During the approach the re-circulating snow around Tactical No 1 was observed and described as moderate. After passing the stand the helicopter curved left and while decelerating it was slightly left of the corresponding marshaller (viewed from the approach direction). The flight engineer confirmed that the landing gear had been extended, asked the pilot if he could see the marshaller and turned off the heating. The pilot acknowledged this information either with "Ja" (Yes) or "Okay". The video recordings show that the helicopter hovered with reduced forward speed slowly to the right during the descent. It also caused re-circulating snow which engulfed the marshaller and the two helicopters already on the ground. During touch-down the flight engineer reported "Ja null Fuß, oh" (Yes zero feet, oh) before the CVR recording stopped. The Pilot stated that until the flare and the complete deceleration about 2 m in front of the marshaller he had had visual contact with the marshaller at all times. The increased

re-circulating snow had made the image of the marshaller somewhat diffuse and then he suddenly disappeared entirely.



Approaches of the three helicopters

Source: Excerpts Video YouTube™

One video recording showed that the helicopter hovered past the right of the marshaller, the nose wheel and the right main landing gear had ground contact, then the helicopter rolled to the right, and at about 1029 hrs it disappeared in the re-circulating snow. Rotor blade parts and other debris flew from the re-circulating snow.

The marshaller of Tactical No 3 stated that he saw the approaching helicopter swing towards him. Then the re-circulating snow had reached him and he could no longer see the helicopter. He saw the landing light of the approaching helicopter about 2 m obliquely above him and then the downwash pushed him backwards to the right. Except for the landing light he had seen nothing, neither the fuselage nor the rotor of the helicopter (see series of photos in the appendix).



Approach and re-circulating snow during the landing of Tactical No 3



Overview accident site

Photos (3): BFU

The flight engineer of Tactical No 1 stated that he had seen the approaching Tactical No 3 from the corner of his eye. It had disappeared briefly in the re-circulating snow, then it could be seen again in the 10-o'clock position in front of the Tactical No 1 rolling, and crashing onto its side and the rotor blade ends of both helicopters got intermeshed.

1.2 Injuries to Persons

The pilot of Tactical No 1 was fatally injured by debris. Two passengers of Tactical No 1 and two bystanders were severely injured. The flight engineer of Tactical No 1, the pilot of Tactical No 3, and three other people suffered minor injuries. The other passengers of the helicopters were able to disembark without assistance.

Injuries	Crews	Passengers	Third Party
Fatal	1		
Serious		2	2
Minor	2		3

1.3 Damage to Aircraft

After the re-circulating snow had settled again, Tactical No 3 was lying on its right fuselage side and was severely damaged. The rotor blades were destroyed and the tail was severed.

Tactical No 1 was severely damaged and was lying on the fuselage bottom in approximately 90° to the touch-down position. The rotor was destroyed and the tail bent.

Tactical No 2 was undamaged except for claw marks on one rotor blade.

1.4 Other damage

One of the buses used as landing marker was severely damaged and the fencing of the Maifeld in the direction of the Olympia Stadium was slightly damaged by debris.

1.5 Personnel Information

1.5.1 Crew Tactical No 1 (EC155 B)

Pilot

The 40-year-old pilot held an Airline Transport Helicopter Pilot's License (ATPL(H)) issued in accordance with ICAO; valid until 22 June 2014. He had the ratings as Pilot in Command (PIC) for AS332/EC225 and EC155. He was licensed for flights according to instrument flight rules.

His class 1 medical certificate was last issued on 18 September 2012 and valid until 17 October 2013.

He had a total flying experience of about 3,841 hours; about 928 hours of which were flown on the EC 155 B. Within the last 90 days he had flown about 27 hours and within the last 30 days about 14 hours on the EC 155 B.

Flight Engineer

The 55-year-old flight engineer held an open-ended flight engineer license for helicopters; initially issued on 7 June 1984. He held the ratings for servicing the AS332/EC225, EC155 and SA330.

His latest class 1 medical certificate was issued on 25 June 2012 and valid until 19 July 2013.

He had a total flying experience of about 3,197 hours; about 446 hours of which were flown on the EC155 B. Within the last 90 days he had flown about 25 hours and within the last 30 days about 13 hours on the EC 155 B.

1.5.2 Crew Tactical No 2 (AS 332 L1)

Pilot

The 45-year-old pilot held an Airline Transport Helicopter Pilot's License (ATPL(H)) issued in accordance with ICAO; valid until 4 December 2014. He had the ratings as PIC for AS332/EC225 and EC135P/135T. He was licensed for flights according to instrument flight rules.

His class 1 medical certificate was last issued on 14 March 2013 and valid until 22 April 2014.

He had a total flying experience of about 4,140 hours. Of which he had flown about 30 hours within the last 90 days and about 15 hours and within the last 30 days.

During this mission he was the formation leader.

Flight Engineer

The 42-year-old flight engineer held an open-ended flight engineer license for helicopters; initially issued on 10 December 1996. He held the ratings for servicing the AS332/EC225 and EC135P/135T.

His class 1 medical certificate was last issued on 3 December 2012 and valid until 12 January 2014.

He had a total flying experience of about 4,369 hours. Within the last 90 days he had flown about 25 hours and within the last 30 days about 10 hours.

1.5.3 Crew Tactical No 3 (AS 332 L1)

Pilot

The 53-year-old pilot held an Airline Transport Helicopter Pilot's License (ATPL(H)) issued in accordance with JAR-FCL; valid until 28 September 2014. He had the ratings as PIC for AS332/EC225 and EC155. He was licensed for flights according to instrument flight rules.

His class 1 medical certificate was last issued on 4 March 2013 and valid until 29 March 2014.

He had a total flying experience of about 4,577 hours; about 585 hour of which were on the AS 332 L1. Within the last 90 days he had flown about 24 hours and within the last 30 days about 13 hours on the AS 332 L1.

Squadron leader and other crew members stated that he was very experienced in regard to landings on snow due to his long-time flying experience in the mountains. During the briefing he had requested to have the marshallers in front of the buses as additional reference points due to the unclear snow situation.

Flight Engineer

The 46-year-old flight engineer held an open-ended flight engineer license for helicopters; initially issued on 12 December 1996. He held the ratings for servicing the AS332/332L2 and EC135P/135T.

His class 1 medical certificate was last issued on 23 November 2012 and valid until 15 December 2013.

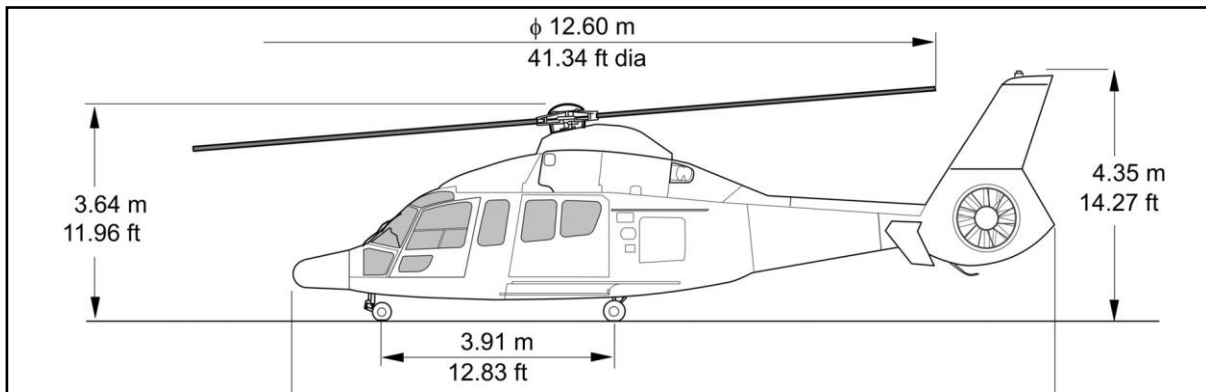
He had a total flying experience of about 3,092 hours; about 251 hours of which were flown on the AS 332 L1. Within the last 90 days he had flown about 15 hours and within the last 30 days about 1 hour on the AS 332 L1.

1.6 Aircraft Information

1.6.1 Tactical No 1 (EC155 B)

The twin-engine helicopter EC 155 B manufactured by Eurocopter is a multi-purpose helicopter for up to 15 occupants. This model succeeded the SA 365. It is equipped

with two Turbomeca Arriel 2C1 engines, a five-blade main rotor and a retractable wheel landing gear. Maximum take-off mass is 4,800 kg. In 2000 the helicopter type was certificated in accordance with JAR 29. As minimum crew one pilot in the right seat is required.



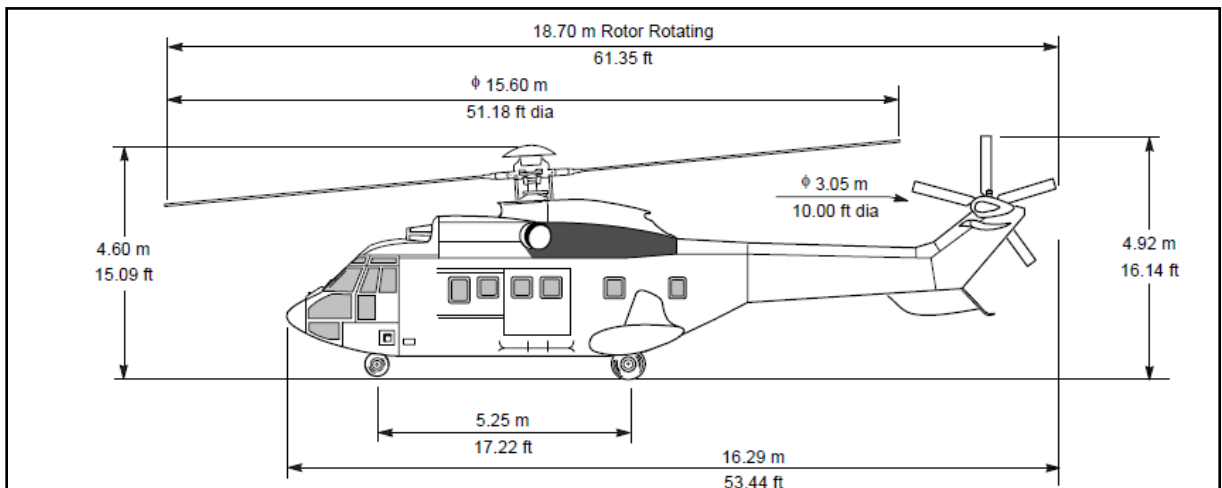
Side view of the helicopter EC155 B

Source: Eurocopter

The helicopter in question, year of manufacture 2001, manufacturer's serial number 6601, had a certificate of registration issued by the Luftfahrt-Bundesamt (German civil aviation authority, LBA). The empty weight was about 3,231 kg. The last Airworthiness Review Certificate (ARC) was issued on 24 September 2012. At the time of the accident, the helicopter had a total of about 2,099 operating hours.

1.6.2 Tactical No 2 and 3 (AS 332 L1)

The twin-engine helicopter AS 332 L1 manufactured by Eurocopter is a multi-purpose helicopter for up to 27 occupants. This model succeeded the SA 330. It is equipped with two Turbomeca Makila 1A1 engines, a four-blade main rotor and a retractable wheel landing gear. Maximum take-off mass is 8,600 kg. The helicopter was certified in 1985 in accordance with FAR 29 as Large Rotorcraft, Category A and B. The required minimum crew for instrument flight rules is two pilots and for visual flight rules one pilot and one other qualified crew member or a fully functional autopilot.



Side view of the helicopter AS 332 L1

Source: Eurocopter

Due to the extensive glazing of the cockpit down to the floor the outside view is only limited by the instrument panel, the centre console and the window struts.



Glazing of the AS 332 L1 cockpit

Source: Feuerboether, Kloss

The helicopter in question, year of manufacture 1988, manufacturer's serial number 2265, had a certificate of registration issued by the Luftfahrt-Bundesamt (German civil aviation authority, LBA). The empty weight was 5,567 kg. The last Airworthiness Review Certificate (ARC) was issued on 1 February 2013. At the time of the accident, the helicopter had a total of about 3,469 operating hours.

All three helicopters were equipped with radar altimeters.

1.7 Meteorological Information

The aviation routine weather report (METAR) of Berlin Tegel Airport (EDDT), located about 3 NM from the accident site, of 1020 hrs on the day of the accident showed: visibility 1,800 m, broken clouds (BKN) in 800 ft and 1,100 ft, wind 310° at 5 kt, temperature -1°C, dewpoint -2°C. Barometric air pressure (QNH) was 1,015 hPa.

The Deutsche Wetterdienst (German meteorological service provider, DWD) stated that Tegel had at 0700 hrs approximately 18 cm of snow; about 5 cm of which were fresh snow. The BFU determined about 17 cm snow at the Maifeld measured outside the downwash area of the helicopters. There were approximately 15 cm of snow at the accident site.

The DWD stated that during the morning the temperature decreased slightly and the wet sticky snow froze. Then fresh snow fell on the already frozen snow.

The video recordings show that during the approaches it was snowing slightly.

The crew of Tactical No 2 described the wind at the Maifeld as slightly windy from a northern direction, i.e. from the left or front left and there was no tail wind component during the approach.

1.8 Aids to Navigation

The formation flew in accordance with visual flight rules with the support of GPS with moving map capabilities. The crew of Tactical No 1 was responsible for the main navigation.

The formation leader stated the flight route within the control zone Tegel Airport had beforehand been agreed on with the supervisor at the airport by telephone.

1.9 Radio Communications

The helicopters were in radio contact with each other. Radio communications were recorded on the respective CVRs and available to the BFU for this investigation.

There were no radio communications between the three helicopters except for the landing reports of Tactical No 1 and the position change of Tactical Nos 2 and 3 during the landing phase.

1.10 Landing Site

The Maifeld is a non-public, fenced-off sports field of 112,000 m² located west of the Berlin Olympia Stadium. Part of the lawn had been strengthened by sunken plastic grids. West of the lawn stands and a bell tower are located.

Buses were parked at the eastern end of the Maifeld as landing markers for the helicopters. The distance between the buses was approximately 20 m and 27 m, respectively. About 15 m in front of each of them stood one marshallsers.



Overview landing site Maifeld

Photo: BFU

An application for permission for take-off and landing outside an airfield was not made at the Gemeinsame Obere Luftfahrtbehörde Berlin-Brandenburg (regional civil aviation authority). The regional civil aviation authority stated such a permission was not needed and not stipulated because training flights met the requirements of Para 30 of the German Aviation Regulation (LuftVG) as do other special tasks of the federal police.

The protocol of the 82. Tagung des Bund-Länder-Fachausschusses Luftfahrt (conference of the Bund Länder committee of aviation experts) on 8/9 June 2010 stated: that police flights do not require special permissions by the civil aviation authorities but are to be conducted on the basis of Para 30 Subpara 1 of the German Aviation Regulation (LuftVG).

1.11 Flight Recorders

The flight path of the formation was recorded by radar from the take-off to the landing. The radar data was made available to the BFU.

The BFU has four video recordings from different positions on the ground of the approaches of the three helicopters, the re-settling of the re-circulating snow after the accident and the evacuation of the occupants.



Camera positions, camera angle and distance to the accident site

Photo: BFU

Tactical No 1 (EC 155 B)

The helicopter was equipped with a Honeywell AR Combi flight data and cockpit voice recorder. The combi recorder was read-out and available for evaluation.

Tactical No 2 (AS 332 L1)

The CVR was neither seized nor read out.

Tactical No 3 (AS 332 L1)

The aircraft was equipped with a Fairchild A100 SS Kit CVR. The CVR was read-out and available for evaluation.

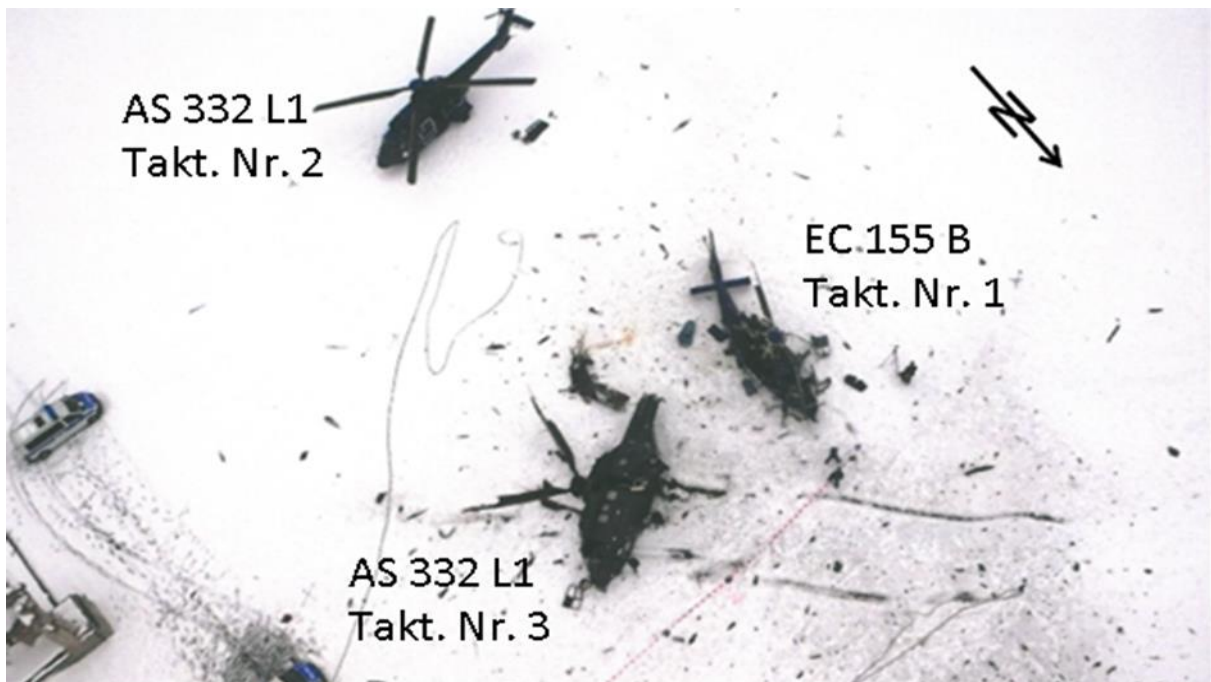
The helicopter was not equipped with a FDR. Because the helicopter had been certified before 1 January 1989, equipment with a FDR was not stipulated by aviation regulation.

The CVR recordings of Tacital Nos 1 and 3 did not contain any indications of the crew that technical problems during the landings had occurred or any warnings or other unusual background noises.

1.12 Wreckage and Impact Information

The accident site was located at the snow-covered Maifeld at the Olympia Stadium Berlin. The three helicopters had approached the stadium in approximately eastern direction.

After the collision the right helicopter (Tactical No 2) stood on its wheel landing gear and was slightly damaged. The centre helicopter which had landed first (Tactical No 1) was lying upright on its fuselage in approximately 358°. About 10 m east, Tactical No 3 was lying on its right fuselage side towards 052°. Two approximately 20 m long traces in the snow connected the initial ground contact and the nose wheel and the main landing gear of the rolled over helicopter. Debris of the two helicopters was strewn across a very large radius.



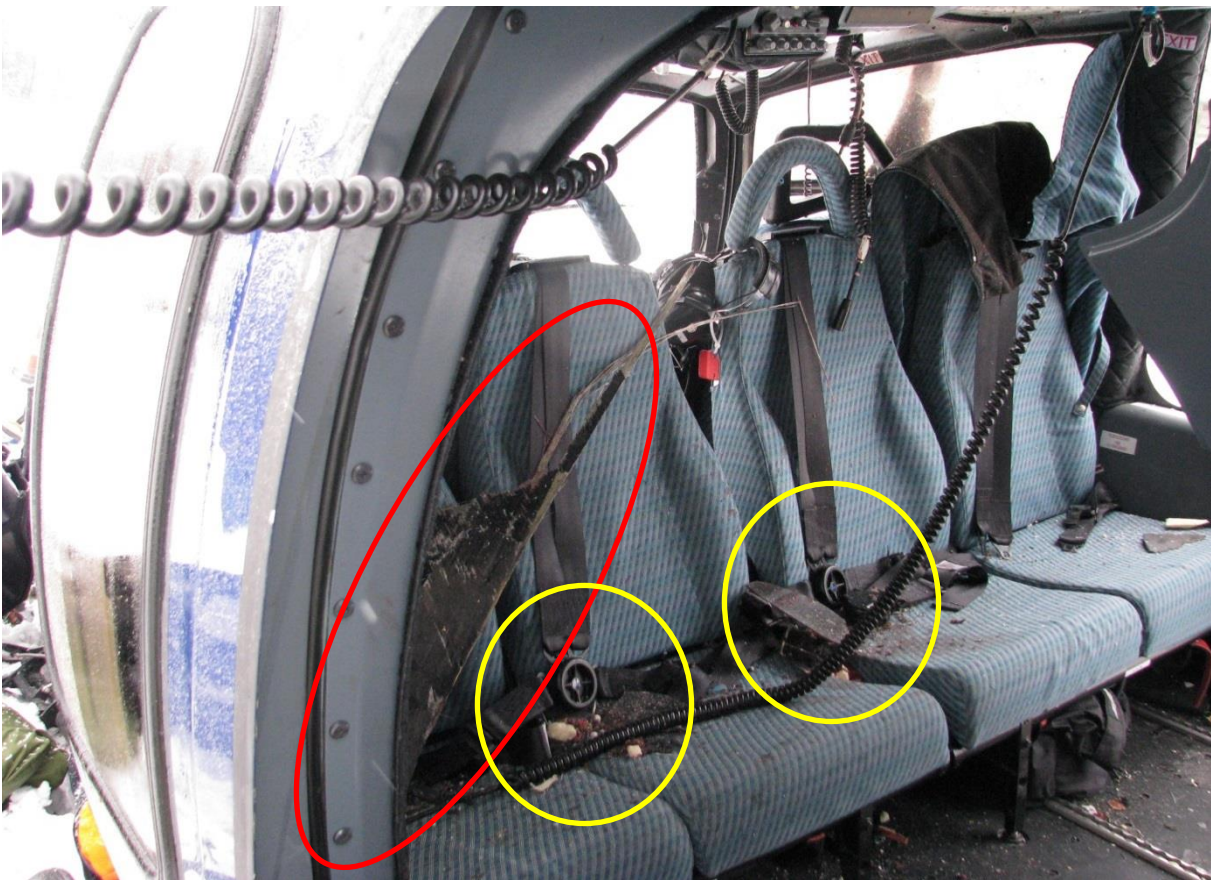
Location of the helicopters and traces in the snow

Photo: BFU

Individual Damages

Tactical No 1, EC 155 B, was lying on the fuselage, the main rotor blades were destroyed, the cabin roof including the main gear box had been pushed inside the

cabin; the tail boom had been cut off the fuselage. The fairings of the main gear box and engines were missing. The radar dome was torn open, the left cockpit glazing and the left cockpit door including beam were torn out. On the ride side of the cockpit, the glazing of the sliding window of the door up to the lower door beam and the side window next to the instrument panel were punctured. On the front seat in the cabin, a torn-off main rotor blade piece of the rolled over helicopter AS 332 L1 was found. The safety belts of two of the eight seats were closed.



Rotor blade piece and fastened seat belts in the cabin



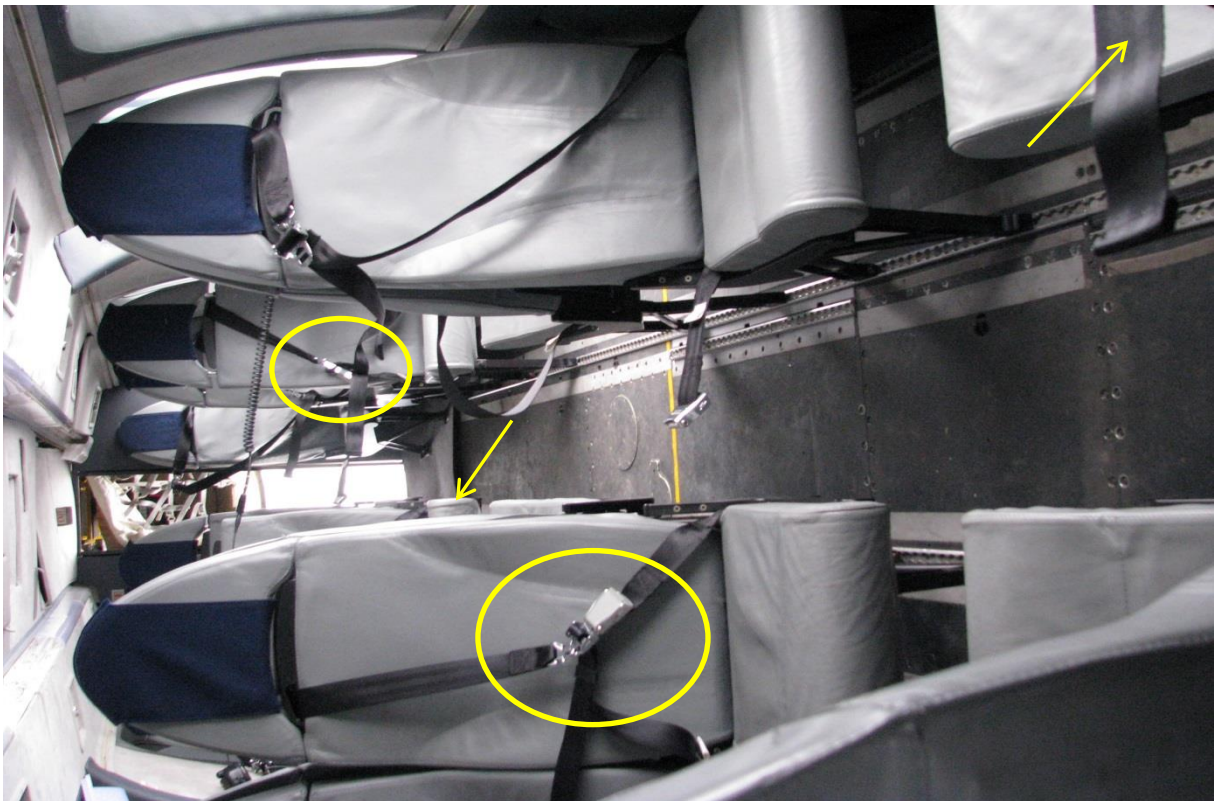
Damages on EC 155 B



Photos (3): BFU

Tactical No 2, AS 332 L1, stood on its wheel landing gear. One of the main rotor blades (yellow) showed claw marks. After a technical inspection and release to service by inspection personnel the helicopter was flown back on the day of the accident.

Tactical No 3, also an AS 332 L1, was lying on its right fuselage side. The aft part of the tail boom had been severed. It was found about 1 m south and perpendicular to the fuselage direction; the tail rotor pointing upward. The tail rotor blades had split; the control tube had been torn off. The horizontal stabilizer was found approximately 18 m away and in the vicinity of the other AS 332 L1 helicopter. The main rotor blades had been torn off and were destroyed. The connection between control column, pitch, hydraulic reservoir, swash-plate and main rotor blades was intact. The connection between the tail rotor and the end of the control cables of the torn-off tail boom was intact. On at least five seats the safety belts were closed.



Fastened seat belts in the cabin

Photo: BFU



Damages on AS 332 L1



Photos (2): BFU

1.13 Medical and Pathological Information

The pilot of the EC 155 B died at the accident site due to multiple injuries caused by a rotor blade piece which had penetrated the cockpit from the lower right front to the upper left side.

Two of the severely injured people had suffered leg injuries, one person shoulder injuries and one person a craniocerebral injury. The five people with minor injuries suffered from shock, bruising and abrasions.

1.14 Fire

There was no fire.

1.15 Survival Aspects

All passengers of the three helicopters, except for the journalist, were wearing police protective clothing, including upper body protectors and helmets.

Several safety belts in the accident helicopters were found closed. During the interview by police several passengers of Tactical No 3 stated they had been unable to secure their safety belts due to the protective clothing they were wearing or had already opened them to be able to disembark swiftly after landing.

Checking the safety belts in the affected helicopter types revealed that securing a safety belt while wearing police protective clothing was possible but required time and training due to the cramped space.

1.16 Tests and Research

Not applicable.

1.17 Organisational and Management Information

The Bundespolizei is the largest operator of civilian registered helicopters in Germany. The air services consist of five flying squadrons, twelve air rescue services centres and the police pilot school.

According to Regulation (EC) No 216/2008 of the European parliament and of the Council of 20 February 2008 the air services of the police forces are not part of the responsibility of the European Aviation Safety Agency (EASA) or any national aviation authority like the LBA which is responsible for the approval and oversight of commercial air operators, among other things. The JAR OPS 3 regulations concerning the commercial air transport with helicopters under 3.001 Applicability state: [...] *does not apply: (1) To helicopters when used in military, customs, police services [...]*

1.17.1 Organisation and Stipulations of the Bundespolizei Flying Squadron

The Bundespolizei stated that during landings with expected re-circulating snow and sufficient reference point visibility the approach is conducted as usual, i.e. with normal angle and speed, not especially flat and fast nor especially steep and slow. However, the descent will be finished in a higher hover altitude than normal. It is common to hover with constant visual contact of the pilot flying with the reference point inside the re-circulating snow. In case the visual contact with the reference point becomes lost, a go-around has to be initiated. This procedure proved its value over the last decades. This approach procedure was not documented, however.

On 27 January 2012 a hard landing occurred with a HEMS helicopter during a snow landing. The Bundespolizei Flying Squadron came to the conclusion that the incident and the hazard for flight operations was a Level B hazard: increased hazard. The following corrective actions were issued on 12 April 2012 and should have been implemented by 30 September 2013:

1. *Description of winter flight operations, especially snow landings and their hazards (e.g. whiteout) in the trainings and flight operations manual.*

2. *Development of training programs for crews (including HCM) to avoid the dangers of a whiteout or to leave a whiteout; the use of simulators/procedure trainers was to be considered.*

3. *Annual trainings taking place at the beginning of winter concerning the hazards of winter flying operations and the respective actions. Making sure every crew member participating in winter flying operations attends. [...]*

The Bundespolizei standard crew consists of one pilot and one flight engineer. In accordance with Regulation on Personnel Licensing (LuftPersV) para 62 - 65 the flight engineer is a trained and licensed air crew member. The Bundespolizei stated that in accordance with the Crew Coordination Concept (CCC) and the stipulations of the Aircraft Operations Manual (AOM) the flight engineer performs tasks which are basically tasks of a pilot non flying.

Since 1995 the Bundespolizei training for crew cooperation is conducted in accordance with the crew coordination concept. Since 2009 so-called Multi Crew Cooperation (MCC) trainings are conducted with the aim to improve cooperation, communication and Situational Awareness (SA). As part of their training, the flight engineers participate in the MCC trainings. Bit by bit, flight engineers who had been trained before 2009 also participate in the MCC trainings. The Bundespolizei stated that pilots and flight engineers participate regularly in Crew Resource Management (CRM) trainings.

The AOM of the Bundespolizei Flying Squadron (Revision 1 of 21 December 2012) Chapter 4 Normal Procedures (Revision 0 of 30 September 2011) described, among other things, crew cooperation under visual flight rules during final approach. It stated:

- *PF reports decision point*
- *In addition the PF can ask the PNF to announce values. These (announcements) are to be reduced to a minimum*
- *When adhering to standard approach procedures the PNF reports are omitted [...]*

The AOM for the AS 332 (Revision 0 of 30 October 2012) referred to "Additional reports after instruction of PF" when describing crew coordination during the landing. There were no stipulations for so-called standardised callouts, such as altitude, speed and performance parameters, of the pilot non-flying to the pilot flying to support and maintain the situational awareness during the approach.

According to the flight operations manual of the Bundespolizei Flying Squadron II.7.1 Formation Flights VFR/IFR/Day/Night the flight crew of the helicopter with the formation leader aboard of a MTH formation/part formation consist of two pilots (at night with BIV-PIC status) and one flight engineer. Chapter 3.5 Assignment of Tasks / Crew Cooperation stated: *In addition to the normal crew coordination the special work (writing down instructions, selection of frequencies or QNH, position announcements, etc.) of a second crew member significantly supports the pilot flying in concentrating on flying in the formation.* From the point of view of the Bundespolizei, the lack of a third crew member aboard the helicopter with the formation leader was not objectionable because all crew members were experienced and familiar with the location in Berlin and the course of events had been briefed in detail.

According to the Polizeidienstvorschrift (PDV, police service regulation) 145 - Transport of Tactical Forces, Command and Operating Equipment - during the day the standard value for the landing site size for light and medium transport helicopters is 35 m x 35 m as stipulated in the general administrative regulation for the approval of the site and the operation of helicopter airports. The PDV 145, 3.3.8.1 further stipulated that loose snow is to be trod down. The PDV 550, 4.5.4.11 also stipulates: *Deep snow is to be trod down or cleared.* The Bundespolizei stated that during the winter of 2012/2013 it was never possible to trod down or clear the snow before landings during police missions. They also said, from a flight operations perspective PDV 145 and PDV 550 are obsolete. On 19 March 2013 a working group for the revision of the regulations was appointed. Flight operations regulations would no longer be taken into consideration only the guidelines of the Flight Operations Manual of the Bundespolizei Flying Squadron. The Flight Operations Manual (Page 16, dated 14 October 2010) did not stipulate minimum distances during landings: *The distances between the helicopters depends on the available space and is given by position 2.* On enquiry by the BFU the Bundespolizei stated that on operating areas the distances between helicopters are marked by the parking positions and during off-field landings it is the responsibility of the formation leader to assess the suitability of the landing site. It was his decision whether the size of the landing site was large enough for the entire formation or whether the helicopters should approach individually or in groups to drop off tactical forces. In any case, the formation leader decided which landing formation should be flown. The adherence to sufficient safety distances between helicopters rests with the respective pilot in command.

1.17.2 Flying Squadron

This particular flying squadron operated a total of 17 helicopters and had more than 100 employees. In general the flying squadron met demands of public agencies (Bund and Länder) especially Berlin, Brandenburg and Saxony.

The flying squadron stated that on 14 December 2012 the last theoretical training concerning winter flight operations was conducted. The presentation had been published on the Intranet as well so that the members of the flying squadron could use it for self-study. The presentation was made available to the BFU. It basically describes hazards and effects of icing and snowfall during a flight. In regard to landings the presentation lists the following:

- *If possible landing on ground with no ice, with snow-covered areas search for a fix point, blow the area free;*
- *If there is whiteout initiate go-around and gain altitude;*
- *Touch down slowly to avoid jerky sinking [...]*

The squadron leader stated that until the accident no problems with snow landings had become known. Neither had problems during landings been reported nor had there been any incidents. Because of the long winter 2012/2013 all crews had been familiar with snow landings.

1.17.3 Planning the Flight on 21 March 2013

The head of flight operations of the Bundespolizei Flying Squadron involved stated that the order for the deployment of the helicopters had come on 5 March 2013. In calendar week 11 arrangements with the training leader were made and a date for an on-site reconnaissance at the Maifeld on 18 March 2013 was set. The squadron leader who later also was the formation leader, had gone to the on-site reconnaissance. At that time the Maifeld had been snow-covered. On 19 March 2013 an on-site reconnaissance with a helicopter was planned for the tactical troop leaders but was cancelled due to poor weather conditions.

On 20 March 2013 initial briefings with the crews had occurred. On 21 March 2013 the first check of the weather occurred at around 0715 hrs. Based on the weather forecast for the morning the flight order had been accepted. At about 0915 hrs the daily briefing took place and then the formation briefing with all crew members and the leaders of the tactical forces which lasted about 30 minutes. Part of the briefing was the weather situation and the planned flight path. As flight formation "staggered trail left" was defined. It was decided that the formation leader, who was also

responsible for tactical radio communications, should be flying on position two because the leader of the tactical forces was aboard the EC 155 B and wanted to land first.

In regard to the landing the snow situation was discussed in detail. It was assumed that it was rather wet and sticky fresh snow. The crews should still anticipate heavy re-circulating snow. For better orientation and as landing markers the on-site forces were instructed to place vehicles approximately 30 m apart. The pilot of Tactical No 3 had asked that one marshaller each was to be placed about 15 m in front of each bus as additional reference points. This was arranged after the briefing. It was decided that Tactical No 1 with the leader of the tactical forces aboard should land in the centre and Tactical Nos 2 and 3 with the tactical forces aboard left and right, respectively. This would correspond with the usual landing formation during transport of tactical forces. Due to the wind situation the approaches of Nos 2 and 3 were changed on short notice. It was discussed that as approach procedure an approach with slow forward speed until close to the marshaller as reference point and speedy touch-down was to be flown. The landings were to be conducted as individual landings one after the other. The passengers were instructed to disembark only after all three helicopters had landed.

According to witness statements, at 1000 hrs at the Berlin Maifeld, the leader of the Bundespolizei division Blumberg received the order to have three police officers ready to act as reference points in addition to the buses. The police officers were equipped with reflective vests and helmets. The police officers stated that it had been explained to them they should act as reference points for the landing helicopters and therefore should stand about 15 m in front of the buses.

1.18 Additional Information

1.18.1 Whiteout and Brownout Procedures

Landings with helicopters on snow-covered ground are not unusual in winter. Due to the downwash re-circulating snow with visibility obstruction to the point of so-called whiteout can occur with powder, loose or fresh snow. Because loss of orientation and visual references in the landing phase is possible, specific approach procedures were developed.

These are described in different documents.

For example, in the Safety Letter TP2228E-25 (01/2008) Snow Landing and Take-off Techniques for Helicopter, Transport Canada describes three landing techniques. These are: High-Hover Technique - [...] in a high hover above the landing site, [...] once solid references have been obtained a slow vertical descent to a touch-down is all that is needed. No-Hover Technique - [...]. The idea is to fly the approach fast enough to keep ahead of the re-circulating snow and complete a no-hover landing before the re-circulating snow engulfs the aircraft [...]. Run-On Landing - [...] if your aircraft is equipped with a wheeled undercarriage and you are landing on a runway. The technique is to fly the approach fast enough to stay ahead of the re-circulating snow [...].

The United States Army writes in the book "Fundamentals of Flight" FM 3-04.203 in Chapter 3 "Rotary-Wing Environmental Flight":

Landing

3-28. When landing a helicopter in snow-covered terrain (including an established runway), expect to be engulfed by a snow cloud unless a proper landing procedure is used. In loose snow conditions, there are essentially two types of approaches; to the ground or to a hover. Either type of approach should be performed into the wind. This assists in keeping any snow cloud to the rear of the aircraft.

Approach to the Ground, With Forward Speed

3-29. This type of approach demands aviators maintain sufficient forward speed to keep their aircraft in front of the snow cloud ensuring contact with the ground before being engulfed by blowing snow. While this is often the preferred technique for landing, it is frequently avoided due to problems such as obstacles or too little space in the landing area. Although no two approaches are the same and any approach technique will vary by aircraft type, the basic technique remains the same. Because this approach involves touching down with some forward speed, the crew must be familiar with the landing surface and any potential obstacles that could damage the aircraft. The essential elements of this approach are the following:

- Sufficient forward airspeed is maintained to ensure the aircraft is traveling slightly ahead of the snow cloud being created by the aircraft.*
- A shallow approach is generally used.*
- The entire crew is prepared to call out the position of the snow cloud; for example, "at the tail" or "at the cabin."*

- *Both rate of closure and rate of descent are minimized ensuring the most controlled touchdown possible.*
- *This flight attitude is maintained until the aircraft contacts the ground and the collective is reduced to flat pitch.*

Note. The optimum approach is marked by aircraft touchdown just before any snow cloud engulfs the cockpit. If the snow cloud engulfs the aircraft before contact is made with the ground, the rate of closure was too slow. Conversely, if the aircraft is completely in contact with the ground and sliding, and the snow cloud has not yet engulfed the cockpit, the aircraft was traveling too fast; an unnecessarily fast rate of closure was maintained.

Approach to the Ground, With No Forward Speed

3-30. This landing is similar to the termination to the surface with forward airspeed, except this termination should be made to landing areas where slopes, obstacles, or unfamiliar terrain precludes a landing with forward speed. It is not recommended when new or powder snow or fine dust is present because whiteout conditions will occur. The termination is made directly to a reference point on the ground with no forward speed. Both the angle should be slightly steeper and the approach speed faster than a normal approach. After ground contact, slowly lower the collective to the full down position, neutralize the flight controls, and apply brakes as necessary to ensure no forward movement.

Approach to the Ground from a Hover

3-31. This technique generally requires termination over the designated landing point at an OGE altitude. This higher altitude is necessary due to the potential snow cloud and is an integral part of this approach technique. The increase in altitude minimizes effects of the snow cloud. It also allows the crew to maintain visual contact with the ground even while the snow cloud is dissipating. The crew can then begin descent to the ground. Termination at a lower altitude (for example, 10 feet) will not permit this visual contact; the crew will likely find itself in a whiteout. This technique works well and may be the only option in certain cases; for example, in a confined area or landing beside a slingload for hook-up. Caution must be used with this technique due to the snow cloud building under the aircraft.

The Bundeswehr describes in the Aircraft Operation Procedure - AOP UH-1D (1 July 2003) Snow Procedures:

Flying in snow means flight operations under very difficult environmental conditions regarding the hazard of spatial disorientation (Whiteout) and misjudgement. During manoeuvres the focal point is on the area close to the ground (take-off, hover and landing) and over snow-covered areas. These manoeuvres demand full attention from the entire crew and good cooperation (CRM). [...] the pilot non flying announces the radio altitude. [...] Conduct the landing, contingent on the situation, speedy and low, according to the landing site conditions. [...] initiate Go-around if "Whiteout" conditions close to the ground without visual references to the ground occur [...].

For brownout landings, landings on desert sand, dust or ash, which are comparable to whiteout landings, the Bundeswehr developed an explicit integrated procedure based on their experiences and the accident frequency in mission countries. The Bundeswehr flight operations with CH53 helicopters train brownout landings in Germany during the winter under whiteout conditions, among others.

The Flight Operations Manual Volume 4, Chapter VI Flight in Deserts / Desert-like Areas, Item 531: *Brownout is the loss of visual contact with the ground or reference points necessary for the landing. Re-circulation of the loose ground (dust, sand) at the landing site by the landing helicopter causes this effect. The results of a brownout can be a hard landing [...], contact with obstacles, [...] spatial disorientation, unusual attitudes or dynamic rollover.*

In addition to the extensively described procedure with explicitly stipulated callouts of the crew members, Item 526 Crew Coordination describes: *Take-offs and landings in sandy environment demand full attention of the entire crew. An intensive Crew Management and good Crew Coordination are, therefore, of vital importance. This also applies in particular to very experienced crews who already have conducted several desert landings and who believe they have mastered them (routine hazard).*

The Swiss air force and the French army use variants of the AS 332 helicopter. On enquiry by the BFU it was reported that during snow and expected visibility obstruction due to re-circulating snow the high-hover procedure is applied during landings on principle. After visual contact with the reference point on the ground has been established landing occurs slowly without forward speed from above the re-circulating snow.

1.18.2 Dynamic Rollover

Helicopters can rollover under certain conditions. One skid or the wheeled undercarriage has to have ground contact and serve as pivot point and a rolling movement has to be present. This is a so-called static or dynamic rollover. Due to the high centre of gravity, because the main gear box and the engine being mounted so high up and the narrow skid or wheeled undercarriage width, dynamic rollovers are one of the most common accident causes for helicopters. As soon as the critical roll angle is exceeded, the pilot has, generally, no chance to prevent the helicopter from rolling over. The attempt to pull the helicopter into the air by using the pitch usually quickens the rollover. Therefore, publications generally recommend pushing the pitch down immediately.

Because this type of accident happens quite frequently already a number of documents, including recommendations, have been published. Examples are:

Federal Aviation Administration (FAA) 1986: Advisory Circular 90-87 "Helicopter Dynamic Rollover"

Flight Safety Foundation (FSF) 1989: Volume 14 No.1 "Preventing Dynamic Rollover"

European Helicopter Safety Team (EHST) 2011: HE1 - Safety Considerations - "Static and Dynamic Rollover"

1.18.3 Communication during the Flight and the Landing

Commercial transport aviation has developed procedures which resulted in the present MCC and CRM trainings and actions. It was recognised that compared with single-pilot operation, flight crews can improve the conduct of the flight, their situational awareness and flight safety if they act and communicate correctly and supervise each other.

It was also determined that electronic announcements, especially during the landing, support the pilot or pilots better than just the cockpit indications alone. Therefore, commercial air transport aircraft and some newer helicopter types are equipped with electronic systems which announce, for example, the flight altitude, speeds, and flight attitudes.

2. Analysis

2.1 Course of the Flight

The video recordings show the approaches of all three helicopters. The BFU is of the opinion that none of the conducted landings corresponded with the recommended landing techniques under whiteout conditions due to re-circulating snow described in different publications. Neither was the approach flown low and swift ahead of the re-circulating snow to the touch-down point nor was a slow vertical descent above the re-circulating snow conducted. However, the landings corresponded with the general Bundespolizei procedure as it was described to the BFU.

After deceleration, all three helicopters were inside re-circulating snow in an altitude of several meters. Tactical No 2 was hovering unusually long to the touch-down point before finally touching down inside the re-circulating snow. The flight engineer of Tactical No 1 and the crew of Tactical No 2 stated that inside the re-circulating snow there always was sufficient visual contact with the reference points and the marshalls, respectively.

The recordings show that Tactical No 3 flew around the re-circulating snow of Tactical No 2 and during descent and deceleration hovered sideways with raised fuselage nose toward the marshaller. At the end of the approach, a few seconds prior to the accident, the visual contact to the marshaller was lost. This presumably occurred initially inside the re-circulating snow caused by the own helicopter and then because of the direction of the fuselage toward the marshaller and then past him to the right. The instrument panel and the cockpit floor could have contributed to the loss of visual contact. The marshaller stated he had seen the landing light about 2 m obliquely above him (the landing lights are mounted to the wheel housings right and left of the cabin) and then got pushed to the ground. The BFU is of the opinion that this did not influence the course of the accident. Analysis of the recordings show unambiguously that the marshaller remained in his position; eventually the pilot could no longer see him because of the fuselage position to the right (see series of photos of the approach in the appendix). The helicopter hovered sideways past the marshaller, had ground contact and entered a so-called dynamic rollover and rolled onto its right side. This is verified by traces at the accident site and the statements of several helicopter occupants. In this phase the rotor disc and the tail section of the AS 332 L1 intermeshed with the rotor disc of the EC 155 B.

2.2 Crews

All crew members involved were properly licensed. Each of the pilots held an airline transport pilot's license. Therefore, they should be qualified and trained to: Lead a flight crew, apply target-oriented crew communication and procedures corresponding with MCC basics, and, in accordance with the basic rules of CRM, maintain a productive atmosphere and communication.

Everyone involved had sufficient flying and type experience. They had been flying for decades. It is to be assumed, and the crews confirmed this, that there had been many landings in snow, sand and dust. The pilot of Tactical No 3 had also flown HEMS missions in the mountains for years. He, therefore, was familiar with snow landings on ground not cleared of snow.

All crew members were familiar with the local conditions from the take-off site to the Maifeld. The analysis of the CVR recordings of both accident helicopters show that neither the weather, nor the navigation, nor the operation of the helicopter triggered stress in the crew members. The recordings did not indicate any health impairment of any of the crew members.

2.3 Helicopters

The video and CVR recordings did not indicate any technical problems with the deployed helicopters.

The controls of Tactical No 3 were examined on site. No indications for any technical malfunction were found. The weight calculations showed that the centre of gravity and the take-off mass of the helicopters had been within prescribed limits.

An on-site inspection showed that several safety belts in the two accident helicopters were closed.

The BFU is of the opinion that after the briefing prior to the flight, the securing of the seat belts should have been checked and the passengers instructed to keep the safety belts fastened until after the landing.

Based on these findings the Bundespolizei is currently working on so-called Safety Cards containing information for passengers and an "Einweisungsrichtlinie Lufttransport" (briefing guideline air transport).

2.4 Weather

The weather was suitable for the mission: Transport of tactical forces under Visual Flight Rules (VFR) as formation flight to the Maifeld. In regard to visibility and cloud base the values were above the prescribed minimums. The CVR recordings confirm sufficient, although challenging, visibilities and possible flight altitudes of about 900 ft AGL. The CVR recordings did not indicate any problems of the crew during the flight to the Maifeld due to the weather nor were adverse effects on the conduct of the flight addressed. Within the control zone of Tegel Airport the flight was conducted in accordance with special VFR.

During the landings there was slight snowfall in the vicinity of the Maifeld. The video recordings show sufficient visibilities so that the snowfall did not pose an additional problem. The wind came from about 310° which corresponded with the weather report of Tegel Airport. The chosen landing direction of about 080° toward the Olympia Stadium resulted in a lateral tail wind component. The crew of Tactical No 2 stated that the wind had come from the left and there had been no tail wind component during the approach. The video recordings show that the wind blew the re-circulating snow toward the right into the line of vision of the pilot in the right seat.

In the weeks leading up to the event it had been snowing in Berlin several times. During the on-site reconnaissance, four days prior to the accident, the Maifeld had been covered by snow. Two days prior to the accident, a helicopter flight to the Maifeld for another on-site inspection had to be cancelled due to poor weather conditions. During the night before the accident day, about 5 cm fresh snow had fallen onto the about 12 cm old snow already on the ground. According to the German meteorological service provider the snow was powdery and dry due to the low temperatures. Hence the Maifeld was covered with relatively hard and crust old snow on which powdery new snow was lying. The result was that during the landing, prior to touch-down, after the fresh snow was re-circulating no dark underground high in contrast (e.g. lawn) became visible, but a white underground poor in contrast (old snow).

2.5 Landing Site

Under adherence to all Category A procedures the Maifeld provides ideal conditions for helicopter landings. Due to its size it is possible to reduce altitude and speed above obstacle-free ground (lawn) after passing the outer obstacles in a low overflight with safe forward speed. The size of the lawn allows for large distances

between landing helicopters. The ground was flat, partly reinforced with sunken plastic grids and was frozen on the day of the accident. Hence, there were no limitations in regard to the carrying capacity. The BFU is of the opinion that the chosen landing site at the eastern edge of the Maifeld - centred and close together - was not ideal due to, among other things: The Olympia Stadium was the largest obstacle in the departure direction in case of a go-around, the prevailing wind from the north-west and the chosen distances between the helicopters.

2.6 Organisations and Procedures

2.6.1 General

The Bundespolizei Flying Squadron is the largest civilian helicopter operator in Germany. Due to the number of helicopters and helicopter types, mission procedures and personnel it is necessary to have a deliberate management structure, process descriptions with their corresponding implementations and control to ensure that everybody involved receives the information, all instructions, etc. and adheres to them. In this respect the Bundespolizei Flying Squadron is comparable with a large air operator but does not have to adhere to the procedures and checks a commercial operator is required to by aviation regulation.

2.6.2 Snow Landing Procedure

At the latest, after the hard landing of one of their HEMS helicopters and the subsequent evaluation, the Bundespolizei Flying Squadron was aware of the need for action in regard to snow landings. In April 2012, their own investigation revealed that the hazard for their flight operations was increased. It was decided to order a compilation of procedures and trainings which had to be implemented by September 2013. There were no short-term actions issued for the winter of 2012/2013.

The BFU agrees with these actions (see page 25) which had been decided after the evaluation of the hard landing. As soon as possible, these should be implemented and the training of the crews started. One key aspect should be the correct cooperation and communication of the crew during the landing. The video recordings of the three landings show that none of the landings occurred "fast and low" even though the formation leader stated the approach procedure had been part of the briefing.

The helicopters approached in accordance with the usual Bundespolizei procedure used whenever sufficient visual references during snow landings are expected and which was described to the BFU. The BFU is of the opinion that this procedure is inappropriate and not comprehensible. During the approach with normal sink angle and normal deceleration it is inevitable that close to the ground the helicopter is engulfed by re-circulating snow caused by the downwash. Hence, the visual contact to a reference point can become suddenly lost. It cannot be reliably determined how strong, dense and limiting the re-circulating snow will be. If the visual contact to the reference point is lost, a go-around has to be initiated, if appropriate, before the helicopter becomes uncontrollable or ground contact occurs. However, all this occurs in low altitudes and the crew has to realise the loss of visual contact with the reference point, accept it and react to it. This requires time and demands an extensive situational awareness in this phase of the landing.

In case a second pilot is part of the crew, it usually is not possible for him to take over control of the helicopter due to the limited visual contact with that reference point. The pilot flying has to position the helicopter in a way that he has visual contact with his reference point on his side of the helicopter at all times. The second crew member hardly has any visual contact with that reference point due to the cockpit design, the instrument panel and the flight attitude, first "nose up" during deceleration and then hovering sideways above the reference point.

For example, the Bundeswehr (German Armed Forces) encounters the same hazard during the described landing procedure under brownout conditions (from static hover prior to touch-down). The Bundeswehr compensates this hazard through explicitly described procedures that the pilots have to expect the abortion of the approach and the initiation of a go-around at all times. These procedures are part of recurring trainings for all crew members

Icing hazards were one key aspect of the training of the squadron involved in regard to the winter flight operations 2012/2013. The presentation was rather short in regard to snow landings and possible hazards, approach techniques, etc. The squadron leader stated that in the past there had not been any signs of problems with snow landings.

2.6.3 Crew Cooperation Procedure

In general, the flying personnel of the Bundespolizei is deployed on several different helicopter types and sometimes even in different roles. Pilots fly in single-pilot

operation as pilot in command and as pilot flying with a HEMS crew member. During multi-crew operation they fly as pilot in command with a flight engineer or co-pilot, or as co-pilot or as part of a crew of three. Tasks and duties vary depending on the helicopter type and the role within the crew. In order to meet these requirements, MCC and CRM trainings and check flights are conducted and procedures described in documents, among other things.

The CVR recordings of Tactical Nos 1 and 3 show that there were significant deficiencies in the target-oriented, flight-safety improving cooperation of the crews in their respective helicopters. Both crews interacted in a very friendly and cooperative manner. Based on the recordings it was hard to discern who flew the helicopter, was responsible and made decisions. Essentially each crew member did what he saw fit and necessary at the time without informing others or adhering to challenge and response procedures or checklists. Prior to the landing the so-called approach briefing was missing, during which such things as the hazard of re-circulating snow, or the criteria for an aborted approach and a possibly necessary go-around are discussed. During the approach a decision point for the landing was neither defined nor discussed. There were no supporting call-outs for the pilot flying such as performance values, speed, radar height, or flight attitude (to prevent ground contact with the tail section during touch-down) nor were they requested. The pilot flying did not keep his flight engineer informed by saying, for example, "I decelerate, I descent, I still have reference".

The instructions in the Aircraft Operation Manual, Chapter 4, Normal Procedures disagree with the MCC basics, because they explicitly demand to reduce communication to a minimum or to stop altogether during standard approach procedures. If during standard approach procedures the correct communication is practised and internalised, deviations from the standard during non-standard approaches and landings can be much sooner noticed, discussed and corrected, if necessary. During flights under Instrument Flight Rules (IFR) and at night using night vision goggles flight crew callouts to maintain situational awareness are viewed as absolutely necessary due to the increased control demands with limited visibility. The stipulations in the AOM Chapter 4 are contradictory to this. Under these conditions standardised callouts are daily practice in flight operations worldwide including the Bundespolizei. The Bundeswehr explicitly stipulated the time and the corresponding callout for each crew member in the brownout approach and landing procedure.

Publications highlight the importance of good and target-oriented cooperation and communication within a crew to improve operation safety (see BFU Investigation Report 3X050-11, or Flight Safety Information V134 The co-pilot - more than just ballast in the right seat).

Due to the constantly changing crew combinations and the different roles and responsibilities it is necessary for the Bundespolizei to have standardised procedures and callouts which are trained and practised regularly. Crew cooperation should be part of the checkflights.

2.6.4 Formation Flight Procedure

In general, the procedural instructions for the formation flight of the Bundespolizei stipulated a two-pilot crew for all MTH formations or partial formations for the helicopter with the formation leader aboard. It described under 3.5 the necessary additional support for the pilot flying. The BFU is of the opinion that this is reasonable because the formation leader is often busy with tasks such as navigation, coordination with the client, adhering to overflight times, or time of arrival. The simultaneous safe control of the helicopter increases the workload considerably or is even impossible.

In this case the pilot of Tactical No 2 was the formation leader. It was planned that he take over the task of keeping in radio contact with the ground forces. The pilot of Tactical No 1 had the following tasks: Navigation, radio contact with the air traffic service provider (because Tactical No 2 had radio trouble), coordination with the client regarding the passengers which were in radio contact with the ground forces. In addition, a journalist was on board. Toward the end of the CVR recording the pilot's voice indicates a corresponding strain and operational stress prior to the landing. The BFU is of the opinion that for flight safety reasons Tactical No 1 should have been manned with two pilots because in-flight formation management was centred there.

According to the CVR recording the landing positions of Tactical Nos 2 and 3 were changed on short notice. The recordings show, that this position change did not pose a problem for the pilot of Tactical No 3. He noticed the change in time and asked for confirmation via radio. This position change would have posed an advantage for the pilot in the right seat because visual contact to the marshaller would have been better. But in this case the position change has to be viewed as contributory factor, because the re-circulating snow caused by the hover of Tactical No 2 limited the field

of vision of Tactical No 3 toward the right to Tactical No 1 during the approach until he was close to the ground. As the re-circulating snow caused by Tactical No 2 settled, the re-circulating snow created by Tactical No 3 limited the field of vision of its pilot. The video recordings show, that the marshaller for Tactical No 3 had been visible until a few seconds prior to the accident (see Appendix).

2.6.5 Touch-down Position Distances

The distances between the touch-down positions of the helicopters were indicated by three buses and marshalls. After the accident these distances were measured with 20 m and 27 m. The rotor diameters of the helicopters used were 12.6 m and 15.6 m. The BFU is of the opinion that the distances between the individual helicopters were therefore very short. After a successful landing, the distances between the rotor discs computed from the positions of the respective marshalls were about 6 m and 13 m. Because it was possible that visibility would become limited due to re-circulating snow and it was planned that the passengers would disembark while the rotors were still turning, although only after Tactical No 3 had landed, these short distances posed an unnecessary hazard especially since the size of the Maifeld did not limit them in any way.

The police regulations, the general administrative regulation for the approval of the site and the operation of helicopter airports, Appendix 1 to JAR OPS 3.005 (d)(c)(2)(C), specifications for civilian rescue services with helicopter, and military regulations for Bundeswehr flight operations (FBH Heer No. 224), stipulated larger distances or at least one rotor diameter between the rotor discs of parking helicopters or to an obstacle.

2.6.6 Conduct of the Flight

The BFU does not view the transport of tactical forces by formation flight to a familiar and large landing site including enough time beforehand, coordination, on-site reconnaissance and briefings as unusually difficult tasks. Essentially such a transport equates classic commercial passenger transport.

The media hype and knowledge that high-ranking superiors were present should not have caused unusual psychological stress for the crews. Landings which caused large public interest were part of the daily routine of everyone involved.

According to the flight manual it was allowed to operate the AS 332 L1 in single-pilot operation. It is for the BFU not understandable why the Bundespolizei operates such

a transport category helicopter type for up to 27 occupants, where technical redundancy tries to minimise failure hazards, in single-pilot operation during the day under visual flight rules. Compared to passenger transport flight operations with this helicopter type this is world-wide an exemption.

2.6.7 Aviation Regulation Concerning Police Flight Operations

In accordance with Federal Aviation Act Para 30 (Luftverkehrsgesetz) certain flight operations (police, armed forces and rescue services) are permitted to deviate from aviation regulations to avoid major damages, if necessary. It has not become clear to the BFU why the entire flight operations are subject to this exception. And the Bundespolizei (German federal police) - with the exception of air rescue operations and so-called Richtlinienflüge - the Bund-Länder-Fachausschuss, and the responsible supervisory authorities are of the opinion that flight operations are permanently subject to this exception paragraph. By order of the responsible aviation authority, an application for an off-field landing and take-off permit was not submitted. A competent official in charge of such an application might have asked about the distances between the helicopters or would have criticised narrow distances or at least questioned them. In the past, several accidents occurred during police flight operations; e.g. SWAT procedure training or infringement of the minimum safety height by applying Federal Aviation Act (Luft VG) Para 30.

The BFU is of the opinion that flight operations of Bund- and Landespolizei need a competent and independent supervisory board. Its task should be: to recognise and name hazards at an early stage, to compensate them with clear procedures and regulations and, if deviations occur, to indicate solutions by issuing warnings and so help preventing accidents.

The LBA is responsible for supervision of commercial air transport (e.g. JAR OPS 3 and Regulation (EU) No 965/2012). The General Flugsicherheit der Bundeswehr is an assisting supervisory body. Both aim at recognising organisational discrepancies, missing procedures or possible hazards at an early stage and standardising proven and safe procedures and techniques beyond the individual organisational unit or operator.

The Safety Recommendations 01/2006 and 02/2011 the BFU issued have been implemented either not at all or only by partially compensatory actions (e.g. by establishing a common police pilot school and annual meetings of office holders). They are still important, however.

3. Conclusions

3.1 Findings

3.1.1 General Conditions for Police Flight Operations

- Non-applicability of the aviation regulations for commercial flight operations with helicopters similar to JAR OPS 3 / Regulation (EU) 965/2012 and no responsible competent supervisory body as stipulated in Regulation (EC) No 216/2008
- Acceptance of the permanent deviation from aviation regulations by applying Federal Aviation Act (LuftVG) Para 30

3.1.2 Organisation / Requirements of Police Flight Operations

- Missing descriptions of aeronautical procedures, trainings and recurrent trainings for flight crews regarding snow landings
- Changing flight crew combinations with changing roles, tasks and responsibilities within the crew
- Insufficient or not standardised communication and contra-productive instructions for the crew communication during the landing
- Missing requirements for the distances between landing and parking helicopters

3.1.3 Flight Deployment / Operating Conditions

- Insecurity whether the flight could be conducted due to the forecast marginal weather situation and weather observations until take-off
- During the flight the weather conditions were better than expected
- Fresh snow on top of old snow at the landing site
- Sufficiently dimensioned off-field landing site with a snow-covered surface located within the control zone Tegel
- Narrow distances between the helicopters / marshallers on the ground

3.1.4 Conduct of the Flight / Crews

- All crews were familiar with the local conditions en-route and the off-field landing site
- Acceptance of the side or slight tail wind during the landing with additional re-circulating snow in the line of vision of the pilot in the right seat
- Change of the landing positions of Tactical Nos 2 and 3 on short notice
- Mistake when assessing the possible hazard by re-circulating snow
- The BFU is of the opinion that the approach profile was disadvantageous
- The crew did not conduct an approach briefing which would have included go-around criteria, among other things
- The BFU is of the opinion that the crew communication during the landing was insufficient as the two CVR recordings show
- Re-circulating snow due to the slow touch-down of Tactical No 2 with the resulting limitation of the field of vision of the pilot of Tactical No 3 toward the already landed helicopters
- The landing was not aborted immediately after the visual contact with the marshaller had been lost

3.1.5 Technical Defects

- There were no indications of technical defects which could have caused the accident or had any influence on the course of events

3.2 Causes

The loss of orientation and the resulting loss of control of the helicopter landing last and the subsequent collision of two helicopters on the ground under whiteout conditions were caused by:

Immediate Causes:

- Insufficient crew communication during the approach and landing
- The chosen approach procedure resulted in re-circulating snow which engulfed the helicopter even before it touched down
- Loss of visual contact with the reference point (marshaller) in the re-circulating snow
- Loss of visual contact with the ground due to snow crust underneath the powder snow
- After the visual contact with the reference point was lost the landing was not aborted immediately
- The distances between the buses and the marshalls in front of them, as landing markers for the helicopters, were short

Systemic Causes:

- Missing and partially contra-productive instructions concerning crew communication
- Insufficiently described procedures and training of the crews regarding snow landings
- Non-binding procedures for minimum distances between helicopters on the ground

4. Safety Recommendation

A few months after the accident the Bundespolizei has stipulated procedures for take-offs and landings under whiteout/brownout conditions (snow, sand, etc.). In the AOM Chapter 6 Special Operations the following procedures were described: pre-flight preparation, take-off, landing, loss of reference, crew coordination, choice of decision point, with marshaller, formation flight and use of BIV. Essentially, the AOM describes and stipulates the high-hover technique, i. e. hovering slowly, vertically toward the ground with visual contact with the ground and then touch down. It was recommended that the minimum distance between several landing helicopters should now be 70 m.

In addition, a flight simulator training program was compiled for take-off and landing under whiteout and brownout conditions. The expected behaviour of the flight crew and callouts within the crew were specified.

In addition, a winter flight operations program for flight crews was compiled (power point presentation including videos) which has to be attended annually (before November 1). This program describes extensively possible dangers and specialities of flight operations in ice and snow conditions and the respective required procedures and regulations.

So-called safety cards for each helicopter type were compiled so that passengers can be informed of the dangerous areas around the helicopter, the use of the safety belts, and the emergency equipment.

The safety recommendations the BFU has already issued still stand:

Recommendation No 01/2006

To ensure a high level of flight safety the Federal Ministry of Transport, Building and Urban Affairs should agree with the Federal and Land authorities responsible for the police on establishing aviation regulations for the operation of police helicopter squadrons such that the specific requirements of police missions are met and a safety level similar to that ruling the commercial use of civil helicopters is ensured (ref. JAR-OPS 3)

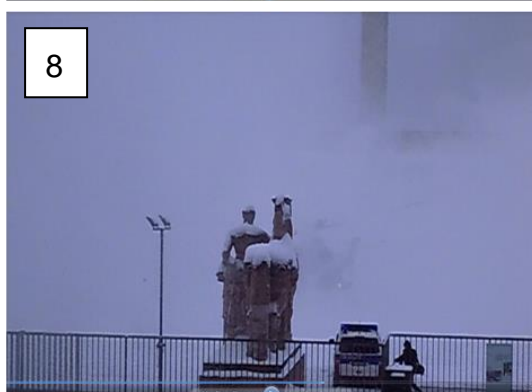
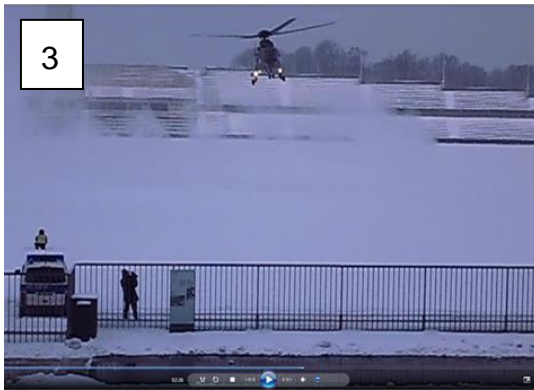
Recommendation No 02/2011

Federal Ministry of Transport, Building and Urban Affairs should establish an independent supervisory body for all police helicopter squadrons - federal or state -

which regularly supervises the quality, safety and standardisation of the flight operations.

Investigator in charge:	Axel Rokohl
Field investigation:	Uwe Berndt, Thomas Karge, Axel Rokohl
Assistance:	Hans-Werner Hempelmann, Dieter Ritschel
Braunschweig ,	23/09/2014

5. Appendices



Sequence of photos of the approach of Tactical No 3

Photos (8): BFU



Tactical No 3 avoiding the re-circulating snow of Tactical No 2 approaching the marshaller (About 7 seconds prior to the accident)



The helicopter hovers with almost constant altitude toward the marshaller (About 4 seconds prior to the accident)



The fuselage of the helicopter is raised a little and turned slightly to the right (About 3 seconds prior to the accident)



The marshaller is obliquely below the fuselage which is turned to the right (About 2 seconds prior to the accident)

Sequence of photos of the approach of Tactical No 3

Photos (4): BFU