

Investigation Report

Identification

Type of Occurrence:	Accident
Date:	10 May 2011
Location:	Near Engelsbrand
Aircraft:	Helicopter
Manufacturer / Model:	MD Helicopters, Inc. / MD 900 (902)
Injuries to Persons:	Three persons suffered severe injuries
Damage:	Airplane destroyed
Other Damage:	Crop damage
Information Source:	Investigation by BFU
State File Number:	BFU 3X050-11

Factual Information

History of the Flight

The crew of a police helicopter - one pilot, one flight engineer and one FLIR operator - took off from Stuttgart Airport at 2037 hrs¹ shortly before sunset. In the scope of their on-call duties a search for a missing person near Engelsbrand was to be conducted. The radar data showed that north of Engelsbrand several turns in about

¹ All times local, unless otherwise stated.

2,300 ft AMSL, about 600 ft AGL, with low forward speed, above a wooded hill were flown.

Several witnesses observed the helicopter from a distance of 500 to 1,500 m. The witnesses stated that the helicopter was about 10 m - 25 m or one tree length above the forest when suddenly, at 2130 hrs, the helicopter dipped and disappeared in the forest. Some witnesses stated that right before the plunge they had heard noise comparable to a car misfiring. Other witnesses reported consistent helicopter noise until the crash. The witnesses stated that before the helicopter lowered the nose and dived into the forest it had hovered above the forest for several seconds. One witness saw the tail section hang down. Then the helicopter had suddenly begun to yaw along its vertical axis and crashed.

During the search the crew had radio contact with the police ground forces. About 13 seconds prior to the crash the flight engineer suddenly transmitted a curse with an agitated voice. One second later he repeated the curse with an even more agitated voice and seven seconds later: „du Obacht du, wir stürzen ab, wir stürzen ab, wir stürzen ab, du“ (You, careful, we are crashing, we are crashing, we are crashing, you).

Shortly after the crash police ground crew members were at the accident site. The FLIR operator had left the wreckage unaided; the fire brigade rescued the pilot and the flight engineer. All three persons suffered severe injuries.

The pilot stated that about 10 minutes prior to the accident the Night Vision Goggles (NVG) were mounted to the helmets during the flight. During daylight the local open space was searched to find the missing person. With darkness approaching the local forest was searched with the help of a digital thermal imager (FLIR). The pilot and the flight engineer had flipped down their night vision goggles. After one or two left turns the FLIR operator reported to have a heat source below the helicopter. He could not identify a heat source on the display in the cockpit. He then tried to position the helicopter close to the alleged heat source. By reducing speed the helicopter was to go into hover. According to his memory the helicopter was in about 800 ft AGL when he checked the radio altimeter prior to the accident. Suddenly the helicopter yawed to the right. He then responded with actuating the left pedal up to the mechanical stop. Because the helicopter continued to yaw to the right he reduced thrust by lowering the pitch and intended to increase horizontal velocity. Thereby the accident happened.

The FLIR operator confirmed the statements concerning the conduct of the flight and the identified heat source. She assumed the crew flew with night vision goggles at the time of the accident. For her it was deep black and dark, respectively, when she looked out the side window.

Personnel Information

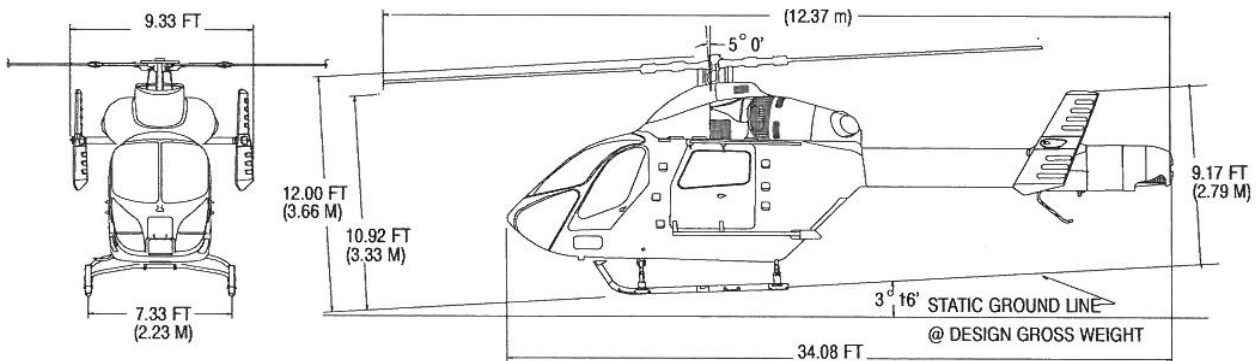
The 35-year old pilot in the right seat held a Commercial Helicopter Pilot's License (CPL(H)) issued on 14 December 2004 according to JAR-FCL 2, German, and valid until 19 October 2015. His license carried the rating as Pilot in Command (PIC) for MD 900/902 valid to 21 January 2012. He held a class 1 medical certificate issued according to JAR-FCL 3, without restrictions and valid until 5 May 2012. His total flying experience and type experience on MD 900/902 was about 1,605 hours; about 204 hours of which with night vision goggles. The last night vision goggle standardisation was conducted on 3 February 2011. In 2011 about 68 hours were flown until the accident; about 27 hours of which with night vision goggles; the last time before the accident on 7 May 2011.

The 44-year old flight engineer sitting in the left seat held a flight mechanic license for helicopters since 9 June 1998. His license carried the type ratings as flight mechanic for Bo105, EC155 and MD 900/902. He held a class 1 medical certificate issued according to JAR-FCL 3, with restrictions and valid until 5 March 2012. His total flying experience as flight engineer was about 2,502 hours, about 478 hours of which with night vision goggles and 1163 hours on MD 900/902. The last night vision goggle standardisation took place on 25 November 2009. In 2011 he had flown about 81 hours until the accident.

On short notice, the flight engineer had taken the place of the second pilot on duty who had not been available. The pilot in question and the second pilot had been working as a permanent crew for some time.

Aircraft Information

The twin-engine helicopter MD 900 (902) manufactured by MD Helicopter Inc. is a lightweight multi-purpose helicopter for up to eight occupants. It was certified according to FAR Part 27 in 1994. The helicopter was equipped with two Pratt & Withney 207E engines, a five-blade main rotor, skids and a NOTAR-System (NO TAIL ROTOR) for anti-torque. Maximum take-off mass is 2,948 kg.



Side view MD 900 (902)

Excerpt from the flight manual: Dimensions Figure 1-1

The helicopter was built in 2001 and had the manufacturer's serial number 900-00099. According to the weighing report, empty weight was about 1,943 kg. The last annual inspection was conducted on 28 July 2010; at about 3,004 operating hours. The annual inspection was valid until April 2011. The Luftfahrt-Bundesamt (German civil aviation authority, LBA) issued a special permit on 26 April 2011 and extended validity of the annual inspection until 31 May 2011. At the time of the accident, the helicopter had a total of 3,291 operating hours.

The helicopter was equipped for police operations and had dual controls. The helicopter was equipped with a push-to-talk switch on each control stick and one floor-mounted switch on the cockpit floor of the copilot. The intercom for crew communication was voice activated. The cockpit lighting and the indications in the instrument panel were night vision goggle compatible. The helicopter was equipped with a radio altimeter.

In accordance with the Rotorcraft Flight Manual (Figure 5-34. Controllability Envelop and Azimuth Range for Crosswind Operations and Figure 5-37. Hover Ceiling, OGE, Standard Engine Inlet, Takeoff Power, Cabin Heat Off) there were no hover restrictions outside the ground effect in regard to the performance and yaw controllability up to the maximum take-off mass given the prevailing outside air temperature, the wind and the pressure altitude.

Meteorological Information

Ten minutes prior to the accident the corresponding aviation routine weather report (METAR) at Stuttgart Airport (about 20 Nautical Miles (NM) away) reported the following weather conditions:

Wind 300°, with 4 knots. Ground visibility was more than 10 km and there was little cloud cover in more than 5,000 ft (CAVOK). Air temperature was 18°C, dewpoint was 6°C and the barometric air pressure (QNH) was 1,025 hPa.

Sunset was at about 2050 hrs.

At the time of the accident, at 2130 hrs, several witnesses stated: "es war noch nicht dunkel" (it was not yet dark) and "es war ja schon duster" (it was already dark), respectively. One witness worked in his garden when he witnessed the crash. Others took a walk. One observed the helicopter with binoculars. Other witnesses saw the helicopter above the forest and described its outer form, the colour and the flight manoeuvres.

According to the Appendix for night flights with NVG of the Deutscher Wetterdienst (German meteorological service provider, DWD) for Baden-Württemberg for 22:00 hrs a mean night-time brightness of 29 mlx and a minimum of 19 mlx was expected. Minimum visibility with glasses was more than 2.1 km.

Communication

During the search for the missing person the helicopter crew was in radio contact with the police ground crew. Radio communications were recorded.

Flight Recorders

The helicopter was not equipped with a Flight Data Recorder (FDR) or a Cockpit Voice Recorder (CVR). There were no legal requirements for such equipment to be fitted.

The helicopter was equipped with an Integrated Instrument Display System (IIDS). It records several system parameters if, for example, limits are exceeded: RPM, temperature, pressure, load, pedal position. The IIDS was read out. There was no recorded data prior to the accident except for one flight on 12 March 2011.

Both engines were equipped with one Data Collecting Unit (DCU) each. The DCUs could be read out with the help of the manufacturer. The read-out showed that the pitch was reduced to 29.9% about 8 seconds prior to the end of the recording and then within one second it was pulled up to 105%. Up until the accident no malfunctions were recorded and the engine controller was in auto mode.

The radar recorded the flight path from the take-off in Stuttgart until the accident.

Wreckage and Impact Information

The accident site was located north of Engelsbrand in a forest on a hill. The main wreckage lay on its right fuselage side and pointed toward the south opposite to the direction of the flight. An uprooted tree rose from the cabin. From about the crown down to the final resting place of the wreckage tree limbs and bark had been scraped off the tree trunk. There was an additional tree south of the wreckage whose crown had been severed.



Main wreckage position with uprooted tree

Photo: BFU



View from the direction of flight at the point of initial tree contact.

Photo: BFU

The tail boom of the helicopter was about 25 m away from the main wreckage in the direction of the initial tree contact. Three of the five main rotor blades were scattered around the helicopter; two were wrapped around the rotor head. The H4K Artex 406 emergency locator transmitter had deployed. Several night vision goggles were lying in front of the helicopter in the area of the cockpit. On the pilot's helmet the mounting for the night vision goggles and the batteries were fitted. On the helmet of the flight engineer the batteries were missing; they were found in the area of the accident site.

After the salvage operation, the BFU examined the helicopter in the presence of a representative of the manufacturer, engineers of the police squadron and an expert working for the public prosecutor. It was determined that both engines were running at the time of the accident, the main gear box was free-wheeling and the NOTAR fan was powered. The chip detector of the main gear box was clean and the gear box was filled with oil. The free-wheeling units between engines and main gear box opened and closed according to design. The two hydraulic systems for the controls were free of leakages, the oil was clean and filled to target range. The examination of the controls did not reveal any malfunction prior to the accident. By way of calculation the tank was still filled with about 200 litres fuel. For checking purposes the fuel was drained on site.

Fire

There was no fire.

Survival Aspects

The helicopter was equipped with crash seats. The hard landing energy absorbing mechanism was not triggered. The pilots wore helmets during the flight.

Organisations and their Procedures

General

The Landespolizei Hubschrauberstaffel (state police helicopter squadron) operated eight helicopters and at times a chartered airplane at two locations. The deployment range included flights during the day and night if necessary with night vision goggles and flights in accordance with Instrument Flight Rules (IFR). The conduct of flight operations occurred in accordance with the flight operations manual of 16 February 2001, revision 17 of 1 June 2010. The crews of the helicopters always consisted of two pilots or one pilot and one flight engineer. In general, they were grouped, i.e. one pilot always works together with one particular second pilot or flight engineer. The flight operations manual chapter 8 (of 1 January 2004) described the Crew Coordination Concept (CCC). Item 8.4 Standard Task Division stipulates for pilots and flight engineers the following:

Pilot: Control / operation of the aircraft, communication with ATC, tactical flying according to standard operation procedures

Flight engineer: Support with checklists, cross checks, note time of take-off and landing, concept flight report, tactical radio communications, operation of instruments / cabin lighting

Together: Airspace observation, competence checks

Flight Operations Manual, Chapter 10, Special Method of Employment, described various methods of helicopter deployment. Flights to search for missing persons or subsequently applying procedures for the use of digital thermal imager (FLIR) was not described.

Flight Operations Manual, Appendix 1, Flight Operations Instruction for the flight with night vision goggles of 30 April 2008 described the squadron internal procedures for

NVG flights. The flights with NVG were conducted by utilising Federal Aviation Act (LuftVG) para 30. Item 5 defined the minimum flight altitude. These reached down to 200 ft AGL if the terrain was known and the radio altimeter fully functional. The flight operations instruction did not include: a description of the tasks division in the cockpit, applicable procedures, changes from day to night flying, environmental influences on the NVG, procedures by NVG failure, system-related restrictions of the pilot's performance during NVG operations and possible emergencies.

The draft of the Training Handbook, Part B, Acquiring the qualification "Flying with Night Vision Goggles (NVG)" of the helicopter squadron of 1 August 2010, Item B 2.1 General, points out the special features of NVG flights. *Flying under NVG conditions is one of the most difficult challenges possible. With a horizontal angle of vision of only about 40° the pilot is presented with a two-dimensional image. Distances can only be interpreted based on known factors. Interpretation and processing of the perceived information have to be learned. Therefore, an extended training is needed which places great demand on the relaying of theory and practice.*

Item B 2.4.9 Emergencies describes the failure of the NVG and by failure / malfunction of helicopter systems refers to the procedures of the flight manual.

Item B 2.4.10 Tactical Flying described search missions for missing persons. An altitude of 500 ft AGND during the search was recommended.

In 2010, the Bundespolizei (German federal police) issued a specimen draft of a flight operations manual for the German police flight service. This specimen draft was meant to be a template for the flight operations manual of the individual state helicopter squadrons. Part E Police Flight Operations, Chapter II.5, Police flight operations with NVG, referred to the existing procedures of the individual squadron which were to be incorporated. The specimen draft did not include procedures such as searching for missing persons at night or during the transition between day and night flying.

Additional Information

Night vision goggles enable and support, respectively, the visual perception in the dark or during twilight. In the technical sense it is an image converter and an image intensifier, respectively. A lens system sends any collected light to a glass plate coated with a photoelectric material on the back side. The photoelectrons are accelerated through a potential difference of several hundred volts and cause a most often green image on a fluorescent screen. The intensified image is viewed on a small

monitor. In flight operations two tubes, similar to binoculars, are folded down in front of the eyes.



NVG mounted to a pilot's helmet, components and an example image

Photos (3): Police NDS

In 2003 the Joint Aviation Authority (JAA) published Leaflet No 34 Night Vision Imaging System (NVIS) Operations as part of the administrative and guidance material. The Leaflet No 34 of 1 June 2003 contained possible systems, crew training procedures, aircraft equipment, flight operations procedures and possible restrictions.

According to the Leaflet No 34 restrictions due to the system design are for example: limited field of view from 200° during the day to about 40° at night using NVG which makes it necessary for the crew to turn the head and scan the area. Compared to colour vision, perceptibility and vision are further limited by the monochromatic image in green and black. The spacial orientation is limited by the restriction of the field of view because the peripheral vision is no longer there. Spacial vision, depth perception and distance estimation is affected because of the design of the night vision goggles and the depiction in one image. In addition, there is a time lag between the adaption of the eyes from looking through the NVG and looking past the NVG to the helicopter's lighted instruments. Looking through the window into the dark without the NVG a night adaption is necessary.

The NATO conducted a study in 2007 concerning Flight Testing of Night Vision Systems in Rotorcraft. Chapter 2 Background and Overview of NVG Systems describes night vision systems for flight operations. Pros and cons and characteristics were illustrated. In summary, the study came to the following conclusion:

[...] While NVGs are a mature technology and an impressive sensor for night flight, they have some adverse effects on the way we perceive the world. Moreover, although NVGs appear to turn night conditions into day conditions almost all aspects of visual performance are degraded while wearing NVGs in comparison to natural un-

aided day vision. It is important to emphasize that though this technology significantly enhances our operational capability at night, it does not make night into day. [...]

All documentation concerning the use of night vision goggles in aircraft stress the necessity of good crew cooperation to compensate the system related restrictions.

In the past, several accidents have happened with police helicopters. The BFU and its predecessor (FUS) at the Luftfahrt-Bundesamt (German civil aviation authority, LBA) determined that in the squadrons in question the flight operations procedures were not sufficiently described or proven procedures of other state police, of the Bundespolizei (German federal police) or from the commercial civil helicopter aviation were not known. Therefore, several safety recommendations were issued which were only partially implemented or not at all.

SE-FUS 12/97: A trans-regional working group should be established in which an exchange of experiences between the individual squadrons takes place and joint, binding standards for the safe and effective conduct of the different types of deployment of police helicopter squadrons are compiled. If applicable, the helicopter manufacturer should be included in the committee.

SR-BFU 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)

SR-BFU 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.

Analysis

The crew was licensed in accordance with the regulations and based on the flying experience on the helicopter type and the flights at night with night vision goggles qualified for the conduct of the flight.

The helicopter was properly registered and maintained. The annual inspection was due since the end of April but because of the special permit issued by the LBA flight

operations were permissible until the end of May. Mass and centre of gravity were within their prescribed limits. The investigation determined no indications of a malfunction or impairment of the controls. The analysis of the IIDS and the DCU showed no malfunctions or limit exceedings until the accident. The analysis of the Rotorcraft Flight Manual did not show any restrictions on the stationary hover outside of the ground effect in relation to the available engine thrust and yaw controllability, respectively.

The weather was very suitable for a flight under visual flight rules day and for a flight at night with night vision goggles. The wind was not very strong, there were very little clouds, cloud base was high and visibility good. It is highly likely that the values forecast for the night-time brightness resulted in a clear, high-contrast NVG image. Due to the short time after sunset, about 40 minutes, it is highly likely that towards the west - line of vision - there was still some glare due to the remaining residual light. The statements concerning the brightness at the time of the accident were contradictory. The pilot and the FLIR operator described a darkness which had made the use of NVG necessary. The statements of witnesses and their respective actions at the time of the accident prove that there was enough residual light which made it possible for the witnesses to observe the helicopter; some from a considerable distance.

The mission, to search for a missing person during on-call duty of the crew was no unusual deployment of a police helicopter. The task did not constitute an exceptional demand. The flight operations manual of the helicopter squadron did not contain this kind of mission in spite of the frequency of occurrence of searches for missing persons. The draft trainings manual, however, contained a description as one of the most frequent tasks at night.

It is likely that while trying to position the helicopter as close as possible to the identified heat source an unnoticed loss of altitude and backward movement of the helicopter occurred. This is supported by the altitude discrepancies of the recorded altitude of the radar track, the recollections of the crew, the described altitude estimates of the witnesses and the observation of a witness who saw the tail section hang down. Such an unnoticed altitude loss would explain the insufficient altitude to stop the yaw movement. Due to a descent and backward movement the helicopter could become unstable about the yaw axis and turn right in the direction of the torque moment which the powered rotor creates.

It is highly likely that the restricted spatial perception of the pilot due to the NVG has contributed to the occurrence; the same is true for the crew members whose atten-

tion was focused on the search. The FLIR operator who was not wearing NVG could not see due to the darkness; she concentrated on her monitor and the search with the FLIR camera. It is possible that the flight engineer, who was wearing NVG, tried to establish visual contact with the person assumed to be on the ground so that the ground forces could be led to the person. So he was probably not able to support the pilot in regard to calling his attention in due time to the movement of the helicopter. The pilot stated he tried to position the helicopter so that the assumed heat source would once again be visible on the display in the cockpit. At the same time the flight engineer in the left seat should have a clear FLIR image available to him. During the attempt to regain control - by actuating the left pedal, reducing the power to decrease torque and increase speed - of the turning helicopter a loss in altitude occurred which was recognised too late. This resulted in the contact with obstacles and the crash.

The BFU is of the opinion that the missing procedures describing the often occurring search for missing persons at night with the respective dangers and limitations when wearing NVG in the flight operations manual contributed to the accident. Procedures were missing describing how a safe transition from conventional VFR Day to VFR Night wearing NVG during a mission is to be conducted. Especially considering that the crew consisted of one pilot and one flight engineer. There was neither a clear task division within the crew nor were there standardised processes to support the pilot during the time of the highest work load, when in the dark above a target outside of the ground effect the helicopter has to be kept stationary. So far, in this moment the pilot is on his own. Since both other crew members were busy with the search for the missing person and police tasks.

The various studies concerning flight operations with NVG show how challenging a safe conduct of flight under the optical limitations of NVG is. All studies refer to the great significance of good crew resource management in regard to the spatial orientation and the recognition of the flight attitude to compensate the existing limitations. The helicopter squadron in question also knew this which was reflected in the draft for the new training hand book for the flights under NVG; but it was not yet implemented and from the BFU point of view not comprehensive enough. An exchange of experiences with other state and federal police helicopter squadrons should take place. The specimen draft of a flight operations manual of the federal police laid down the framework but was still in process and therefore insufficient.

Past investigations of accidents with police helicopters determined repeatedly procedural and organizational deficiencies. The BFU is of the opinion that the three safety

recommendations already issued are still valid. Had they been implemented the existing procedures in regard to the use of NVG might have been questioned.

Conclusions

The accident is due to the loss of control of the helicopter which resulted in the contact with obstacles.

It is highly likely that the following contributed:

- Flight at night while wearing night vision goggles
- Visual restrictions due to the system design of the NVG
- The attention of the crew was distracted by the search
- Insufficient procedures for the search for missing persons at night
- Loss of the spatial perception in regard to altitude and speed

Safety Recommendation

Actions of the Landespolizeihubschrauberstaffel (state police helicopter squadron) involved:

After the accident, on 8 August 2011, the Landespolizeihubschrauberstaffel has issued the procedural instruction No FBH AM 05 "Mounting night vision goggles on the helmet". It stipulated:

If the total flight time of a flight begun at daylight reaches into the night at least 30 minutes prior to the start of night time (sunset) a landing outside an airfield is to be conducted so that the night vision goggles can be mounted to the helmets while the helicopter is safely on the ground.

Furthermore, the Landespolizeihubschrauberstaffel prepared Standard Operating Procedures (SOP of 1 June 2012) "Flights with Night Vision Goggles".

In addition, a new flight operations manual on the basis of JAR OPS 3 is being prepared. It should be put into effect in 2012.

Due to these actions the BFU has not issued any safety recommendations.

Investigator in charge: Axel Rokohl
Assistance: Holger Röstel
Braunschweig, 18 July 2012

The investigation has been conducted in compliance with the law relating to the Investigation of Accidents and Incidents associated with the Operation of Civil Aircraft (Flugunfall-Untersuchungsgesetz - FIUUG) dated 26 August 1998.

According to the law the sole objective of the investigation shall be the prevention of future accidents and incidents. It is not the purpose of this activity to assign blame or liability or to establish claims.

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