Investigation Report

Identification

Type of Occurrence: Accident
Date: 8 December 2012
Location: Wölfersheim-Melbach
Type of aircraft: 1. Airplane
2. Airplane
Manufacturer / Model: 1. Piper Aircraft Corporation / PA 32-301
   "Saratoga"
2. Avions Pierre Robin / DR 400-180
   "Regent"
Injuries to Persons: 1. Five persons fatally injured
2. Three persons fatally injured
Damage: 1. Airplane destroyed
2. Airplane destroyed
Other Damage: Crop damage
State File Number: BFU 3X163-12
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 - FlUUG) 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

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<th>Definition</th>
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<tr>
<td>AIP</td>
<td>Aeronautical Information Publication</td>
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<tr>
<td>AMSL</td>
<td>Above Mean Sea Level</td>
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<tr>
<td>AME</td>
<td>Aeromedical Examiner</td>
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<tr>
<td>ATPL</td>
<td>Airline Transport Pilot License</td>
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<tr>
<td>BFU</td>
<td>Bundesstelle für Flugunfalluntersuchung</td>
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<tr>
<td></td>
<td>(German Federal Bureau of Aircraft Accident Investigation)</td>
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<td>BKA</td>
<td>Bundeskriminalamt</td>
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<td></td>
<td>(Federal Office of Criminal Investigation)</td>
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<tr>
<td>BZF</td>
<td>Beschränkt gültiges Sprechfunkzeugnis</td>
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<tr>
<td>BMVI</td>
<td>Bundesministerium für Verkehr und Digitale Infrastruktur</td>
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<td></td>
<td>(Federal Ministry of Transport and Digital Infrastructure)</td>
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<tr>
<td>CAVOK</td>
<td>Clouds and Visibility Okay</td>
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<td>DWD</td>
<td>Deutscher Wetterdienst</td>
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<td></td>
<td>(German meteorological service provider)</td>
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<tr>
<td>FL</td>
<td>Flight Level</td>
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<td>FIS</td>
<td>Flight Information Service</td>
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<td>GAFOR</td>
<td>General Aviation Forecast</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>hPa</td>
<td>hectoPascal</td>
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<td>IFR</td>
<td>Instrument Flight Rules</td>
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<td>JAR-FCL</td>
<td>Joint Aviation Requirements Flight Crew Licensing</td>
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<td>LKA</td>
<td>Landeskriminalamt</td>
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<td></td>
<td>(State Office of Criminal Investigation)</td>
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<tr>
<td>LuftVO</td>
<td>Air Traffic Order</td>
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<td>NfL</td>
<td>Nachrichten für Luftfahrer</td>
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<td></td>
<td>(German Language Publication for Aviation)</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>NM</td>
<td>Nautical Miles</td>
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<tr>
<td>METAR</td>
<td>Meteorological Aerodrome Report</td>
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<tr>
<td>NOSIG</td>
<td>No Significant Change</td>
</tr>
<tr>
<td>PIC</td>
<td>Pilot in Command</td>
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<tr>
<td>QNH</td>
<td>Altimeter pressure setting to indicate elevation AMSL</td>
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<tr>
<td>SE</td>
<td>Single Engine</td>
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<tr>
<td>TMG</td>
<td>Touring Motor Glider</td>
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<tr>
<td>VFR</td>
<td>Visual Flight Rules</td>
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<tr>
<td>VNL</td>
<td>Correction for Defective Near Vision</td>
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<tr>
<td>PPL (A)</td>
<td>Private Pilot License (Aeroplanes)</td>
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Synopsis

On 8 December 2012 at 1634 hrs\(^1\) the BFU was informed by the police in Friedberg (Hessen) that east of Bad Nauheim an air accident had occurred involving two aircraft.

The BFU dispatched four investigators to the accident site.

A Piper PA 32-301 Saratoga, with 5 persons on board, and a DR 400-180 Regent, with three occupants, had collided in cruise flight. Both airplanes impacted the ground.

All eight occupants were fatally injured and the aircraft destroyed.

The accident was the result of the two pilots not recognising the conflicting traffic in time or at all.

Contributing factors:

- Approximation of the two aircraft as constant bearing
- The PA 32 pilot was blinded by the low sun
- Orographically caused restrictions of the recognition of the two aircraft

\(^1\)All times local, unless otherwise stated.
1. Factual Information

1.1 History of the Flight

A Piper PA 32-301 Saratoga, hereafter PA 32, took off at 1505 hrs from Stadtlohn Airfield (EDLS) to a VFR flight to Aschaffenburg Airfield (EDFC). On board were the pilot, who was also owner and operator, and four passengers.

At about 1535 hrs a DR 400-180 Regent, hereafter DR 400, took off at Koblenz-Winnigen Airfield (EDRK) to a VFR flight to Reichelsheim (EDFB). On board were the pilot and two passengers.

Both aircraft were on their return flights to their base airports from which they had started on the same day.

The recorded radar data showed that at 1603:01 hrs the PA 32 was at about 3,500 ft AMSL north-west of Wölfersheim. At the same time the DR 400 was north-east of Bad Nauheim at also approximately 3,500 ft AMSL. At that time the distance between the two aircraft was about 2.3 NM. The PA 32 had a track of 160° straight ahead, while the DR 400 was flying a right-hand turn.

At about 1603:28 hrs the two aircraft were flying at approximately 3,500 ft AMSL in the airspace between Bad Nauheim and Wölfersheim. At the time, the distance between the two airplanes was 1.02 NM.
The track of the PA 32 continued to be 160°, the DR 400 had finished the right-hand turn and had now a track of 120°. From this position on until the collision the airplanes converged during a time period of 39 seconds with a calculated closure rate of 90 kt.
Collision and approach scenario according to radar and GPS data

Source (2): BFU/Google Earth™
At 1603:40 hrs the person occupying the right-hand seat in the DR 400 informed the Flugleiter (A person required by German regulation at uncontrolled aerodromes to provide aerodrome information service to pilots) at Reichelsheim via radio of the intended landing in 5 minutes. At the time, the DR 400 was about 3 NM north-west of Reichelsheim Airfield.

At 1603:52 hrs both aircraft were in the airspace between Bad Nauheim and Melbach, had unchanged headings and altitudes and a distance of 0.42 NM to each other.

At about 1604:07 hrs the airplanes collided south of Melbach and impacted the ground.

All eight occupants were fatally injured and the aircraft destroyed.
1.2 Injuries to Persons

1.2.1 Occupants PA 32

<table>
<thead>
<tr>
<th>Injuries</th>
<th>Crew</th>
<th>Passengers</th>
<th>Third Parties</th>
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<tr>
<td>Fatal</td>
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<td>4</td>
<td></td>
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<tr>
<td>Serious</td>
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<tr>
<td>Minor/none</td>
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1.2.2 Occupants DR 400

<table>
<thead>
<tr>
<th>Injuries</th>
<th>Crew</th>
<th>Passengers</th>
<th>Third Parties</th>
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<tbody>
<tr>
<td>Fatal</td>
<td>1</td>
<td>2</td>
<td></td>
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<tr>
<td>Serious</td>
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<tr>
<td>Minor/none</td>
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1.3 Damage to Aircraft

Both aircraft were destroyed.

1.4. Other Damage

There was crop damage.

1.5 Personnel Information

1.5.1 PA 32 Pilot

Since 24 September 2010, the 40-year-old pilot held a Private Pilot’s License (PPL(A)) issued in accordance with JAR-FCL, German. The licence listed the class rating PIC SE piston (land).

The licence was valid until 24 September 2017 and the class rating until 24 September 2014. His Class 2 Medical Certificate was valid until 27 July 2016. It showed the limitation VNL.
He also held an open-ended licence for glider pilots which had first been issued in 1994. The licence listed the take-off type aero tow.

He had a total flying experience of 206 hours and 684 cycles; 149 hours and 413 cycles of which were flown on gliders and 57 hours and 271 cycles on motor planes.

Between 30 September and 24 November 2012 he had had familiarisation flights on PA 32 of 5 hours and 40 minutes involving 31 cycles; 3 of these flights of 14 minutes he had conducted without instructor. He had completed his flight training on DA 20 and PA 28 with a total of 51 hours and 240 cycles.

1.5.2 Person in the Right-hand Seat of the PA 32

The 42-year-old female person occupying the right-hand seat had been in flight training for private pilots in accordance with JAR-FCL (German) since 8 May 2011 and had successfully completed the theoretical exam.

She held a BZF 1 (English) and had a flying experience of 41 hours.

1.5.3 DR 400 Pilot

The 33-year-old female pilot held a private pilot's license issued on 28 January 2003, which was valid until 13 February 2016. The PPL (A) issued in accordance with JAR-FCL (German) listed the rating SE piston (land) and TMG, each valid until 13 February 2014.

Towing without pick-up manoeuvres was also listed.

She also held an open-ended licence for glider pilots which had first been issued in 1999. The licence listed the take-off types: aero tow and winch.

Her class 1 medical certificate without restrictions was valid until 10 December 2013.

She had a total flying experience of 582 hours and 1,005 cycles; 446 hours and 663 cycles of which were flown on gliders and 136 hours and 342 cycles on motor planes and powered sailplanes.

According to her pilot log book the last flight with a motor plane occurred on 9 September 2012.

1.5.4 Person in the Right-hand Seat of the DR 400

The male person in the right-hand seat held an Airline Transport Pilot's License (ATPL) issued in accordance with JAR-FCL (German) on 9 July 1993. The licence listed the ratings as PIC for various transport aircraft.
It also listed the rating for SEP (land) and TMG, each valid until 31 August 2014. In addition, it listed the instructor rating for PPL (A) valid until 30 September 2014.

He also held an open-ended licence for glider pilots which had first been issued in 1987. The licence listed TMG and the take-off types: aero tow, self, winch.

It also listed the instructor rating valid until 27 April 2013, aerobatics rating for sailplanes, and towing without pick-up manoeuvres.

The BFU did not have any other information regarding his flying experience available.

1.6 Aircraft Information

1.6.1 PA 32-301 Saratoga

The PA 32-301 Saratoga is an all-metal low wing airplane of the manufacturer Piper Aircraft Corporation. The single engine aircraft, seating up to six, with the manufacturer’s serial number 31-8106068 was built in 1981 in the United States of America. The aircraft was equipped with a Lycoming IO 540 K1G5D engine with variable-pitch propeller.

The aircraft had a German certificate of registration and was privately operated. The last annual check was performed on 12 July 2012. On 24 November 2012 (last technical flight log entry) total operating time was 1,146 hours and 1,378 cycles.
1.6.2 DR 400-180 Regent

The DR 400-180 Regent is an all-wood single engine cantilever low wing aircraft, seating up to four, with fixed main and nose wheel landing gear. The aircraft with the manufacturer’s serial number 2181 was manufactured in 1993 by Avions Pierre Robin.

It is equipped with a Lycoming O-360-A3A four-cylinder engine with 134 kW (180 PS) and fixed two-blade metal propeller.

The aircraft had a German certificate of registration and was privately operated.

The last annual check was performed on 14 August 2012. At that time, total operating time was 409 hours at 912 cycles.
1.7 Meteorological Information

According to the Deutscher Wetterdienst (German meteorological service provider, DWD) on 8 December 2012 in the area of the Wetterau high pressure influence with dry cold air prevailed.

There was no precipitation except for individual high and medium high clouds; visibility was 15 to 20 km. Surface wind with 5 kt from northern directions. In higher altitudes the wind changed to west and up until 3,000 ft AMSL the wind was also 5 kt.

According to the GAFOR, the Rhine-Main area and the Wetterau (GAFOR area 45 with reference height 800 ft AMSL) were classified as Charlie for the time of the accident. This classification means visibility 10 km and a cloud base of 5,000 ft above the reference height.
The Taunus adjacent to the west of the Wetterau (GAFOR area 42 with a reference height of 2,000 ft AMSL) was also classified as Charlie.

The Vogelsberg adjacent to the east of the Wetterau (GAFOR area 43 with a reference height of 2,000 ft AMSL) was classified as Oscar. This means visibility of at least 8 km and a cloud base of at least 2,000 ft above the reference height.

The aviation routine weather reports (METAR) for Frankfurt Main Airport:

METAR 1450 EDDF 20003KT CAVOK M01/M08 Q1021 1010 2982
NOSIG R07L/1/0095 R07C/1/0095 R07R/1/0095 R18/1/0095
COMMENTS: TG: M06.2 VIS: 30KM

METAR 1520 EDDF 17002KT CAVOK M01/M08 Q1024 A3024 1011 2985
NOSIG R07L/1/0095 R07C/1/0095 R07R/1/0095 R18/1/0095
COMMENTS: TG:M08.8 VIS:30KM

At about 1604 hrs, at the time of the accident, the sun was in a position of approximately 219° and an angle of 8° above the horizon (refer to Appendix 5.2).

For the accident site the time of sunset was 1622 hrs.

At the time of the accident the Wetterau had a snow cover of about 5 cm.

![Position of the sun at Wölfersheim at the time of the accident](source: Internet (www.sonnenerlauf.de))
1.8 Aids to Navigation
Not applicable

1.9 Radio Communications
The DR 400 was in radio contact with the Flugleiter at Reichelsheim. The radio communications were recorded and made available for evaluation. The recording of the radio communications was clearly understandable.

At 1603:40 hrs the person occupying the right-hand seat in the DR 400 informed the Flugleiter at Reichelsheim of the intended landing in 5 minutes.

According to the statement of the air traffic service provider of 8 December 2012 the two aircraft had at no time contact with the responsible Flight Information Service (FIS) Langen Info.

1.10 Aerodrome Information
Not applicable

1.11 Flight Recorders
Both aircraft were equipped with navigation aids (radio navigation). The DR 400 was equipped with a GPS.

The aircraft were not equipped with a flight data recorder or a cockpit voice recorder. There were no legal requirements for such equipment to be fitted.

The air traffic service provider recorded the radar data of the flight paths of both aircraft and made them available to the BFU for evaluation purposes.

1.12 Wreckage and Impact Information
The accident occurred about 35 km north-east of Frankfurt am Main in the area of the parish Wölfersheim-Melbach (Wetterau). The southern outskirts of the township Melbach formed the northern boundary of the accident site, the country road Bundesstrasse (national highway) B 455 the western and the Landstrasse (country road) L 3412 the southern. It consisted of two parts including the final position of each airplane.
The northern part showed a debris field of about 200 x 300 m including the wreckage of the DR 400. The southern part showed a debris field of about 50 x 50 m including the wreckage of the PA 32.

The distance between the two wreckages was approximately 600 m.

In the northern part mostly wooden parts of the DR 400 were found. But there also were some parts of the PA 32. These were: the right main landing gear, the nose wheel, fracture pieces of the wheel spats and other small parts.

The three fatally injured occupants of the DR 400 were also found at different places within this area. The respective seats of the pilots were lying in the immediate vicinity of the two persons, who had sat in the front.

Both main wreckages and individual pieces showed paint transfer marks of the other aircraft.
In the aft lateral segment of the PA 32 landing gear cover stuck a strip of wood of about 30 cm of the DR 400. Both pieces were connected in an angle of about 40°.

The DR 400 wreckage lay inverted on the ground and its longitudinal axis pointed toward west. The part of the left wing from the left main landing gear on was missing. A multitude of pieces no larger than 50 x 50 cm of the left wing were found within the debris field.
The aft fuselage segment including the tail boom was bent and lying west of the main wreckage. The vertical tail and the left part of the all-flying tail were severed.

Engine including propeller was lying beneath the aircraft. The outer third of one of the propeller blades showed wavelike deformations and was missing its tip. The leading edge had been damaged by a multitude of adjoining indentations. The entire propeller blade showed white paint transfer marks.

The entire length of the second propeller blade was deformed but did not show any damage.
The entire surface of the upper cowling segment of the DR 400 showed paint abrasions.

The cockpit area was destroyed. Individual segments of control equipment and of the instrument panel were strewn around the wreckage or partially still connected with it.

All electrical fuses were pushed in. All lamps including the strobe and navigation lights were switched off.

The two main wheels and the landing gear cover were complete and on visual inspection intact. The left landing gear cover showed tears at the side. The nose wheel was bent and connected with the wreckage.

The right wing did not show any greater damage, except for its leading edge which was partially torn open.

The function of the control cables and the positions of switches and levers could only be partially checked due to the high degree of destruction. The tanks had been torn open and did not contain any fuel.
The southern debris field including the wreckage of the PA 32 bordered the Landstrasse-L 3412.

The BFU investigators arriving at the site did not find the wreckage of the PA 32 in the original position, because rescue personnel of the fire brigade had moved the wreckage in order to recover the 5 fatally injured occupants.

The front part of the aircraft, including engine, propeller, and cockpit stuck more than 2 m deep in the ground. There were no sliding marks.

The three-blade propeller was bent; one blade had been torn off at the hub.

The entire length of the leading edges of both wings had been compressed several times and stuck up to 40 cm in the ground.

The PA 32 aft fuselage segment had been severed and was torn open at several places. The tail section showed damages in places, but was complete and on visual inspection intact.
The function of the control cables and the positions of switches and levers including the activation of the autopilot could only be partially checked due to the high degree of destruction.

The tanks had been torn open. Traces of fuel having leaked into the ground were found.

In the PA 32 cockpit a supply of glucose pads, a blood glucose meter, and an Insulin Pen (subcutaneous injection of insulin) were found. It contained one ampoule of “Lispro”.

The personal documentation of the PA 32 pilot proved the use of the medication “Lantus” and Lispro”.

The debris field of 50 x 50 m only contained PA 32 segments. Most of the individual pieces were either found directly at the wreckage or only a few meters south-east.

The Technische Hilfswerk (Federal Agency for Technical Relief) covered the two wrecksages and a large part of the debris field for the night (to 9 December 2012), because of the weather conditions with snow and strong winds.

1.13 Medical and Pathological Information

All 8 fatally injured occupants of the two aircraft were subject to post mortem examinations.

As cause of death it was determined that they died due to multiple trauma as a result of the impact forces.

It was possible to determine that the medical paraphernalia (syringes, etc.) found in the PA 32 cockpit belonged to the 40-year-old pilot.

Interviews of witnesses in the direct environment of the pilot determined that he was diagnosed with juvenile Type 1 diabetes during his adolescence. Since then he had been regularly injecting himself subcutaneously with insulin (Basal Bolus Therapy).

The witnesses stated that with this form of therapy the diabetic metabolic status had to be considered stable. It was not known that he had any episodes of acute hypoglycaemia. Monitoring the blood glucose level occurred via a skin sensor and the respective blood glucose meter, which was found in the cockpit. The blood glucose meter indicates deviations from the norm acoustically and visually.
1.14 Fire

There were no indications of fire.

1.15 Survival Aspects

Not applicable

1.16 Tests and Research

1.16.1 Animation of the Flight Paths

Based on the existing data (radar data, GPS positions) and the collision traces on the wreckage parts (e.g. paint transfer marks) the aim was to determine and visualize the approximation of the aircraft.

By way of assistance, the Bundeskriminalmat (BKA) (Federal Office of Criminal Investigation) scanned two identically constructed airplanes as the aircraft types involved from the outside and inside (cockpit).

Based on the scanning data the aircraft were generated as three-dimensional models.

With the support of the Landeskriminalamt (LKA) Hamburg (State Office of Criminal Investigation) a multi-level process followed where, with the help of a special software, the aircraft models, terrain data, flight path data (radar and GPS) were consolidated, synchronised, and animated.

The result was a real-time animation of the approximation from different perspectives and angles of view, especially from the inside of the cockpit from the front seat of the airplanes.
Scanning of the aircraft, DR 400 (above), PA 32 (below)  
Source (2): BFU
Animation of the collision scenario from the perspective of the left-hand seat of the DR 400

Source: LKA/BKA/BFU
Animation of the collision scenario from the perspective of the left-hand seat of the PA 32

Source (2): LKA/BKA/BFU
1.16.2  Expert Opinion regarding Visual Recognition Probability

The technical literature did not mention any special investigation technique regarding the specific general conditions for the approximation scenario between the DR 400 and the PA 32.

The BFU charged the Technische Universität (Technical University) Darmstadt with an expert opinion to determine if and to what extent the crews of the aircraft involved were able to see the conflicting traffic.

A simulator test with subjects was conducted to determine the attention distribution of the crews in the aircraft involved.

The data so obtained was then used by the experts to analytically assess the visual recognition probability.

The experts summaries their results as follows:

*It is the aim of expert opinion to assist the BFU investigators in their assessment of the occurrences resulting in the air accident BFU 3X163-12.*

*The key question of the expert opinion is whether the collision could have been avoided with an unobstructed view between the two airplanes.*

*In order to answer this question a recognition model known from literature was presented. This model depicts in analytical form the probability with which one crew member can detect another aircraft by observing the air space. It can be applied to accident investigation. The attention parameter, which describes with which attention the crew observes the task of air space surveillance, is of key importance in this model.*

*Even though literature presents an experimentally determined attention parameter for airspace surveillance it cannot be applied for accident investigation.*

*The test subjects of the test flights, on whose basis the attention parameter mentioned in the literature was identified, had to detect traffic which posed no imminent threat.*

*The crews involved in the accident BFU 3X163-12 would have had to detect conflicting traffic at the same altitude at constant bearing in their peripheral vision to prevent the accident. Therefore, the task of the accident crews and the test subjects differed and the literature value could not be applied.*
Due to this, the attention value for accident prevention (detection of the conflicting traffic at the same altitude at constant bearing) was identified in simulator tests.

A total of 17 crews participated in the simulator test at FSR in which the situation on board the accident aircraft was re-enacted.

All crew members in the simulator tests detected the conflicting traffic before it crossed their own flight path right in front of their aircraft. This occurred, however, between 22 and 2 seconds prior to crossing.

On average the detection of the conflicting traffic occurred 9.2 seconds with a standard deviation of 6.1 seconds prior to crossing.

Based on the results of the simulator test it was possible to identify a new attention value. This attention value refers to the task of detecting conflicting traffic at the same altitude at constant bearing in peripheral vision.

The attention value for accident prevention identified in the simulator tests was used to draw conclusions to the visual recognition probability during the approximation of the accident BFU 3X163-12.

The recognition model known from literature was used and supplemented with flight path data. It became clear that even with optimistic model assumptions (no glare due to low sun, no blocking by aircraft components) the concept of See and Avoid reached its limit.

After the two accident aircraft had entered collision heading the accident could not have been reliably avoided, according to these findings.
The following images obtained during the test from the cockpit of a Diamond DA 40 refer exclusively to the detection aspect during lateral approximation (constant bearing). They depict the approximation of the DR 400 from the perspective of the PA 32 between 12 seconds and 1 second prior to the collision. The red circle indicates the approximation area of the DR 400.

Other aspects such as view restrictions due to the cockpit design, the wings, the relief, sun position, and glare were not taken into consideration during this test.
View to the right from the PA 32 cockpit 10 seconds prior to the collision

View to the right from the PA 32 cockpit 8 seconds prior to the collision

Approximation scenario in the simulator

Source: Technische Universität Darmstadt/ BFU
View to the right from the PA 32 cockpit 6 seconds prior to the collision

View to the right from the PA 32 cockpit 4 seconds prior to the collision

Approximation scenario in the simulator

Source: Technische Universität Darmstadt/ BFU
View to the right from the PA 32 cockpit 2 seconds prior to the collision

View to the right from the PA 32 cockpit 1 seconds prior to the collision

Approximation scenario in the simulator

Source: Technische Universität Darmstadt/ BFU
1.17. Organisational and Management Information

In Germany physicians, trained as Aeromedical Examiners (AME), assess aeromedical fitness. These physicians usually perform this task as part of their medical practice. Depending on their training they are authorised to issue different classes of medical certificates.

The PA 32 pilot consulted the same AME throughout his flying career whenever his medical certificate had to be renewed.

At the time JAR-FCL 3 dated 27 March 2007 had to be applied.

Subpart C Class 2 Medical Requirements point JAR-FCL 3.295 Metabolic, nutritional and endocrine [systems] states:

d) Applicants with diabetes requiring insulin shall be assessed as unfit

1.18 Additional Information

1.18.1 Right of Way

Both aircraft were flying in accordance with VFR in uncontrolled airspace.

At the time of the accident the valid LuftVO (Air Traffic Order) para 12 and 13 stated, among other things:

*In order to avoid collisions, the pilot has to keep sufficient distance to aircraft, other vehicles, and other obstacles.*

and

*Aircraft approaching each other on the downwind leg have to turn right if danger of a collision exists. When two aircraft are converging at approximately the same altitude, the aircraft that comes from the left shall give way.*

and

*If one aircraft overtakes another the overtaker, even in climb or descent, has to avoid the other aircraft’s flight path and change the course to the right. An aircraft overtakes another if it approaches from behind in a flight direction which is less than 70° of the flight path of the other.*

*The provisions of the rules of right-of-way do not release the pilots concerned from their responsibility to take such action as will best avert collision.*
1.18.2 Flying in Airspace E

According to the AIP Germany, airspace E is a controlled airspace with VFR and IFR traffic. Its upper limit is at FL100 (at the Alps FL130) and the lower limit at the transition to airspace G between 1,000 ft and 2,500 ft GND.

There is no separation between the different traffic types.

VFR flights have to adhere to a minimum vertical distance to clouds of 1,000 ft and a minimum horizontal distance of 1.5 km.

In airspace E visibility must be at least 5 km up to FL100 and 8 km above FL100 for VFR flights.

For powered aircraft transponders are mandatory from 5,000 ft AMSL or 3,500 ft GND on.
Below 5,000 ft at airspace E cruise level for the chosen heading can be selected freely. Air pressure settings up to 5,000 ft are based on the respective regional weather based QNH.

For the avoidance of collisions during cruise flight the so-called semi-circular rule is applied in Germany from 5,000 ft on. One characteristic of this rule is that aircraft have to adhere to different altitudes depending on their track and traffic type (VFR or IFR). These are altitudes levels of 500 ft. To ensure consistent distances of all aircraft a standard QNH of 1,013 hPa is selected at the altimeters from 5,000 ft on.

1.18.3 See and Avoid

The BEKLAS project *Erkennbarkeit von Segelflugzeugen und kleinen motorisierten Luftfahrzeugen* (BEKLAS, 2004) by order of the Ministry for Transport, Building and Urban Affairs has extensively looked into the subject of detecting gliders and small powered aircraft.

The final report states: *Air traffic is based on the principle See and Avoid [...]. Even though it originates from the beginning of aviation it still is valid today. As the name suggests it is essential to see other traffic and be seen in order to prevent collisions. Key aspect here is the pilot's ability to detect other airplanes, to estimate heading and speed, and to deduce the right action. [...] If one observes another flying object in flight it usually moves against the foreground. Depending on the angle of the two headings there is a certain speed where the movement can no longer be detected and the observed object seems to not change position any more compared to the foreground (e.g. instruments, struts, etc.). This effect is called constant bearing.* (BEKLAS, 2004)

1.18.4 Flight Information Service

For the sovereign territory of the Federal Republic of Germany, the Deutsche Flugsicherung provides the Flight Information Service (FIS). In the area of the accident this service is provided on the frequency of Langen Information.

The Manual of Operations Air Traffic Services defines FIS as follows: “A service provided for the purpose of giving advice and information useful for the safe and efficient conduct of flights.”

FIS is responsible for provision of information regarding collision risks for aircraft operating in airspaces E, F, and G. The aircraft involved were not in contact with Langen Information and had not tried to call FIS during the flight.
1.18.5 Collision Warning Systems

There are several collision warning systems available for General Aviation. They use different resources (e.g. ADS-B, Mode-S, FLARM) and assist the pilots to detect possible collision risks early and initiate adequate avoidance manoeuvres.

These systems can only assist See and Avoid and contribute to collision avoidance if the respective other aircraft transmits the respective information.

The aircraft involved were not equipped with such systems.

1.18.6 Relief

The Taunus west of the Wetterau is up to 880 m AMSL high. The Vogelsberg in the north-east is up to 770 m AMSL high.

Aircraft flying in the same altitude above flat terrain and having each other in sight see each at the horizon line, if the air is sufficiently clear.

![Visibility of aircraft flying above or below the horizon](source: BFU)

An aircraft flying higher can generally be better recognised because it is above the horizon. An aircraft flying lower is harder to detect because of the contrast since its silhouette is below the horizon.
If the relief is raised the horizon is higher. An aircraft flying in front of such a setting is flying below the horizon and can therefore be harder to detect by an aircraft flying at the same altitude.

The following image was taken on 30 December 2012 from the perspective of the PA 32 at an altitude of 3,500 ft and at a position which corresponded with the one of the airplane of 39 seconds prior to the collision. In the following image the Taunus is circled red. The DR 400 approached as constant bearing from this airspace segment which was at the 3 o’clock position of the PA 32.

1.18.7 Glare and View Restriction

A depiction of the approximation scenario in the last phase under real conditions from the perspective of the persons in the pilots’ seats is only possible to a limited extent. The visualisations from the perspective of the persons involved and acting are based on straight and parallel orientation of the two aircraft. Even the slightest deviation of the position in space, e.g. correction angle due to wind, or slight bank angle due to course corrections, result in significantly changed views to an aircraft approaching from the side. The seating position also influences the view. The following image shows the PA 32 pilot’s view to the right. The red circle indicates the airspace segment from which the DR 400 as conflicting traffic - probably below the horizon line - approached.
In the worst case scenario, it must be assumed that in addition the right wing and cockpit segments obstructed the view either partially or totally.

In addition, there were the view restrictions due to glare and reflection, respectively, from the low sun and the snow cover on the ground. The following image shows the glare and view restrictions due to the sun position taken on 30 December 2012 under similar weather conditions, clear sky, the same altitude, at the same time period, only a few minutes before sun set, as at the time of the accident.
The additional view restrictions due to dirty surfaces of the Plexiglas windows are characteristic for this aspect and the position of the sun, respectively. It is highly likely that similar conditions prevailed from the PA 32 cockpit toward the setting sun.

1.18.8 Constant Bearing

If two aircraft are on collision course and seem not to move to each other this is known as constant bearing. The missing movement makes it more difficult for the pilots to detect conflicting traffic.

1.19. Useful or Effective Investigation Techniques

Not applicable
2. Analysis

2.1 General

The pilots of the two aircraft held the required licences to conduct the flight and each had a valid medical certificate.

The DR 400 pilot had a flying experience of about 600 hours and about 1,000 flights and therefore a long-standing experience as glider and motor plane pilot.

The PA 32 pilot had only recently acquired his motor planes licence. As glider pilot he had a total flying experience of more than 200 hours and about 700 flights and therefore a good experience and training level.

With the PA 32 he had a flight time of about 6 hours and 30 flights and therefore become familiar.

Due to the regulations JAR-FCL 3 valid at the time of the accident aeromedical fitness would have had to be denied because the PA 32 pilot suffered from insulin-dependent diabetes mellitus Type 1. The BFU is nevertheless of the opinion, that due to the early diagnosis and the continuous, rigorous checks of the relevant metabolism parameters at close intervals, it is highly likely that at the time of the accident he was not impaired by his health.

The aircraft had a valid certificate of registration and inspected. Indications of technical defects were not found. Neither of the two aircraft was fitted with a collision warning system.

In regard to visibilities and cloud bases, the weather was suitable for the conduct of VRF flights.

At the time of the accident the sun was in about 219° and at about 8° above the horizon, therefore it has to be assumed that glare and view restrictions occurred when looking toward the sun.

2.2 Collision Scenario

Both aircraft flew in accordance with VFR and were in the last phases of prolonged cross-country flights with equal rights in airspace E. Both aircraft flew at 3,500 ft AMSL. Fifteen seconds prior to the collision the DR 400 had established radio contact with Reichelsheim Flugleiter.
The evaluation of the radar and GPS data shows that in the last 39 seconds prior to the collision closing speed was 90 kt.

The aircraft approached each other at an angle of approximately 40° and as constant bearing in the 9 o’clock or 3 o’clock position, respectively.

The analysed radar and GPS data shows that both aircraft had been in level flight.

The paint transfer marks also proof that the aircraft had been in level flight. They also show that neither of the two aircraft had conducted an avoidance manoeuvre. At the time of the collision, the position of the PA 32 in the airspace had been about a half aircraft height above the DR 400.
According to the LuftVO the PA 32 had been in a passing manoeuvre of the DR 400 and therefore would have had to give way. The BFU is of the opinion that due to the external conditions such as constant bearing, sun position, glare, and relief, the PA 32 pilot could not see the aircraft coming from the right in time and give way.

The BFU is of the opinion that since the PA 32 was approaching from behind and left the DR 400 pilot could not see the other airplane in time and give way.

The two persons occupying the right-hand seats in the two aircraft were also familiar with flight operations procedures. It therefore has to be assumed that they assisted the pilots in the left-hand seats with their tasks. For example, the person in the DR 400, holding a licence, conducted radio communications with Reichelsheim Tower Flugleiter shortly before the collision.
The assumed task distribution in the two cockpits was suited to have more capacity available to observe the airspace. These additional resources to observe the airspace did not prevent the collision.

The results of the study of the Technische Universität Darmstadt show that the options to observe conflicting traffic according to See and Avoid are severely restricted with this approximation scenario.

Both aircraft were on different radio frequencies. Active assistance by FIS was therefore not possible.
3. Conclusions

3.1 Findings

- The DR 400 pilot held the required licence to conduct the flight and with a total flying experience of about 600 hours was experienced.
- The person in the right-hand seat of the DR 400 was an experienced pilot, who assisted the pilot by conducting radio communications.
- The PA 32 pilot held the required licence to conduct the flight. This flight was the second since acquiring his licence.
- The PA 32 pilot suffered from insulin-dependent diabetes mellitus Type 1. The BFU is of the opinion, that due to the early diagnosis and the continuous, rigorous checks of the relevant metabolism parameters at close intervals, it is highly likely that at the time of the accident he was not impaired by his health.
- The person occupying the right-hand seat of the PA 32 was a student pilot at the last stage of her training (PPL(A)). It was not possible to determine whether she assisted the pilot with the conduct of the flight.
- Indications of technical defects were not found.
- Both aircraft were not equipped with a collision warning system.
- Both aircraft were on different radio frequencies and flew without assistance from FIS.
- The DR 400 had established radio contact with the aerodrome of destination.
- The aircraft approached at an angle of approximately 40° and an approach speed of 90 kt as constant bearing in horizontal flight on collision course.
- The PA 32 had been in a passing manoeuvre of the DR 400.
- According to the radar and GPS analysis both aircraft had been at 3,500 ft AMSL.
- At the time of the accident visual meteorological conditions prevailed.
- At the time of the accident the sun was at about 219° and 8° above the horizon.
- The landscape surrounding the accident site was covered in snow.
• From the perspective of the PA 32 toward the approaching DR 400, the terrain was raised at the horizon by the Feldberg (Taunus).
• From the perspective of the DR 400 toward the approaching PA32, the terrain was raised at the horizon by the Vogelsberg.

3.2 Causes
The accident was the result of the two pilots not recognising the conflicting traffic in time or at all.

Contributing factors:
• Approximation of the two aircraft as constant bearing.
• The PA 32 pilot was blinded by the low sun.
• Orographically caused restrictions of the recognition of the two aircraft.

4. Safety Information
In the Study Concerning Airproxes and Collisions of Aircraft in German Air Space 2010 - 2015 the BFU comes to the conclusion that the collision risk of all VFR cruise flights and VFR aerodrome traffic can only be reduced with appropriate compatible collision warning systems.

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