Bundesstelle für
Flugunfalluntersuchung

German Federal Bureau of
Aircraft Accident Investigation

Investigation Report

Identification

Type of Occurrence:	Serious Incident
Date:	27 April 2020
Location:	Cologne/Bonn Airport
Aircraft:	Airplane
Manufacturer:	Avions de Transport Régional
Type:	ATR 72-212
Injuries to Persons:	No injuries
Damage:	Minor damage to aircraft
Other Damage:	Runway edge lighting damaged
State File Number:	BFU20-0251-EX

Abstract

At night the flight crew aligned the airplane for take-off with the left runway edge lighting of runway 06 of Cologne/Bonn Airport. During take-off run, the airplane collided with several lamps of the runway edge lighting. Subsequently, take-off was terminated.

Factual Information

History of the Flight

On the day of the occurrence, the two-man flight crew was scheduled to conduct an early morning cargo transport flight with an ATR 72-212 from Cologne/Bonn Airport to Sofia Airport, Bulgaria.

After engine start-up, the crew received the following instruction from Cologne/Bonn Ground: "[…] taxi via Tango hold short 06." At 0353:28 hrs[1] at taxi-holding position of runway 06 they received the following instruction from Cologne/Bonn Tower: "[…] backtrack and line up runway 06." The crew taxied the airplane on the centreline of runway 24 towards the turnpad (paved area next to the runway for turning) for runway 06 (Fig. 1). According to the Pilot in Command's (PIC) statement, he controlled the airplane with his left hand via the Tiller (nose wheel hand steering). According to the CVR recording, the Before Take-off Checklist was completed during taxi. Once the turnpad was reached the airplane initially followed the yellow taxi guidance lines for turning. The airplane turned left abreast of the intersection with taxiway Bravo.

According to the CVR, a sound was heard in the cockpit during the left-hand turn. The crew tried to identify the cause of the sound. Initially, the crew assumed that the cockpit door had opened, but then determined that the PIC's bag had fallen down behind the seat.

The PIC completed the turn and aligned the airplane with the white lights in front of him. The crew waited for take-off clearance because other aircraft were taking off from the crossing runway 32R. According to their statements, both pilots were sure that the airplane was standing on the centreline of runway 06, correctly aligned. At 0356:13 hrs the crew received take-off clearance: "[…] wind one hundred 5 kt runway 06 cleared for takeoff […]."

The crew began take-off run. The PIC controlled the nose landing gear with the Tiller and pushed the power levers. After a short acceleration phase the crew observed several blows to the airplane. They saw objects flying off, but could not identify them. The PIC aborted take-off. The co-pilot was not informed concerning this matter. After a short discussion the crew taxied back via taxiway Tango to their assigned parking position. The crew could not explain the blows and sounds.

[1] All times local, unless otherwise stated.

Fig. 1: Taxi route between the beginning and the stop, based on FDR data Source: BFU

The subsequent runway inspection showed that a total of 9 lamps of the left runway edge lighting had been torn off or destroyed and one taxiway lamp was damaged.

After engine shut-off, the crew determined damage in the area of the nose landing gear, below the fuselage close to the main landing gear and on individual propeller blades.

Personnel Information

Pilot in Command

The 56-year-old PIC held a Dutch Airline Transport Pilot's License (ATPL (A)) issued in accordance with Part-FCL. The licence listed the type rating as PIC for ATR42/72 and the instrument rating, each valid until 30 June 2020, and the unlimited night flight qualification.

His class 1 medical certificate was last issued on 20 February 2020 and valid until 13 March 2021. It listed the limitation VML[2].

[2] Correction for defective distant, intermediate and near vision

He had a total flying experience of about 9,394 hours, of which about 8,347 hours were flown on type. In the last 90 days he had taken off 14 times from Cologne/Bonn Airport.

The planed flight would have been the first after a 36-hour rest period. Prior to the flight he had arrived from Netherlands by car and driven for about 55 minutes.

Co-pilot

The 52-year-old co-pilot held a German Airline Transport Pilot's License ATPL(A) issued in accordance with Part-FCL. The licence listed the type rating as co-pilot for ATR42/72 and the instrument rating each valid until 31 May 2020. In addition, the unlimited rating for aerotow of gliders and banners was listed.

His class 1 medical certificate was last issued on 25 November 2019 and valid until 14 December 2020. It listed the limitation VDL[3].

He had a total flying experience of about 5,365 hours, of which about 4,543 hours were flown on type. In the last 90 days he had taken off 24 times from Cologne/Bonn Airport.

The planed flight would have been the first after a 36-hour rest period. He had arrived the evening before and spent the night in the vicinity of the airport.

Both pilots have known each other for years and often flew together.

Aircraft Information

The type ATR 72-212 of Avions de Transport Régional is a twin engine turboprop transport aircraft in all-metal construction, which received type certificate in 1990. It is a high-wing aircraft with T-tail configuration and equipped with two PW 127 engines of Pratt & Whitney Canada Inc. Maximum take-off mass is 21,500 kg.

The airplane with the manufacturer's serial number 274, year of manufacture 1992, had a Spanish certificate of registration. The last Airworthiness Review Certificate (ARC) was issued on 6 April 2020 and valid until 24 April 2021. Total operating time was about 37,441 hours. Take-off mass at Cologne/Bonn Airport was about 18,789 kg. The crew had determined a V_1 of 109 KIAS.

[3] Wear corrective lenses and carry a spare set of spectacles

Meteorological Information

The aviation routine weather report (METAR) of 0250 hrs of Cologne/Bonn Airport read:

Wind:	Variable 2 kt
Visibility:	More than 10 km
Clouds:	No clouds below 5,000 ft (CAVOK)
Temperature:	5°C
Dewpoint:	3°C
QNH	1,010 hPa

With the take-off clearance surface wind from 100° with 5 kt was given.

At the time of the serious incident it was dark.

Radio Communications

Radio communications between the crew and Cologne/Bonn Tower were recorded and made available to the BFU as transcript for evaluation purposes.

Aerodrome Information

Cologne/Bonn Airport (EDDK) is located 8 NM south-east of Cologne city. Airport elevation is 302 ft AMSL. The airport had 3 crossing concrete runways.

Take-off run occurred on runway 06. It was 2,459 m long and 45 m wide. This runway crossed the runways 14L/32R and 14R/32L. From the different aprons, taxiway Bravo led to the beginning of runway 06. Due to construction work this taxiway had been closed since July 2019 (AIP SUP IFR 15/19 of 23.05.2019).

At the beginning of runway 06, there was a turnpad. Inclusive the runway it was 105 m wide. It was marked with 2 yellow taxi markings, which were equipped with green underfloor lamps (Fig. 2).

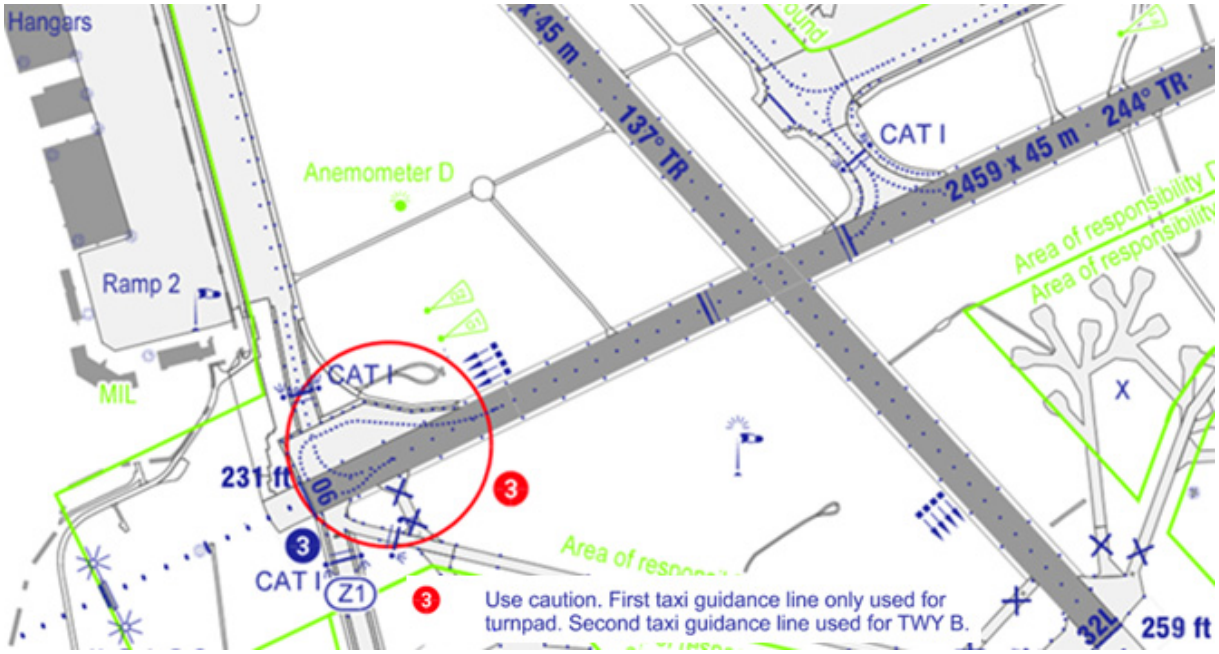


Fig 2: Overview runway 06, turnpad, and taxiway markings Source: AIP

According to the reporting archive of the lighting system of runway 06, the edge lighting of the turnpad, the lamps of the taxiway centreline and the taxiway edge lighting of taxiway Bravo had been switched on at the time of the occurrence. The brightness of the lamps of the taxiway centreline lighting and the ones of the turnpad edge lighting were coordinated. They had been on Level 1, i.e. 1% brightness of the LED lamps or 3% luminance. At 0355:49 hrs and at 0355:53 hrs the system had recorded partial lighting failure.

The overfloor lamps of the runway edge lighting were 36 cm high (including mounting) and had a mass of 3.36 kg.

Fig. 3: Example of an overfloor lamp of the runway edge lighting, intact and torn off Source: BFU

The airport was equipped with surface movement radar, which showed and recorded the turn and the take-off run (Fig. 4).

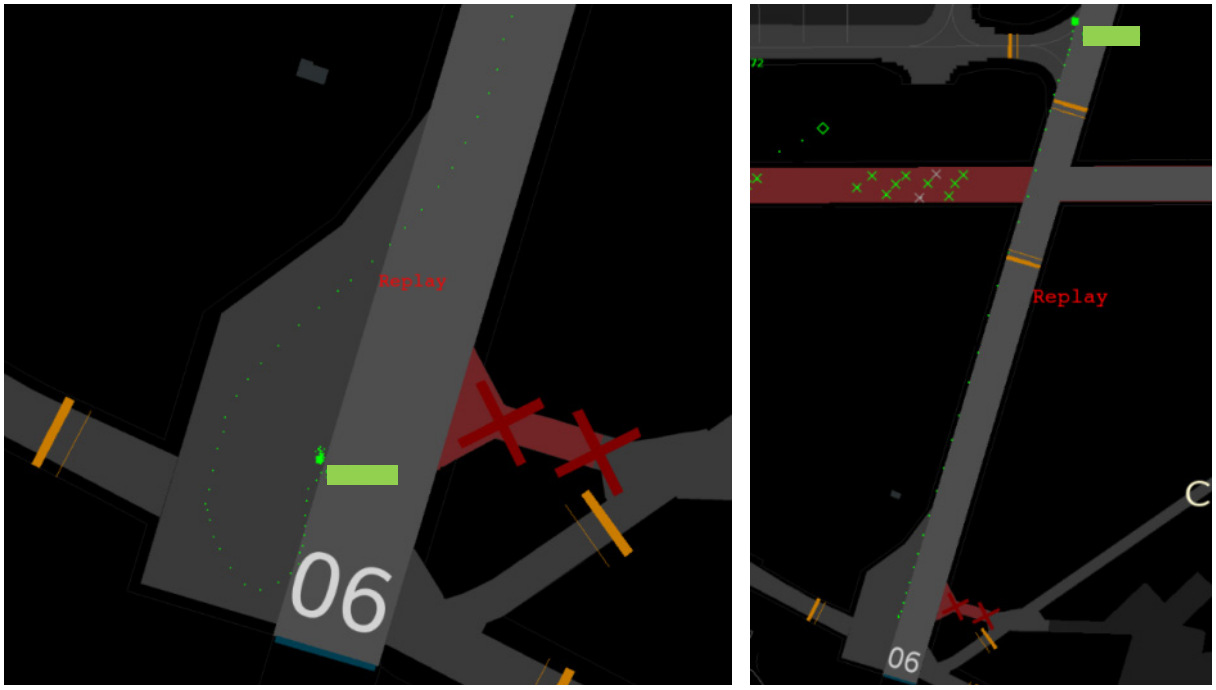


Fig. 4: Enhanced section of the ground radar recording of the turn and the take-off run (green points)

Source: DFS

Cologne/Bonn Tower

According to the statement of the air navigation service provider, the workstation of the tower controller was oriented towards runway 14L/32R because 90% of the traffic was processed there. One could see an airplane at take-off position 06, but you had to turn around and stand up. In darkness, it was difficult to identify the precise dimensions of an airplane and its correct position, due to the distance and the lack of reference points. The controller had ground radar available. The depiction was selected to not just show a section but all runways and taxiways. The size of the radar targets were not true to scale and therefore commonly almost as wide as the runway, due to the magnification.

Flight Recorder

The BFU seized the FDR and the CVR and analysed the data (Fig. 5 and Fig. 6).

FDR:

Manufacturer:	L3 Communications
Type:	Fairchild FA 2100
Part Number:	2100-4043-00
Serial Number:	01650

CVR:

Manufacturer:	L3 Communications
Type:	Fairchild FA 2100
Part Number:	2100-1020-02
Serial Number:	000354261
Recording:	120 minutes

The recorders were undamaged. All recorded parameters were readable.

Based on the FDR data, the statements of the flight crew made after the occurrence could be verified. Take-off run was terminated with a ground speed of about 86 kt.

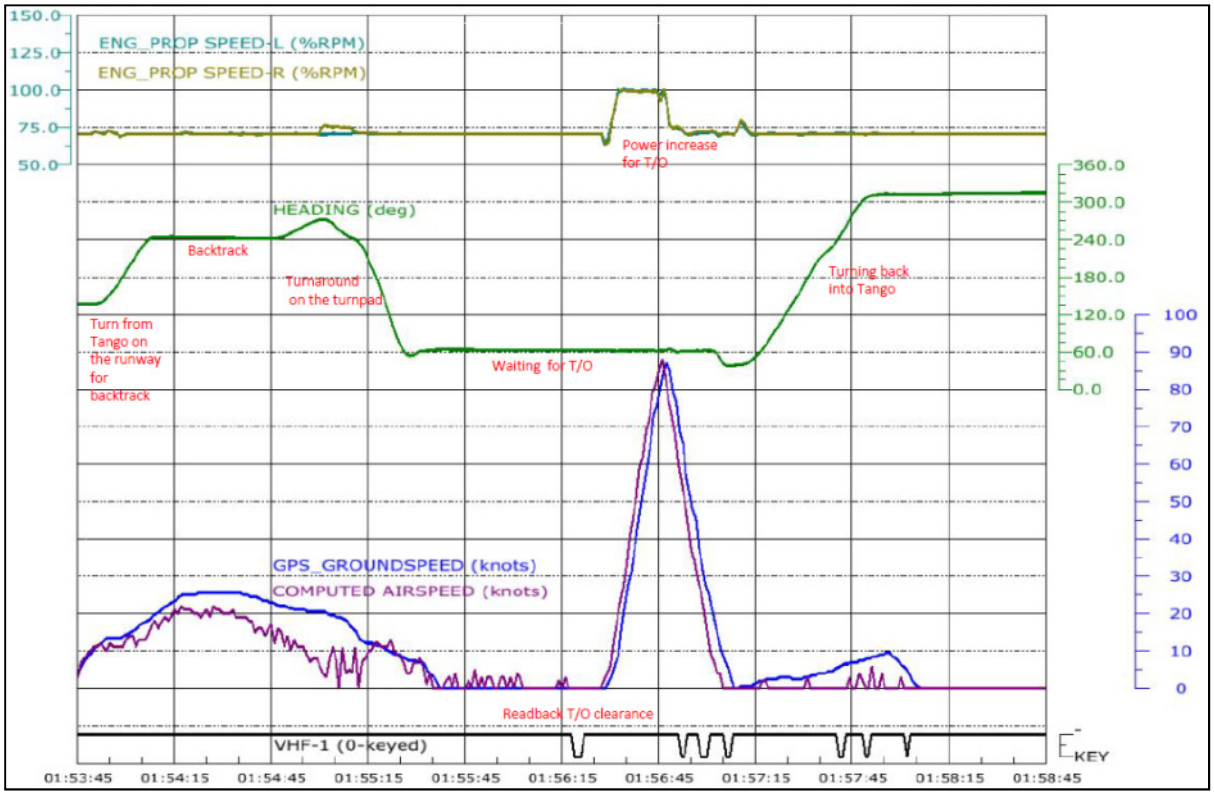
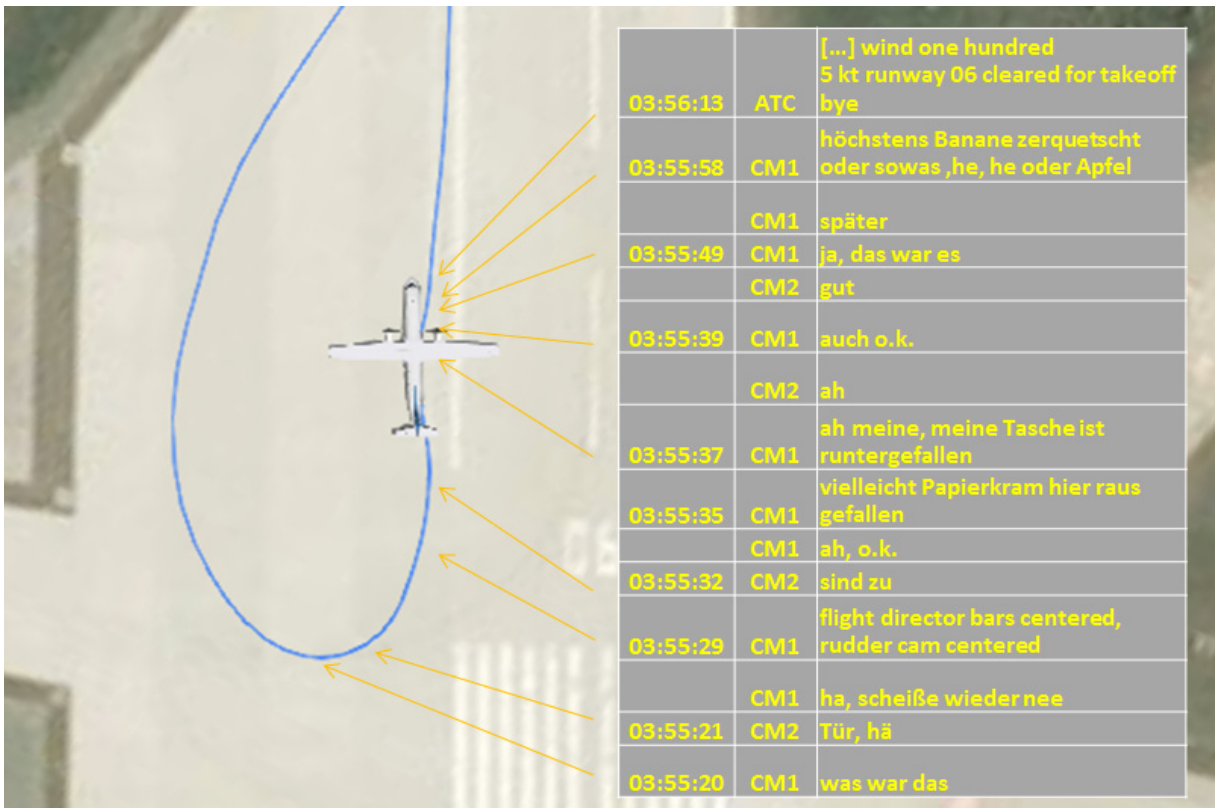


Fig. 5: Excerpt of relevant FDR data (times UTC) Source: BFU



03:56:13	ATC	[...] wind one hundred 5 kt runway 06 cleared for takeoff bye
03:55:58	CM1	höchstens Banane zerquetscht oder sowas ,he, he oder Apfel
	CM1	später
03:55:49	CM1	ja, das war es
	CM2	gut
03:55:39	CM1	auch o.k.
	CM2	ah
03:55:37	CM1	ah meine, meine Tasche ist runtergefallen
03:55:35	CM1	vielleicht Papierkram hier raus gefallen
	CM1	ah, o.k.
03:55:32	CM2	sind zu
03:55:29	CM1	flight director bars centered, rudder cam centered
	CM1	ha, scheiße wieder nee
03:55:21	CM2	Tür, hä
03:55:20	CM1	was war das

Fig. 6: Cockpit conversation during the turn Source: BFU

Wreckage and Impact Information

According to the wheel tracks the take-off run occurred from the turnpad along the paved left shoulder of runway 06. The shoulder was about 7 m wide. The wheel tracks showed that the airplane had been aligned almost central with the runway edge lighting, in regard to the total width of turnpad and runway (Fig. 7).

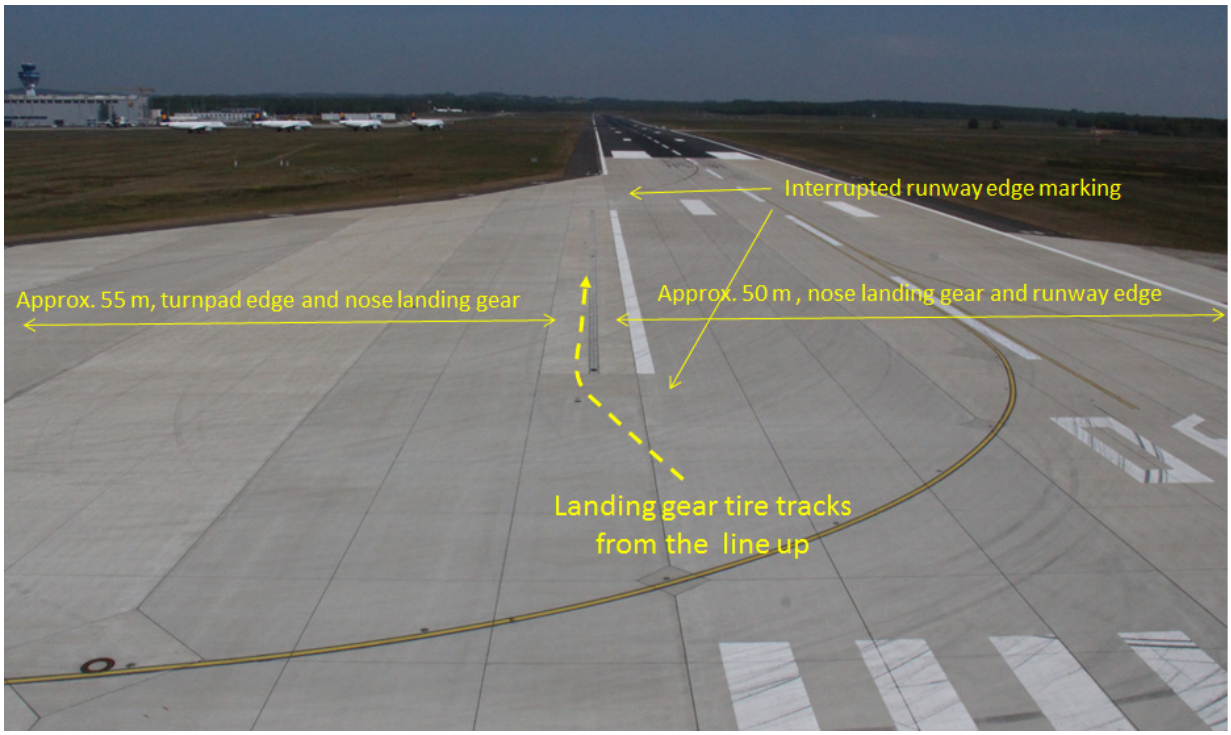


Fig. 7: Taxi traces of the landing gears, which originate from the alignment with the runway edge lighting

Source: BFU

Up until the crossing runway 14R/32L all 7 overfloor lamps of the runway edge lighting had been torn off and between runway 14R/32L and taxiway Tango 2 others. In addition, one taxiway edge lamp was damaged at the intersection with taxiway Tango (Fig. 8). The damaged foundations and lamps had been scattered across the runway.

Total length between the beginning of the traces until the stop at intersection taxiway Tango was about 805 m.

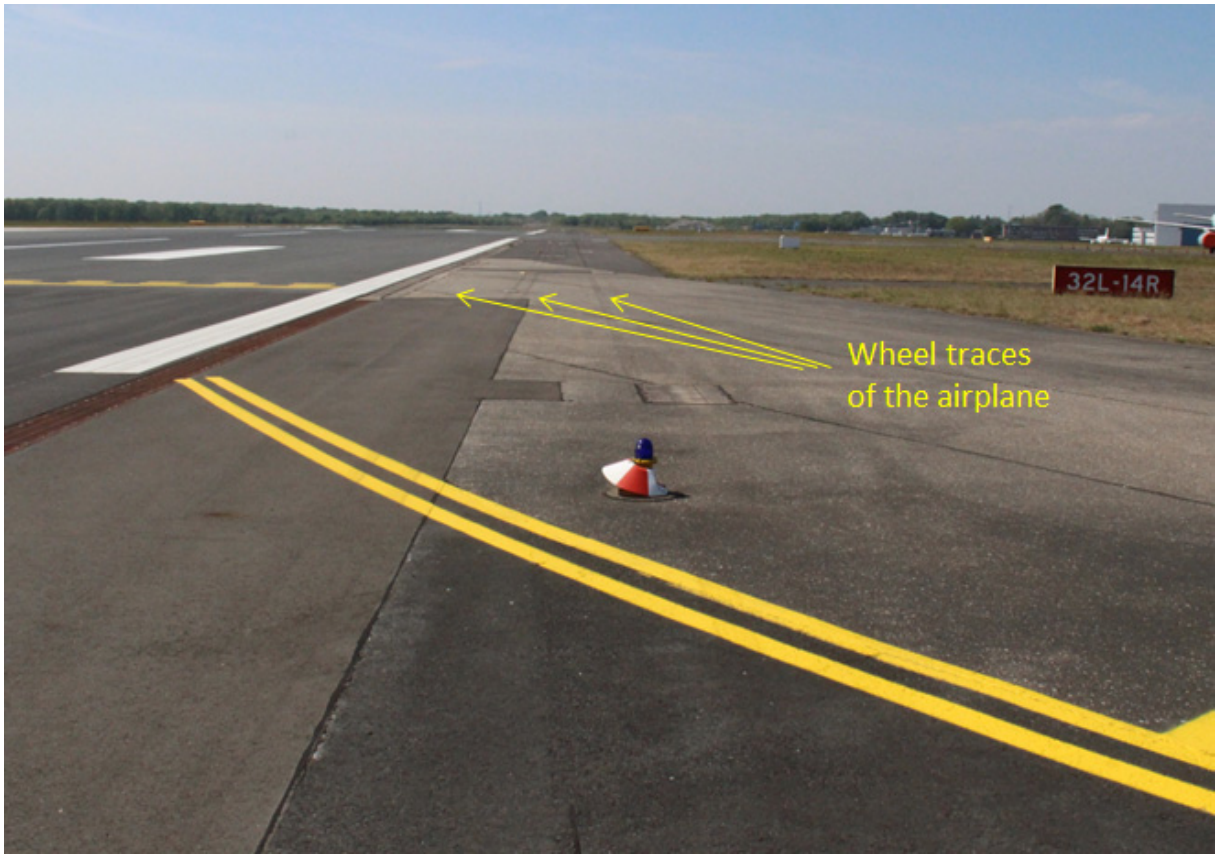


Fig. 8: Left shoulder (opposite the take-off direction of runway 06) Source: BFU

The examination of the airplane determined minor damage in the area of at the nose landing gear, the right nose landing gear door, the lower surface of the fuselage close to the main landing gear, the left main landing gear well and both propellers.

After the occurrence several photos were taken and a video created to understand the visual conditions during backtrack taxiing, the turn at the beginning of runway 06 and the turnpad and at Line-up (Fig. 9 and 10).

Fig. 9: View from the cockpit of an ATR 72 at night with runway lighting turned on, aligned for take-off with the centreline of runway 06 Source: Operator

Fig. 10: View from the turnpad along the left runway edge lighting Source: Airport

Fire

There was no fire during the take-off run or as result of the collision with the lamps of the runway edge lighting.

Organisational and Management Information

The airplane was operated by a Spanish operator, whose fleet comprised 47 aircraft.

In the Operation Manual (OM) the operator had stipulated procedures for taxiing, take-off with reduced visibility or by night, among other things. Several places in the OM referred to the importance of knowing the location of the aircraft during taxiing and take-off run, minimizing distractions and mutual crew monitoring and support.

Some exemplary excerpts:

OM Part A 8.3.0.7.2 Taxi Procedures: *[…] If the pilot taxiing the aircraft is not sure about their position, he must stop the aircraft and communicate to ATC;*

The Pilot Monitoring has to monitor the progression of the taxi in compliance with the clearances received and assist the pilot taxiing;

Any action that may distract the flight crew from taxi should be avoided or done with the parking brake set […]

OM Part A 8.3.0.7.3 Procedures On the Flight Deck: *[…] One of these improvements in the situational awareness is the assignation of monitor the taxi to the Pilot Monitoring, who continuously compares the aircraft's position in the taxi charts.*

Taxi best practices: Only one pilot can control the aircraft during taxi and his/her primary task is to safely taxi the aircraft. He shall have full assistance from the other pilot, who will indicate the authorized taxi run, that will be checked with the aerodrome chart.

Any time there is uncertainty about the location of the aircraft on the movement/maneuvering area, the pilot must stop the aircraft, advise ATC, and seek clarification. Questions should be taken out of the flight deck. If necessary progressive taxi instructions must be requested. […]

g. Situational Awareness, General: *One aspect of situational awareness is pilots knowing where they are and where they want to go, as well as visualizing a picture of the airport traffic in the vicinity. Even during daylight and good visibility, pilots can get lost. Even worse is the situation where pilots think they know their position, but find themselves elsewhere. In darkness or low visibility conditions, additional care must be taken to ensure that accuracy in navigation on the ground and the highest degree of situational awareness is maintained by all members of the flight crew. […]*

- A head-down situation during taxi should be limited to the minimum amount of time possible.

- When the pilot not taxiing the aircraft focuses on the instruments on the flight deck, that pilot is not able to monitor the progress of the aircraft. Before undertaking head-down actions, the other pilot should be advised so that the navigating pilot can place added emphasis on the maintaining navigational accuracy and situational awareness. […]

Other aids: *Instruments on board and compasses should be used to confirm the runway or taxiway alignment with the information available in the cards. If available, the ILS centre line guidance system should be used to confirm correct runway alignment.*

In addition, the operator had compiled PowerPoint presentations for flight crews; such as: *RUNWAY INCURSIONS, GOOD PRACTICES* DE and *AIRPORT SIGNALING*.

Additional Information

Guidelines and Stipulations concerning Runway Lighting

International Standards and Recommendations for design of facilities, markings, lights and lighting at airports were published in ICAO Annex 14, Volume I, Aerodrome Design and Operations.

Chapters 5.3.*9 Runway Edge Lights* and 5.3.12 *Runway Centre Line Lights* described the use, position to the runway and the characteristics of the lighting.

On a national level, in Germany these guidelines were implemented with NfL I 95/03 - *Gemeinsame Grundsätze des Bundes und der Länder über die Markierung und die Befeuerung von Flugplätzen mit Instrumentenflugverkehr*.

Similar Occurrences

In the past, several similar serious incidents or accidents occurred due to the alignment with the runway edge lighting instead of the runway centreline during the take-off run, which were investigated by different safety investigations authorities. Some examples:

BFU 5X005-0/02: 5 March 2002, Dresden Airport, ATR 72- 212, darkness: *The incident occurred because the PIC had confused the runway centreline lighting of runway 22 with the left runway edge lighting. The second pilot did not notice the mix-up.*

AAIB EW/G2006/01/16: 20 January 2006, Glasgow Prestwick Airport, ATR 42- 300, darkness: *The commander initiated a night takeoff when lined up with the left runway edge lights.*

AIB DK HCLJ510-2016-299: 25 February 2016, Karup Airport, ATR 72- 200, darkness: *In darkness and hazy weather conditions, the flight crew lined up the aircraft on the runway edge lights along the right-hand side of runway 27L instead of the runway centreline lights of runway 27L. This resulted in a misaligned take-off roll over the elevated runway edge lights along the right-hand side of runway 27L leading to damages to the runway edge lights and the aircraft itself. […]*

In 2016 an Embraer EMB-120ER of the operator had been involved in a misalignment take-off at darkness at Amsterdam Airport.

In 2009, the Australian safety investigation authority (ATSB) published the following study: *Factors influencing misaligned take-off occurrences at night*. In summary the study came to the conclusion:

From the evidence available, the following conclusions are made with respect to misaligned take-off accidents and should not be read as apportioning blame or liability to any particular organisation or individual.

The following were identified as the most prevalent safety factors in the data reviewed. In all occurrences, one or more of these factors were present and contributed to the event. Each of these factors may increase the risk of a misaligned take-off occurrence.

- *night time operations*
- *the runway and taxiway environment, including confusing runway entry markings or lighting, areas of additional pavement on the runway, the absence of runway centreline lighting, and recessed runway edge lighting.*
- *flight crew distraction (from within the cockpit) or inattention*
- *bad weather or poor/reduced visibility*
- *conducting a displaced threshold or intersection departure*
- *provision of air traffic control clearance when aircraft are entering the runway or still taxiing*
- *flight crew fatigue.*

In 2015 due to a number of occurrences, the British safety investigation authority (AAIB) addressed the Safety Recommendation GB-SIA-2015-0038 to ICAO:

It is recommended that the International Civil Aviation Organisation initiate the process to develop within Annex 14 Volume 1, 'Aerodrome Design and Operations', a

standard for runway edge lights that would allow pilots to identify them specifically, without reference to other lights or other airfield features.

The AAIB justified the Safety Recommendation as follows:

The dominant common factor for misaligned takeoffs is that a visually compelling line of edge lights was visible to the crew and was assumed to be centerline lighting. There is nothing inherent in an individual edge light that distinguishes it from a centreline light when viewed along the axis of the bi-directional element. It is the pattern of edge lights, and the relationship of this pattern to the pattern of other lights and to other visual cues, which identifies them as edge lights. If this complex relationship becomes disrupted or misinterpreted, […], pilots can lose situational awareness. If individual edge lights could be identified as such directly, rather than through a process of interpretation, a crew would notice their error more easily should they line up for takeoff incorrectly. Modern lighting technology offers more options to identify lights directly than does the tungsten lighting technology on which the current standards are based. Global aerodrome lighting standards are, in general, derived from ICAO Annex 14, Volume 1, 'Aerodrome Design and Operations'.

Human Factors

Primarily, it is assumed that each target-oriented human action is triggered by impulse. Information is absorbed from the environment (perception) and processed. A mental model of the situation is created and possible actions are generated and assessed.

Humans act from 3 different action levels, depending on how familiar a trigger, event, or problem is:

- Skill-based action level
- Knowledge-based action level
- Rule-based action level

Ultimately, the decision for one option is made and the subsequent action performed.

However, at any point during the information processing interferences may occur which are often understood as human factors. The Human Factors Analysis and Classification System (HFACS) divides safety-relevant behaviour in errors (perception-based, decision-based, and skill-based errors) and violations (exception violation and breach of rules).

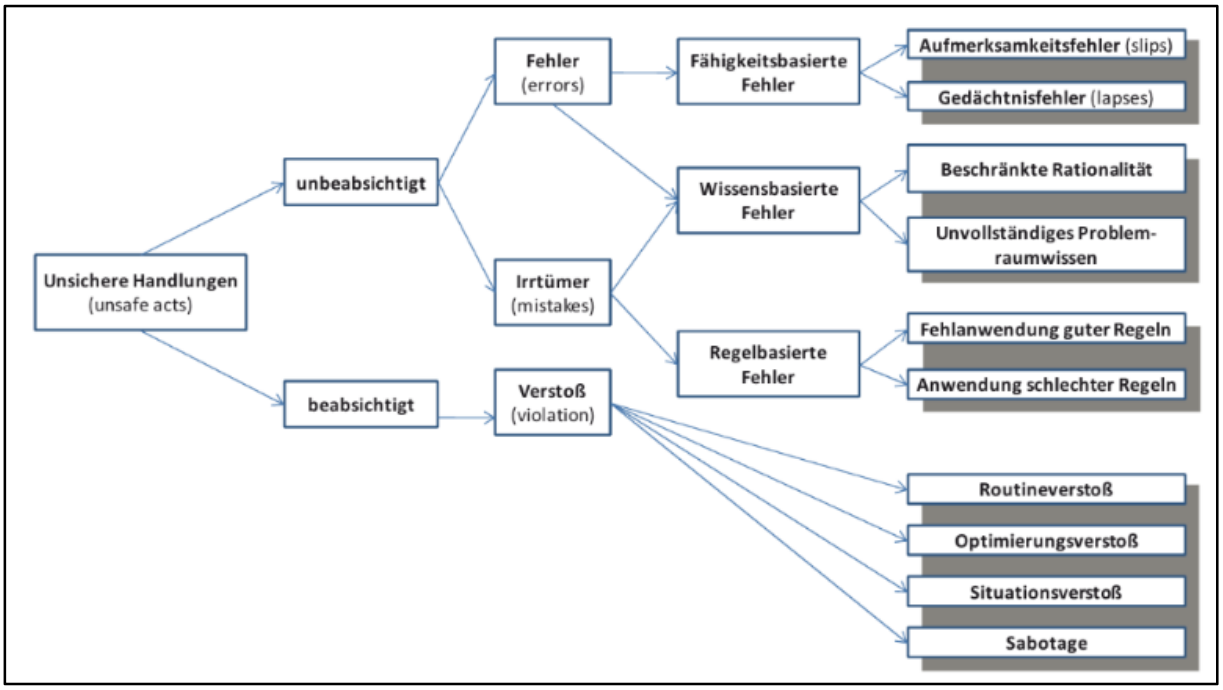


Fig. 11: Error classification according to James Reason Source: Nils Löber

The human cognitive performance depends on the arousal level. A reverse U-shaped connection exists between the physiological activation and the performance. This is also called activation model:

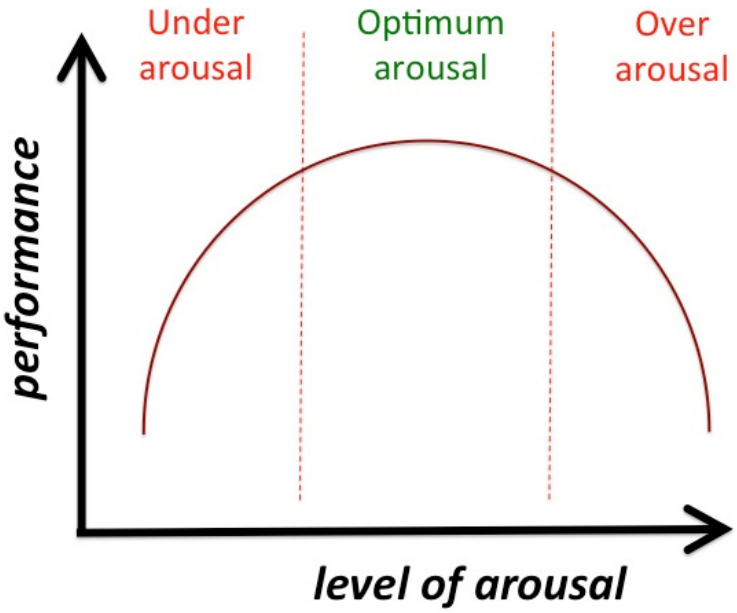


Fig. 12: Yerkes-Dodson Curve of Arousal Source: Skybrary

As part of occurrence investigations of flight operations a number of studies regarding Human Error were conducted and recommendations for improvement of flight safety compiled. As possible countermeasures to Human Error fault-tolerant design, warning devices to recognise errors or technical solutions were proposed. Below are some exemplary excerpts:

The SMS for Aviation–Human Factors a Practical Guide of the Australian Civil Aviation Safety Authority published in 2012:

[…] Making errors is about as normal as breathing oxygen. (James Reason)

Error is a normal and natural part of everyday life—it is generally accepted that we will make errors daily. In fact, research suggests that we make between three to six errors every waking hour, regardless of the task being performed.

Managing error: If you want to find actual solutions for the problems human errors cause, you often need large systemic changes. […] Another way is for you to build error tolerance into the system—limiting the consequences of errors when they do occur. This involves adopting a broad organisational approach to error management, rather than focusing solely on the individuals making the errors. […]

For example, the most common types of errors (slips and lapses) involve attention, vigilance and memory problems. Therefore, developing procedures (checklists that act as memory aids), designing human-centred equipment (alarms and warning devices if operationally critical items are forgotten) and training programs to raise awareness of human factors issues, are all common tools. […]

The study of the British Health and Safety Executive, Reducing error and influencing behaviour, published in 1999:

[…] Everyone can make errors no matter how well trained and motivated they are. Sometimes we are 'set up' by the system to fail. The challenge is to develop error-tolerant systems and to prevent errors from occurring. […]

In 2005, Airbus published the Flight Operations Briefing Notes, Human Performance - Error Management:

[…] Real solutions for human error require systemic improvements in the operation. One way consists of improving working conditions, procedures, and knowledge, in order to reduce the likelihood of error and to improve error detection. Another way is to build more error tolerance into the system, i.e. limit the consequences of errors.

Error Prevention aims at avoiding the error all-together. This is possible only in some specific cases and, almost without exception, requires design-based solutions. […] Error Tolerance aims at making the system as tolerant as possible towards error, i.e. minimizing the consequences of errors. […]

Analysis

Occurrence

At the night of the occurrence, a cargo transport flight was planned from Cologne/Bonn Airport to Sofia. It would have been the first and only flight of the flight crew during the night. Up until the take-off run and the collision with the first runway-edge lights, everything had been unremarkable for the flight crew, except that during the turn on the turnpad a short interruption occurred because the sound made by the PIC's bag falling to the floor caused them to turn their eyes briefly into the cockpit.

Crew

The flight crew held the required licenses and ratings.

According to their medicals, both pilots required glasses. The BFU cannot assess whether the visual impairment at night had been a contributory factor when the mix-up with the runway lighting occurred.

The night of the event had been the first flight duty for the crew after a more than 36-hour rest period. From the CVR recording indications for fatigue could not be deduced.

The pilots communicated friendly in German with each other. Both pilots had known each other for years and in the cockpit were equal to one another. They had a high type experience as well as in their respective roles as Pilot Flying (PF) and Pilot Monitoring (PM). The atmosphere in the cockpit was relaxed. The recordings showed that during engine start-up, taxiing, and take-off preparations the checklist procedures were applied. The respective checks in the Challenge and Response procedure between PF and PM were conducted efficient, confident and situation-based.

Both had taken off from runway 06 of Cologne/Bonn Airport numerous times. They were familiar with the backtrack procedure and turn on the turnpad. The planned flight had been routine for both pilots and did not constitute unusual stress.

It is reasonable to assume that take-off was rejected on mutual agreement, even though it was neither discussed nor announced. Communication during standard and especially emergency procedures is however without doubt important and necessary in order to inform the entire crew and involve possible resources.

Aircraft:

The airplane was certified and maintained in accordance with aeronautical guidelines. It was slightly damaged during the accident. From the CVR recording the BFU could not deduce any indications regarding distractions caused by technical malfunctions of the aircraft, which caused or were a contributory factor in the Misalignment Take-off.

Meteorological Conditions

At the time of the occurrence it was dark. Ground visibility was more than 10 km. Meteorological limitations, except for the darkness, did not cause the event or posed a contributory factor.

On the contrary, the BFU is of the opinion that it is highly likely that the good visibility reduced the attention of the crew and tempted the pilots to not continuously concentrate on following the taxi guidance turnpad markings and question the position of the airplane.

Airport

Due to the construction, the usual taxiway Bravo to the beginning of runway 06 was closed. Therefore all airplanes had to taxi as so-called backtrack on runway 06, then turn on the turnpad at the beginning of runway 06 for take-off run. The tower controller could not discern whether the airplane was aligned with the runway centre line or not when he issued take-off clearance at night. Due to the simplified depiction of the radar targets, it is not clearly evident on the radar monitor either. The BFU is of the opinion that this constitutes limitation of air traffic control at many large airports which should not pose any safety problems as long as flight crews can clearly recognise and identify runway markings and lightings.
Due to the taxiway markings from runway to the turnpad, the white line of the runway edge marking on the turnpad was not a continuous line and therefore showed similarities with centre line markings (Fig. 7). The BFU noted that the alignment for the Misalignment Take-Off occurred along the intermittent runway edge marking and approximately in the centre of the total width of turnpad and runway 06. Therefore, a mix-up is understandable.

The reporting archive of the airport’s lighting system showed that prior to and during the event all lightings had been lit, and the pilots stated that everything had been illuminated as usual.

Due to the flat angle from the cockpit towards the respective lighting (runway edge and centre line) the different distances between the individual lamps of the corresponding chain of lights could barely or not at all be seen. This event shows, as other Misalignment Take-offs have, that in darkness with no reference points it is almost impossible to detect the difference between the runway edge and the centre line lighting.

Contributory factors in the Misalignment Take-off were: non-realisation of the wrong alignment, the width of turnpad including runway, the intermittent line of the runway edge marking and the similar lighting of the runway edge and the centre line.

Human Factors and Causes of Similar Events

Each pilot or flight crew knows that an airplane has to be aligned with the runway centre line for take-off and that take-off run should follow the centre line. Nevertheless, Misalignment Take-offs occur time and again due to even small distractions.

Investigations and studies determined the following causes for Misalignment Take-offs: darkness, bad weather, visibility limitations, unusual construction between taxiways and runways, advanced take-off clearance issued during taxi, fatigue or distractions in the cockpit.

At the time of the event good night flying weather conditions prevailed, there were no technical problems and the procedures of Cologne/Bonn Airport were familiar. There was no other traffic for runway 06, everything was routine and the mood on board was good. It is highly likely that the arousal level of the experienced crew was very low. At the same time, at the moment of the turn a distraction occurred due to a sound which initially was interpreted as a cockpit door which had burst open. Checking for the cause of the sound, identifying it as the PIC's bag which had fallen down, caused head movements and focusing on the inside of the cockpit while the airplane was still taxiing. This must have caused misperception and misinterpretation of the actual position of the airplane and mistaking the intermittent runway edge line on the turnpad with the centre line (perception-based error). The mental model of both pilots concerning the position of the airplane deviated from the actual position. This "diagnosis" or judgement was not questioned or noticed. The alignment, the corrective movement to position the aircraft for take-off, shows that the PF aligned the airplane consciously and precisely with the left runway edge lighting. He applied the correct procedure but on the wrong chain of lights, because his situation model was wrong (skill-based error).

Human performance and error management publications describe such actions as slips. These are actions which occur unintentional, previously unplanned, in a basically right, known, often trained or often repeated line of action at the skill-based level. Especially actions which cause reduced attention due to repetition are susceptible to these kinds of errors.

Additional training and checks are not effective because no one is immune against such errors. In general, the solution is error-tolerant design, warning systems to recognise errors or a technical alternative.

The safety recommendation the AAIB published in 2015 and the respective reasons also aim at technical, visually clearly identifying features which show the pilots in time if they had aligned the airplane with the wrong chain of lights.

Conclusions

The Serious Incident occurred because the crew confused the left runway edge marking and lighting of runway 06 of Cologne/Bonn Airport with the centre line and therefore had aligned the airplane unnoticed with the wrong runway lighting for take-off.

Contributing factors:

- Low attention level of the crew
- Distraction in the cockpit during the turn on the turnpad.
- The width and marking in the area of turnpad and the beginning of runway 06.
- From the cockpit it was difficult to differentiate between runway edge lighting and centre line lighting.

Safety Recommendations

07/2020

The International Civil Aviation Organisation (ICAO) should modify the standard and recommendations regarding runway edge lighting in Annex 14 Volume 1 Aerodrome Design and Operations to ensure clear distinction of other airport lightings.

Investigator in charge:	Axel Rokohl
Field Investigation:	Uwe Berndt, Axel Rokohl
Assistance:	Dr. Susann Winkler, Michel Buchwald
Braunschweig:	7. December 2020

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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Bundesstelle für
Flugunfalluntersuchung
Hermann-Blenk-Str. 16
38108 Braunschweig

Phone +49 531 35 48 - 0
Fax +49 531 35 48 - 246

Mail box@bfu-web.de
Internet www.bfu-web.de