Federal Safety Investigation Authority

Final Report

Accident with helicopter of type Bell 429,
on 21 November 2021, at approx. 15:53 UTC, at airfield Wr. Neustadt/Ost,
A-2700, Wr. Neustadt, Lower Austria
Ref: 2023-0.384.199

Vienna, 2023

Imprint

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Investigation report

This report pursuant to Article 16 of Regulation (EU) No. 996/2010 was approved by the Head of the Federal Safety Investigation Authority after completion of the consultation procedure pursuant to Article 16 of Regulation (EU) 996/2010 in conjunction with § 14 para. 1 UUG 2005.

All data protection information can be found under the following link:
https://www.bmk.gv.at/impressum/daten.html.

Foreword

The safety investigation is carried out in accordance with Regulation (EU) No. 996/2010 and the Accident Investigation Act, Federal Law Gazette [*BGBl. I*] No. 123/2005 as amended.

The sole purpose of the safety investigation is the prevention of future accidents or incidents. The determination of the causes does not imply a finding of blame or administrative, civil, or criminal liability (Article 2 (4) of Regulation (EU) 996/2010).

The regulations cited in the investigation report always refer to the version applicable at the time of the occurrence, unless the investigation report expressly refers to other versions or to regulations that were not adopted until after the occurrence.

This investigation report is based on the information that was provided. In the event that the information base is expanded, the Federal Safety Investigation Authority reserves the right to supplement the present investigation report.

The extent of the safety investigation and the procedure to be followed in conducting the safety investigation shall be determined by the Federal Safety Investigation Authority, taking into account the lessons it expects to draw from the investigation for the improvement of aviation safety (Article 5 (3) of Regulation (EU) 996/2010).

Unless stated otherwise, the safety recommendations are addressed to those bodies in a position to implement these safety recommendations in the form of suitable actions. The decision to implement these safety recommendations will be at the discretion of such bodies.

To protect the anonymity of all persons involved in the occurrence, the report is subject to content restrictions.

All times given in this report are stated in 24 hour format and UTC (at the time of the accident CET (standard time or "winter time") was valid, local time = UTC + 1 hour).

This is a courtesy translation of the draft report on the safety investigation. As accurate as the translation may be, the original text in German is the work of reference.

Content

Introduction

Aircraft operator:	Austrian private operator
Mode of operation:	General aviation
Aircraft manufacturer:	Bell Textron Canada Ltd.
Sample designation:	429WLG
Aircraft type:	Helicopter
Nationality:	Austria
Accident location:	Airfield Wr. Neustadt/Ost (LOAN), taxiway INDIA
Coordinates (WGS84):	N 47°50'32.47", E 016°15'48.07"
Elevation above MSL:	About 273 m
Date and time:	21 November 2021, approx. 15:53 UTC (16:53 local time).

Executive Summary

On 21 November 2021, an accident occurred with a Bell 429 helicopter in the course of a passenger flight from Bolzano, Italy, with the planned destination Wr. Neustadt, Austria. After the passenger was dropped off at an off-field landing site at Semmering between about 15:38 and 15:40, the flight was continued towards the home airfield Wr. Neustadt/Ost. At about 15:53, shortly after ECET, the helicopter collided with the ground on taxiway INDIA in dense fog. The probable causes are continuation of visual flight in instrument flight conditions and spatial disorientation.

The standby service of the Federal Safety Investigation Authority Civil Aviation Division was informed of the incident by the Austro Control GmbH (ACG) Search and Rescue Center at 17:36 local time on November 21, 2021. In accordance with Article 5(1) of Regulation (EU) No 996/2010, a safety investigation into the accident was instituted.

In accordance with Article 9 (2) of Regulation (EU) No 996/2010, the following states concerned were informed of the accident:

State of design, state of manufacture airframe and engines: Canada

1 Factual information

1.1 Events and history of flight

The history of the flight and the course of the accident were reconstructed as follows on the basis of the statements of eyewitnesses and emergency personnel, records of the air traffic control units and the airfield, the flight preparation data, in conjunction with the investigations of the State Office of Criminal Investigations of Lower Austria and the Federal Safety Investigation Authority:

On 20 Nov 2021, the day before the accident, the owner of the helicopter was flown as a passenger to Moritzing (San Moritzio) near Bolzano. According to ADMM and radar data, the flight took off from the airfield Wr. Neustadt/Ost (LOAN) at about 08:45 and proceeded along the Mürztal towards the heliport Goldeck Talstation (LOKO). The pilot recorded 08:35 in his flight log as the start of the flight time.

In addition, the pilot entered a landing in LOKO in his flight log. According to the radar data of the air traffic control (ACG), at 09:41 a descent was initiated starting from approx. 8000 ft past the helipad Goldeck Talstation in the direction of Obervellach, whereby from 09:49:48 at an altitude of 4600 ft no radar data were recorded between Mühldorf and Obervellach for approx. 12 minutes. During the period of this gap, according to the electronic aircraft data recording system (ADMM), the engines were shut down and restarted at approximately 10:03.

Radar data was available again from 10:05:13 at an altitude of 3000 ft. The flight was continued in climb over Zell am See and Alpbach towards Inntal and Innsbruck airport (LOWI) with a maximum altitude of about 8100 ft. The landing at Innsbruck airport took place at 10:51. In the pilot's flight log, 11:00 is entered as the end of the flight.

After full refueling with 511 liters of Jet A1, the pilot requested clearance for takeoff and departure at 11:08 from Innsbruck tower via the VFR reporting points SIERRA and BRENNER; clearance was subsequently granted. The departure from Innsbruck airport was registered at 11:10, but the flight towards Bolzano proceeded along the Stubaital valley, following consultation with Innsbruck Tower.

The Austrian airspace (FIR LOVV) was cleared east of the Zuckerhütl mountain, the flight continued approximately south to the San Genesio airfield (LIGT), which was reached at 11:30 according to its operator. Austrian air traffic control (ACG) radar data ends at 11:25:26 about 5 km south of the Austrian-Italian border at an altitude of 9900 ft.

After a layover of about 5 minutes at San Genesio airfield, the flight was terminated at Moritzing, about 10 km to the south, according to the pilot's flight log record at 11:46. According to the aircraft's ADMM data, the engines were shut down at approximately 11:37[1] and were not restarted for the remainder of the day. A landing at San Genesio airfield is not recorded in the pilot's flight log. The helicopter was not refueled either at San Genesio airfield or at Bolzano airport.

On the day of the accident (21 Nov 2021), the return flight to Wr. Neustadt was carried out. There were no entries in the pilot's flight log for the day of the accident. According to the ADMM record of the aircraft, the engines were started at 14:10:22. According to information from the airfield operator, a stopover was again made at San Genesio airfield at 14:15, and takeoff from there was at 14:20 in an easterly direction towards the Goldeck Talstation helipad. The passenger confirmed that the arrivals and departures to and from Moritzing took place via the San Genesio airfield.

Furthermore, the passenger stated that the return flight was planned in such a way that a landing in Wr. Neustadt/Ost should take place before sunset. Pilot and passenger discussed whether a landing would be possible, also partly due to the weather in Wr. Neustadt. According to the passenger, however, it was assumed that this would not be possible and that a landing would be necessary at the off-field landing site at Semmering.

At 14:22:33, the helicopter was captured for about one minute by the radar of the Austrian ANSP at an altitude of 9100 ft and a speed[2] of about 118 kt. The next radar detection was at 14:32:24 still in Italian airspace north of Monte Cristallo at an altitude of 9600 ft at about 145 kt. From here on, the aircraft was continuously captured by radar until about Kapfenberg, whereby the route led approximately directly first in the direction of the Goldeck Talstation helipad and then directly further in the direction of Semmering.

[1] ADMM Start Time + AIR HRS

[2] Ground speed calculated from radar data

The flight plan from Italy to Goldeck Talstation was closed via AFTN arrival message at 14:48 via RocketRoute and at 14:52 via Vienna ATC (AIS/ARO Wien). In fact, no landing took place there.

At 14:55, the pilot reported to Klagenfurt Radar in the area of Millstätter See and requested to cross the control zone and the terminal control area of Klagenfurt. A clearance was granted by Klagenfurt Radar. At 15:05, the pilot checked out again from Klagenfurt Radar.

Passing Bruck an der Mur, according to the passenger, the pilot had noticed on his iPad that the weather situation in Wr. Neustadt had improved. At this point, the passenger nevertheless decided to be dropped off at Semmering landing site. This maneuver was done with the engines running (according to the ADMM, the engines were not restarted). The pilot planned to continue the flight to Wr. Neustadt and – if a landing was not possible due to weather conditions – to return to the off-field landing site at Semmering and park the helicopter there. Before takeoff from Semmering, the pilot announced his planned arrival at the airfield in Wr. Neustadt/Ost by telephone. This telephone call was not recorded, so the exact content of the call remains unknown.

As of 15:29:45, the aircraft was no longer detected by radar at an altitude of 5100 ft near St. Marein im Mürztal, the intermediate landing at the Semmering landing site is therefore not evident from the radar data. At the last radar recording, the speed was about 155 kt. If the flight had continued at this speed, the aircraft would have reached the landing site Semmering at about 15:38 at the earliest (distance about 21.1 nm); with a speed of 140 kt the arrival time would have been about 15:39.

At about 15:45, Wr. Neustadt/Ost airfield set the runway lighting to maximum brightness.

The aircraft was subsequently detected by radar again from 15:47:18 at an altitude of 1600 ft with a slight descent (about 50-100 ft/min) at Föhrenau about 2.6 nm south of the VFR reporting point "AUTOBAHNKNOTEN" (Figure 1), the speed was about 124 kt. The pilot continued to curve to the north west past Neudörfl. The flight path was approximately 0.5 nm east of the VFR reporting point GOLF, which is exclusively for departures, and continued along the "DEP ONLY RWY 09" route. The tower operator stated that he tracked the approach over GOLF at a speed[1] of 120 kt, then continuing at 117-118 kt. He further

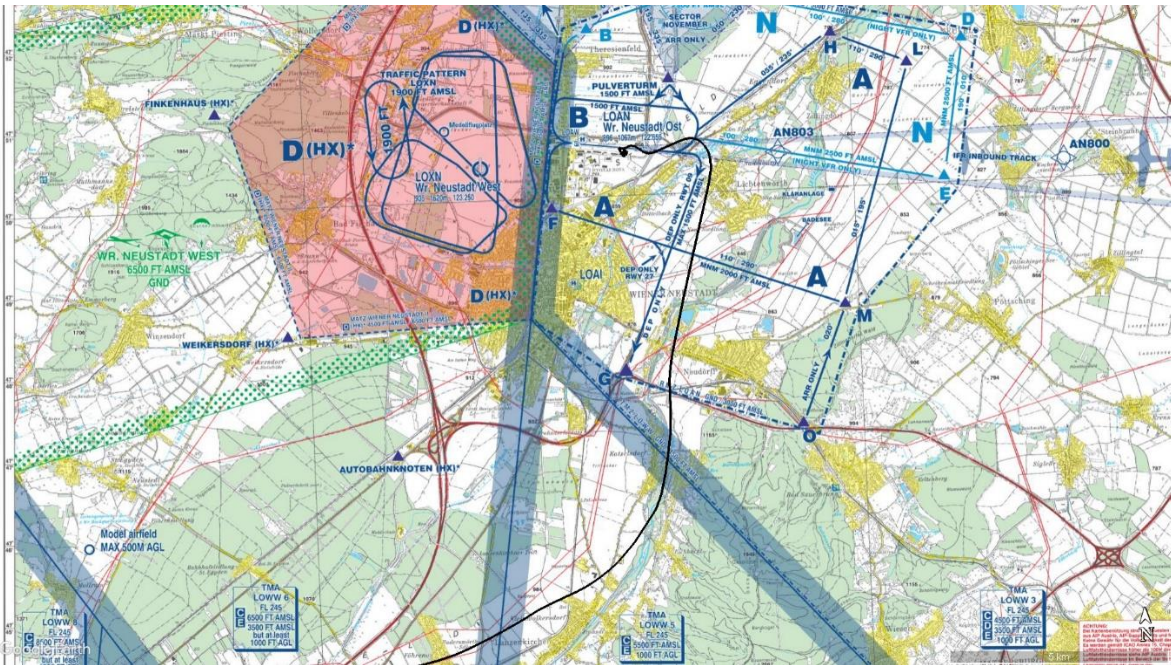
[1] Shown on the display of the tower operator

stated that the pilot subsequently turned onto the centerline of runway 27 at an indicated altitude of 1100 ft MSL. The runway centerline was then overshot several times, as shown on the radar data, by about 350 m (0.2 nm) on the first turn. Passing the runway centerline, the altitude recorded by the radar was about 1200 ft, and the speed was about 110 kt. The flight continued in a serpentine pattern (Figure 2). Passing the runway threshold the altitude was about 1100-1200 ft, the speed about 97 kt. At about the intersection of the INDIA and ECHO taxiways with the runway, the speed was less than 50 kt for the first time. The flight pattern for the last 30 seconds before the end of the recordings cannot be clearly interpreted. It could have been either a slow flight with several sharp changes of direction or a hover with drifting in different directions. The speed was between 15 and 50 kt.

The tower operator stated that he and his colleague initially heard the helicopter, but after about 15 seconds, the turbine noise was no longer audible. After a radio call was not answered twice, the controller checked at the helicopter's usual parking area, but could not find the helicopter in the darkness. While driving back to the tower, he spotted a glow and the crashed helicopter wreckage. He informed his colleague at the tower and the fire emergency service, which was already on its way.

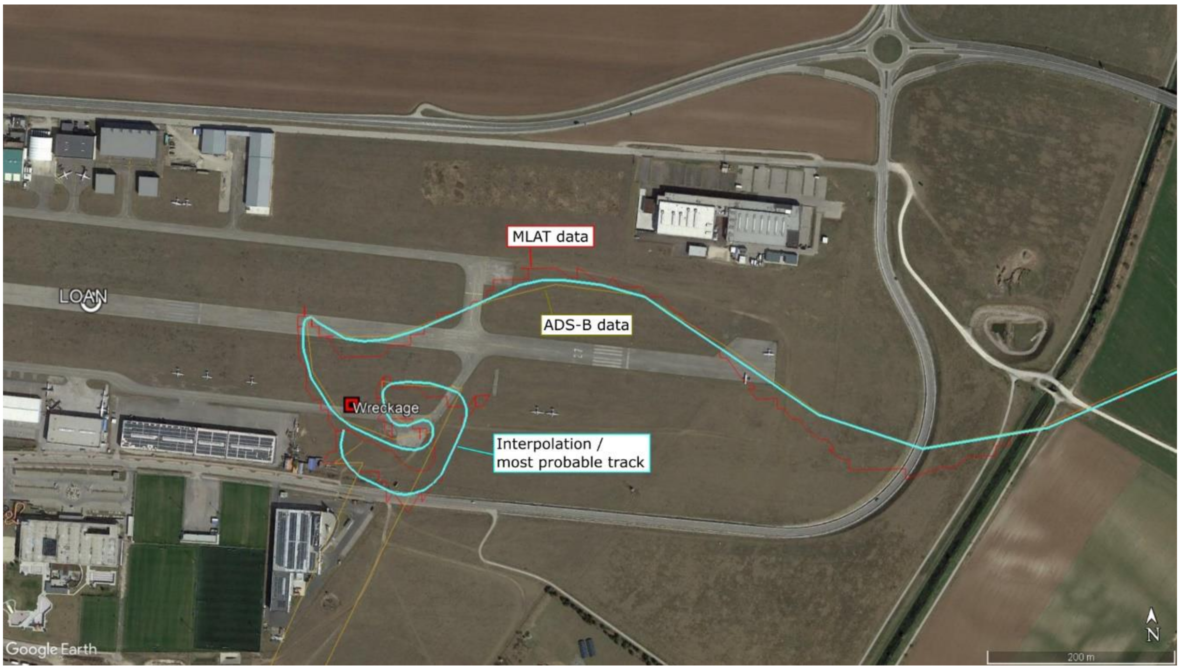
The data in the Figures 1 and 2 were derived and averaged from ADS-B data (in Figure 2 yellow) and MLAT data (multilateration, in Figure 2 red).

Figure 1 Flight path (black) on VFR chart for LOAN



Source: SIA, ACG, Google Earth

Figure 2 Approach runway 27, flight up to the accident site



Source: SIA, Google Earth

The ELT was triggered during the accident and transmitted an emergency signal on 121.5 MHz. Due to difficult access to the installation site of the ELT in the wreckage, the ELT could not be deactivated by the Federal Safety Investigation Authority until the day after next.

The accident was reported to the volunteer fire department Wr. Neustadt at 15:57 by the police and a private person, respectively, the alarm was raised at 15:58. At 16:01 the fire department deployed to the scene.

1.1.1 Pre-flight preparation

The pilot used software and services from RocketRoute for flight planning. RocketRoute provided the Federal Safety Investigation Authority with the relevant flight plans ("briefing packs") for the day before the accident and the day of the accident. These included, among other things, the filed flight plan, the operator's operational flight plan including detailed waypoint data, route segments and route planning, weather data consisting of the METARs and TAFs of the departure and destination airfields, wind charts, significant weather charts (SIG Wx), NOTAMS, a mass and center of gravity calculation, and crew and passenger manifests.

For the accident flight, a briefing pack for the route from Moritzing to the landing site "Goldeck Talstation" (LOKO) was created and the contained flight plan was filed. Corresponding printouts were found in the wreckage (printout created at 08:13, PDF last created at 10:58). A second briefing pack (incl. flight plan) from Goldeck Talstation to Wr. Neustadt/Ost was saved in the system as a draft, but the flight plan had not yet been filed and was therefore not visible to the air traffic control units and also to Wr. Neustadt/Ost airfield. An alternate aerodrome was not indicated on the flight plan or in the briefing pack. Parts of the printout of the draft were also found in the wreckage (created at 08:24).

It can be assumed that, according to the passenger's statement, the pilot also used his tablet in-flight to retrieve current weather information at the destination airfield Wr. Neustadt/Ost.

1.2 Injuries to persons

Table 1 Injuries to persons

Injuries	Crew	Passengers	Other
Fatal	1	0	0
Serious	0	0	0
Minor	0	0	0
None	0	0	

1.3 Damage to aircraft

The aircraft was completely destroyed by the impact and subsequent fire.

1.4 Other damage

Corridor damage at the airfield next to taxiway INDIA.

1.5 Personnel information

1.5.1 Pilot

Age:	50 years
Type of civil pilot license:	CPL(H)
Ratings:	Helicopter
Models / type rating:	Bell 206, Bell 407, Bell 429, R22, R44
Instrument rating:	None
Instructor rating:	FI(H) for PPL, Night, R22, R44, Bell 206, Bell 407
Other permissions:	Night(H)
Validity:	Valid on the day of the accident

Checks:

Medical check:	Medical Class 1 valid until 29 Jul 2022

The type rating for the Type Bell 429 was extended on 26 Apr 2021, and was valid until 30 Apr 2022.

Total flight experience	
(including accident flight):	2081:12 Hours
of which in the last 90 days:	56:56 Hours
of it in the last 30 days:	21:18 Hours
of which in the last 24 hours[1]:	1:41 Hours

In the last 90 days prior to the accident, according to the flight log, the pilot recorded flights exclusively on the accident type. Total flight experience on the accident type could not be determined because only flight log records since 21 Jan 2019, were available. The total flight experience is divided into 1128:27 hours on single-engine and 952:45 hours on multi-engine helicopters. The only multi-engine type listed on the pilot’s license is the accident type Bell 429. Since 21 Jan 2019, a total of 44:15 hours have been completed on the Bell 206, Bell 407, Robinson R22 and Robinson R44 types and 629:48 hours on the Bell 429 type.

The pilot’s flight log also documents the number of landings at night. Since the pilot does not have an instrument rating (IR), it can be assumed that these are night VFR landings. The last 3 such landings were recorded in LOAN on 12 Nov 2020. Prior to that, such landings were recorded on 2 Dec 2019 (2 landings in LOAN), 1 Dec 2019 (3 landings in LOAN), and 30 Mar 2019 (1 landing in LOWW). A total of 115 night VFR landings were recorded in the flight log.

The pilot was generally considered to be calm, uncomplicated, friendly and likeable. In addition, he was described by colleagues as willing and eager to perform his duties.

[1] The only flight within the last 24 hours was the accident flight

1.6 Aircraft information

The Bell 429 model is a helicopter with up to 8 seats, a four-blade main rotor and a four-blade tail rotor. It was first type-certified in Canada on 20 June 2009, under *Airworthiness Manual (AWM) Chapter 527* (equivalent to 14 CFR Part 27) and in the EASA area on 23 Sep 2009, under CS-27 Amdt. 1. The helicopter can optionally be equipped with retractable landing gear and is then designated as Model 429WLG. The helicopter involved in the accident was equipped with such.

Additional equipment in the crashed model also included a Articulated Landing Light, a radar altimeter (Honeywell KRA 405B), an Aux. Fuel Tank with 39 US gallon capacity and a four-axis autopilot.

A techlog[1] was kept for the helicopter. In the remains of the wreckage, the last and therefore most recent pages could not be found. A carbon copy of the page dated 17 Nov 2021 was provided by the operator as the most recent available page.

Aircraft type:	Helicopter
Manufacturer:	Bell Textron Canada Ltd.
Manufacturer's designation:	429WLG
Year of manufacture:	2017
MTOM:	3175 kg (7000 lbs)
Aircraft owner:	Austrian company
Total operating hours[2]:	approx. 779 hours
Landings[2]:	approx. 1375
Engine:	2x turboshaft engine
Engine manufacturer:	Pratt & Whitney Canada Inc.
Engine manufacturer designation:	PW207D1

[1] Aircraft Journey & Technical Log

[2] Total hours of operation and number of landings are the sum of the last page entry in the tech log for 17 Nov 2021, plus the ADMM flight records of 20 Nov and 21 Nov 2021.

1.6.1 Aircraft documents

Registration certificate:	issued on 30 May 2017 by ACG
Certificate of Airworthiness:	Issued on 01 Jun 2017 by ACG
Certificate of the exam of Airworthiness (ARC):	Valid until 07 Mar 2022[1] , issued by the Part M(G) organization of the operator.
Noise certificate:	Issued on 01 Jun 2017 by ACG
Insurance:	valid from 01 Apr 2021 to 01 Apr 2022
Permit for a Aircraft radio station:	Issued on 03 Oct 2017 by the Telecommunications Office for Styria and Carinthia (BMVIT).

1.6.2 Aircraft maintenance

Maintenance events were scheduled and initiated by the operator's CAMO (or Part M(G) organization prior to conversion to the CAMO system) and performed by a Part 145 maintenance organization. The last maintenance events performed prior to the accident were:

Table 2 Most recent maintenance events

Date	Operating hours (Total Time)	Maintenance activity
17 Nov 2021	774:15	50-Hour Inspection ASB 429-21-55 Upper Pitch Link Bolt Inspection Tail Boom Retorque
05 Aug 2021	730:10	50-Hour Inspection 1-Month Inspection
17 May 2021	687:09	Replaced defect IBF Bypass Door Actuator on Engine Nr# 2

Source: Technical helicopter documentation (Work Packages)

[1] Issued on 25 Feb 2020, first extension on 10 Feb 2021

Table 3 Most recent maintenance events, continued

Date	Operating hours (Total Time)	Maintenance activity
03 May 2021	675:59	50-Hour Inspection Engine Oil Sampling
09 Mar 2021	635:09	Retorque 1FH-5FH M/R
01 Feb 2021 to 03 Mar 2021	630:40	Multi-part maintenance activity consisting of: 200-Hour / 12-Month Inspection on 04 Feb 2021 600-Hour / 12-Month Inspection on 04 Feb 2021 800-Hour / 12-Month Inspection on 24 Feb 2021 800-Hour / 24-Month Inspection on 26 Feb 2021 1600-Hour / 2-Year Inspection on 26 Feb 2021 12 Month Inspection on 26 Feb 2021 2-Year Inspection on 26 Feb 2021 4-Year Inspection on 26 Feb 2021 50-Hour Inspection on 26 Feb 2021

Source: Technical helicopter documentation (Work Packages)

1.6.3 Aircraft loading and center of gravity

Included in the pilot’s pre-flight briefing packs is a mass and center of gravity calculation. The pilot, passenger, manuals on board, baggage and fuel were taken into account. Mass and center of gravity were accordingly within the permissible range at all times, and at the time of the accident there was also still a sufficient safety margin available for both mass and center of gravity.

The Model 429 with installed Aux. Fuel Tank equipment (with 39 US gallons and installed in the subject model) has a usable fuel capacity of 256.1 US gallons (or 969 liters). According to the briefing pack, there was approximately 1506 lbs of fuel on board when the helicopter departed Innsbruck (at the last refueling), thus the helicopter was close to full. On landing in Wr. Neustadt/Ost, according to the mass and balance calculation included in the Briefing Pack, about 503 lbs of fuel would still have remained in the helicopter as a reserve.

1.7 Meteorological information

1.7.1 Weather overview, meteorological service of Austro Control GmbH

According to the meteorological service of Austro Control, the following weather was forecast for Austria on the day of the accident:

> "WEATHER SEQUENCE AVIATION WEATHER:
>
> Afternoon widespread VMC conditions. Only from the Weinviertel to southern Burgenland, in Lower Carinthia as well as in the Rhine Valley, there will be some dense patches of high fog under an inversion at 3000ft amsl. By evening, medium-high and higher clouds in the W and NW, increasingly spreading towards the E during the night and sinking further into the low SC level. Tops lie around FL200 with initially light, later moderate icing between 4000ft amsl and FL170. First precipitation sets in during the second half of the night in the western parts of the country. Snow line around 3000ft amsl and dropping. In the eastern lowlands, fog and high fog patches tomorrow morning with still stratified SC/AC clouds." (Weather overview Austria, edition 21 Nov 2021 at 14:00 [translated, original report in German])

1.7.2 METAR and TAF, meteorological service of Austro Control GmbH

At the time of the accident and shortly before then, the weather observations and weather forecasts shown in Tables 4 and 5 were valid.

Table 4 METAR weather reports for the airfield Wr. Neustadt/Ost

METAR weather observation for Wr. Neustadt/Ost
METAR LOAN 211000Z 27003KT 2500 BR BKN005ST RMK OVC=
METAR LOAN 211100Z VRB02KT 2500 BR BKN005ST RMK OVC=
METAR LOAN 211200Z VRB02KT 3000 BR BKN005ST RMK OVC=
METAR LOAN 211300Z 18004KT 2000 BR BKN003ST RMK OVC=
METAR LOAN 211400Z 15003KT 1500 BR BKN003ST RMK OVC=
METAR LOAN 211500Z VRB02KT 0400 FG VV002=
METAR LOAN 211600Z NIL=

Source: ACG

Based on the weather observation, at 14:00 there was a visibility of about 1500 m, humid haze ("Mist", code BR), scattered stratus clouds with a lower limit of about 300 ft. In addition, the indication for overcast cloud cover is stated. One hour later, visibility decreased to about 400 ft. Furthermore, fog and vertical visibility of about 200 ft were reported. This was the last weather observation prior to the accident. At 16:00 only a "NIL" message was issued.

Table 5 TAF weather forecasts for the airfield Wr. Neustadt/Ost

TAF weather forecast for Wr. Neustadt/Ost
TAF LOAN 211125Z 2112/2121 24005KT 2500 BKN005 BECMG 2112/2114 9999 SCT012 TEMPO 2116/2120 1800 BCFG=
TAF AMD LOAN 211340Z 2113/2121 24005KT 2500 BKN004 TEMPO 2113/2116 3000 BKN006=
TAF AMD LOAN 211507Z 2115/2121 24005KT 2500 BKN004 TEMPO 2115/2120 0400 FG VV002=

Source: ACG

A weather forecast for the period from 12:00 to 21:00 was issued at 11:25. It indicated horizontal visibility of 2500 m and scattered clouds at 500 ft. Until 14:00, visibility could exceed 10 km and scattered clouds could occur at 1200 ft. Between 16:00 and 21:00, horizontal visibility was expected to be 1800 ft with moderate fog patches.

At 13:40, the above weather forecast was amended. According to that, between 13:00 and 16:00, visibility up to 3000 m and scattered clouds with a lower limit of 600 ft were to be expected temporarily.

At 15:07, the weather forecast was amended again. Between 15:00 and 20:00, horizontal visibility of 400 m, fog and a vertical visibility of 200 ft were now to be expected temporarily.

1.7.3 TAWES / VAMES

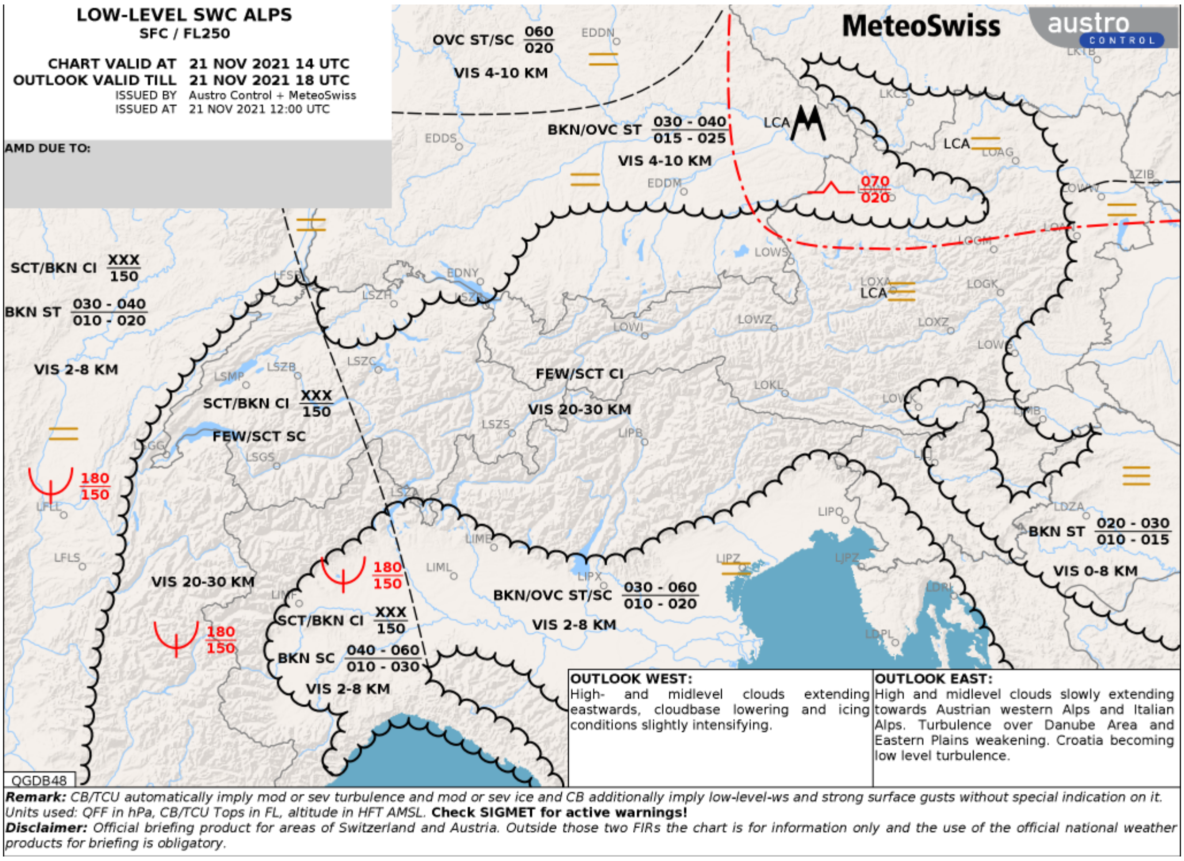
The TAWES measuring station of ZAMG located in the city area of Wr. Neustadt recorded the following data at 16:00 (about 7 minutes before the time of the accident):

202111211600 AAXX 21161 11182 45// /0000 10044 20041 39767 40107 55003 333 55300==

According to this, the temperature was 4.4°C, the dew point was 4.1°C, the barometric air pressure was 976.7 hPa, and the air pressure converted back to sea level was 1010.7 hPa.

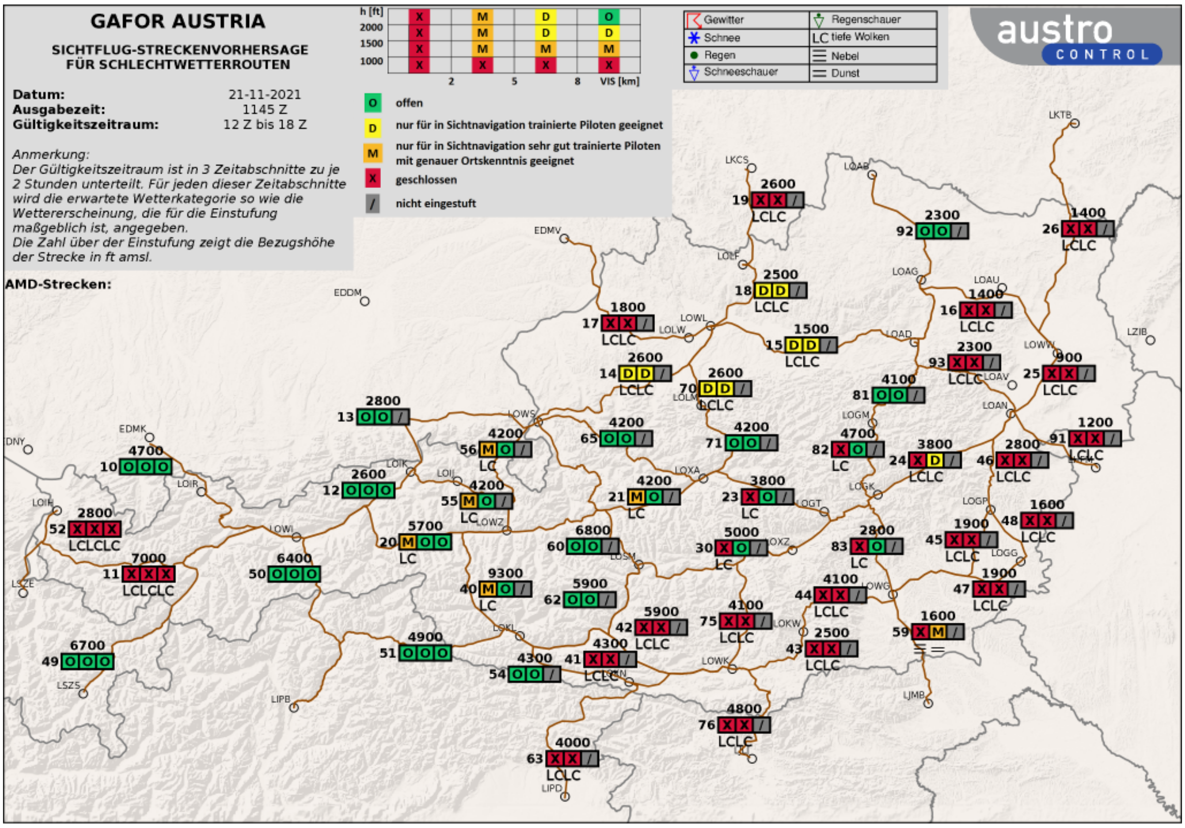
1.7.4 Weather charts, meteorological service of Austro Control GmbH

Figure 3 Significant weather chart, 14:00 to 18:00



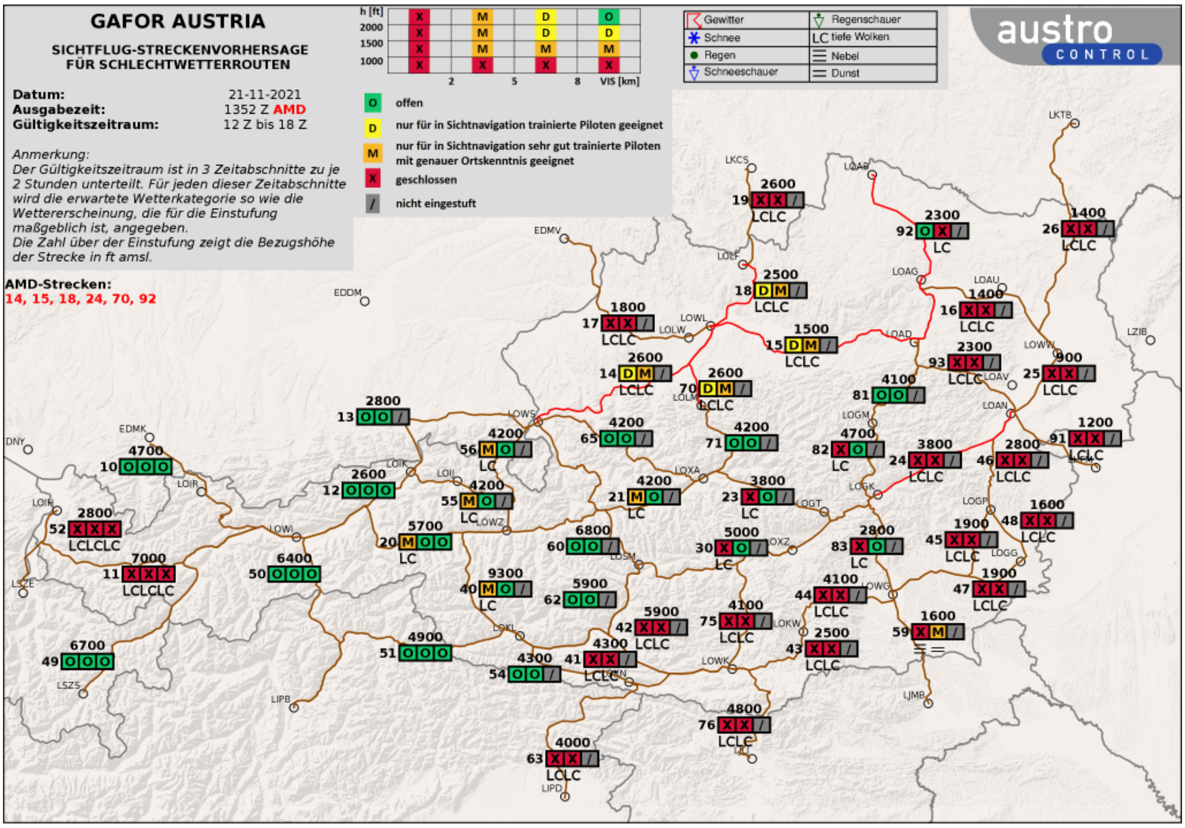
Source: ACG

Figure 4 GAFOR chart 12:00 to 18:00, issued 11:45



Source: ACG

Figure 5 GAFOR chart 12:00 to 18:00, amended, issued 13:52



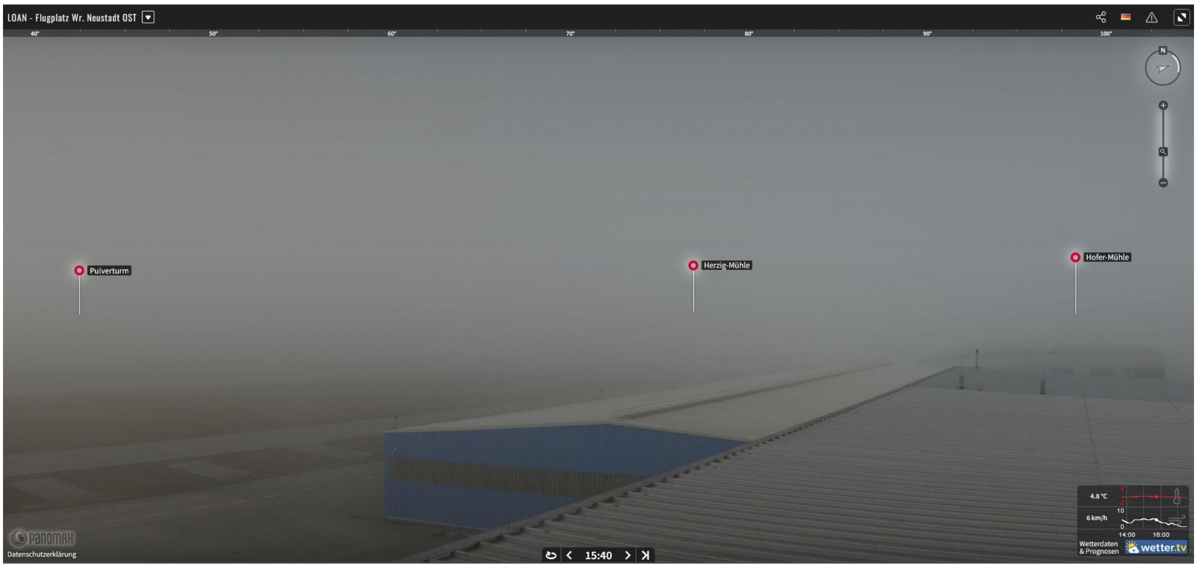
Source: ACG

1.7.5 Webcam images

Photos could be retrieved via a webcam located at the airfield Wr. Neustadt/Ost, which provided an indication of the weather at the time of the accident. The images 6 to 10 show the weather at the airfield looking towards the accident site, in particular the prevailing fog and the onset of twilight between 14:40 and 16:00 UTC (shown as local time on the images).

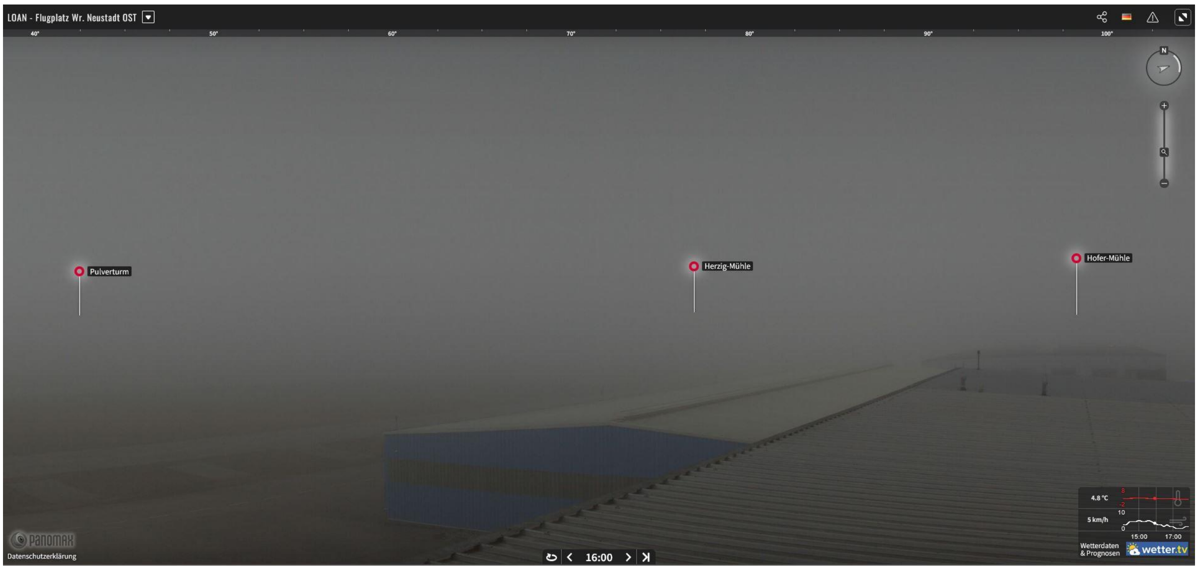
For comparison, Figure 11 shows the same line of sight to the accident site on the day before the accident. The accident site is marked in the figure.

Figure 6 Webcam image looking at accident site, 14:40 UTC



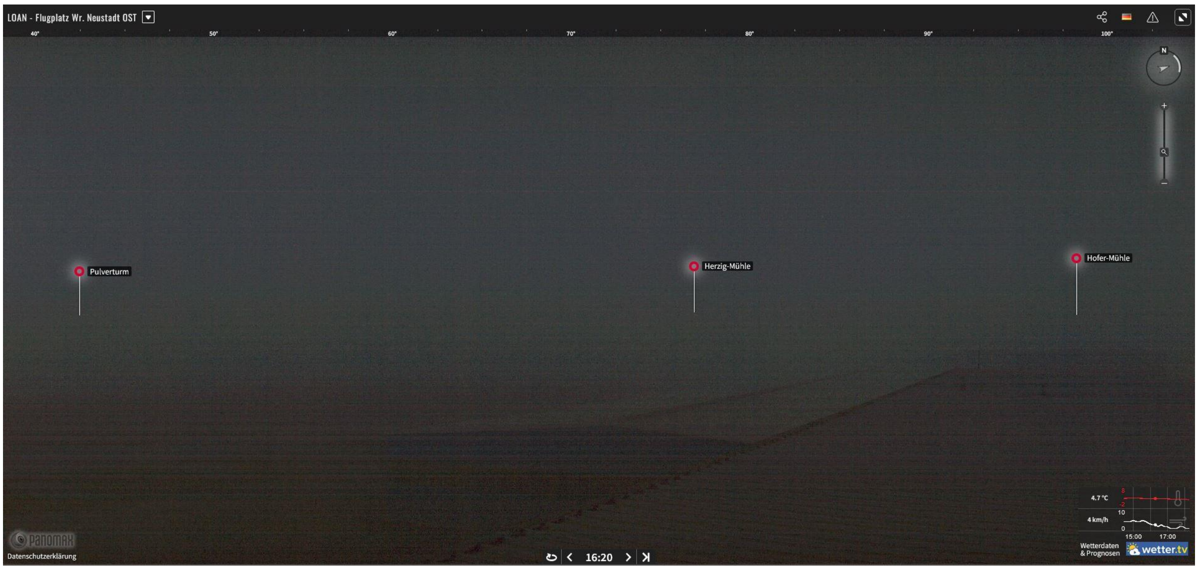
Source: aviationacademy.panomax.com

Figure 7 Webcam image looking at accident site, 15:00 UTC



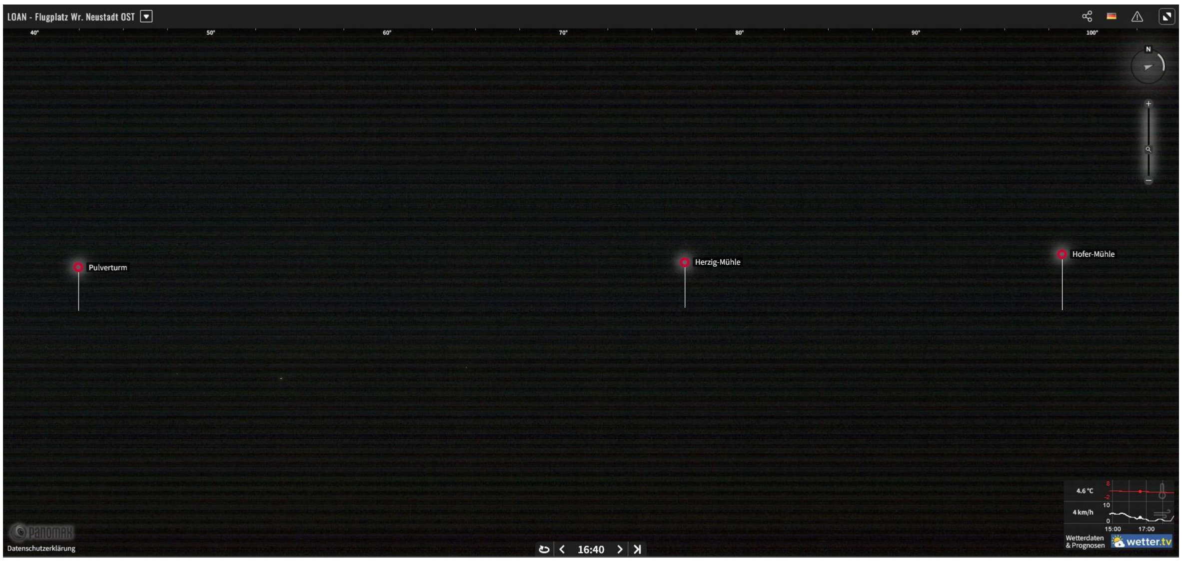
Source: aviationacademy.panomax.com

Figure 8 Webcam image looking at accident site, 15:20 UTC



Source: aviationacademy.panomax.com

Figure 9 Webcam image looking at accident site, 15:40 UTC



Source: aviationacademy.panomax.com

Figure 10 Webcam image looking at accident site, 16:00 UTC

Source: aviationacademy.panomax.com

Figure 11 Webcam image looking at accident site, one day before the accident

Source: aviationacademy.panomax.com, SIA

1.7.6 Pilot weather briefing

Included in the pilot's pre-flight briefing packs is a weather briefing consisting of METARs and TAFs of the departure and destination airports, wind charts and significant weather charts.

1.7.7 Lighting conditions

According to the corresponding table in the AIP Austria, sunset at the nearby Vienna airport occurred at 15:10 and the end of civil evening twilight (ECET) at 15:45.

The sun elevation at the time of the accident (15:53) was calculated to be -7.16° (below the horizon)[1], the azimuth was about 248° (approximately south-west). At the airfield Wr. Neustadt/Ost the end of the civil evening twilight was determined to be 15:46[1].

Accordingly, the time of the accident was after the end of civil twilight, and there were no daylight conditions. The possibility of the pilot being blinded by the sun can be excluded.

1.8 Aids to navigation

A number of satellite and radio navigation equipment was available in the aircraft, including 3 IFR-capable Rogerson Kratos Display Units and a Garmin GTN750/650, which is capable of GPS based area navigation.

The pilot did not hold an instrument rating. The extent to which the satellite and radio navigation equipment on board was used during the accident flight could not be determined.

[1] www.suncalc.org

1.9 Aeronautical Telecommunications

The pilot was in radio contact with Klagenfurt Radar between 14:55 and 15:05 for the purpose of crossing the Klagenfurt control zone. For the approach and landing information at the airfield Wr. Neustadt/Ost, a radio connection had been established on frequency 122.655 MHz.

1.10 Aerodrome information - Airfield Wr. Neustadt/Ost

Location:	1.1 nm north-northeast of Wr. Neustadt city
ICAO identifier:	LOAN
ARP (Aerodrome Reference Point):	47° 50' 36" N, 016° 15' 37" E
Airfield elevation above sea level:	273 m / 896 ft

The helipad of the helicopter emergency service *Christophorus Flugrettungsverein* (LOAW), which is also located at the airfield, was not manned at the time of the accident due to the weather conditions.

The airfield at Wr. Neustadt/Ost is a private airfield for which there is no obligation to operate.[1] Furthermore, it is an airfield without air traffic control. For night flights (except for flights in the near area of the aerodrome), a flight plan must be filed and a radiotelephony connection with the air traffic service must be established.[2]

The operating hours of the tower of the airfield Wr. Neustadt/Ost are published in the AIP. According to this, the tower was in operation from 07:00 to 16:00 at the time of the accident (Central European Winter Time) (Figure 13). Approaches after ECET (15:45 on the day of the accident) were only permitted as night VFR flights (Figure 12).

[1] AIP Austria, section AD 1.4

[2] AIP Austria, section ENR 1.2 - 2.2

Figure 12 LOAN AIP section 2.2 – Aerodrome geographical and administrative data

8	ANMERKUNGEN	Anflüge, die nach ECET durchgeführt werden, müssen als Nachtsichtflüge ausgeführt werden. Jeder Anflug muss mit einer Landung abgeschlossen werden.
	REMARKS	APCH performed AFT ECET shall be executed as NGT VFR-flights only. EV APCH shall be CMPL with a LDG.

Source: ACG, AIP Austria

Figure 13 LOAN AIP section 2.3 – Operational hours

1	FLUGPLATZBETRIEBSLEITUNG	Flugplatz PPR Betriebszeiten Turm: Während der gesetzlichen Sommerzeit 0630-ECET; Während der mitteleuropäischen Winterzeit 0700-1600. Flüge die davor oder danach stattfinden sollen, müssen bis 1200 des Vortages bei der Betriebsleitung beantragt werden. Die zusätzlich dafür anfallenden Gebühren und das Antragsformular sind der Homepage zu entnehmen.
	AD ADMINISTRATION	AD PPR OPS HR of tower: During legal summer time 0630-ECET; During Central European winter time 0700-1600. Permission for flights planned to be performed before or after must be requested from AD OPS office until 1200 of the previous day at the latest. The additional fees and the application form for this can be found on the homepage.

Source: ACG, AIP Austria

Runway 27 has 420 m of approach lighting, which can be regulated in 5 stages, and 1076 m of runway edge lighting, which can also be regulated in 5 stages. The runway threshold is lit in green, the runway end is lit in red. In addition, the stop areas are illuminated in red over a length of 160 m. The glide angle is indicated by a PAPI system consisting of 4 units on the left side of runway 27. The brightness can be adjusted in 5 steps. Taxiway lighting is not available.

1.10.1 Approach procedures

The approach procedures valid at the time of the accident were described in the AIP. Several visual approach procedures were available at the time of the accident. The approach procedure relevant to this accident for the approach to runway 27 from the south is shown in Figures 15 and 16. At night, i.e. after ECET, traffic pattern N must be used exclusively (Figure 14 and Figure 16, light blue).

Figure 14 LOAN AIP section 2.2.1.10 – Night VFR

2.2.1.10. Sichtflüge bei Nacht im Flugplatzverkehr sind ausschließlich in der Platzrunde N durchzuführen. Aus Lärmschutzgründen ist eine Mindestflughöhe von 2500 FT MSL einzuhalten.	2.2.1.10. Night VFR patterns have to be carried out solely in traffic pattern N. Due to noise abatement a minmum traffic pattern altitude of 2500 FT MSL shall be flown.

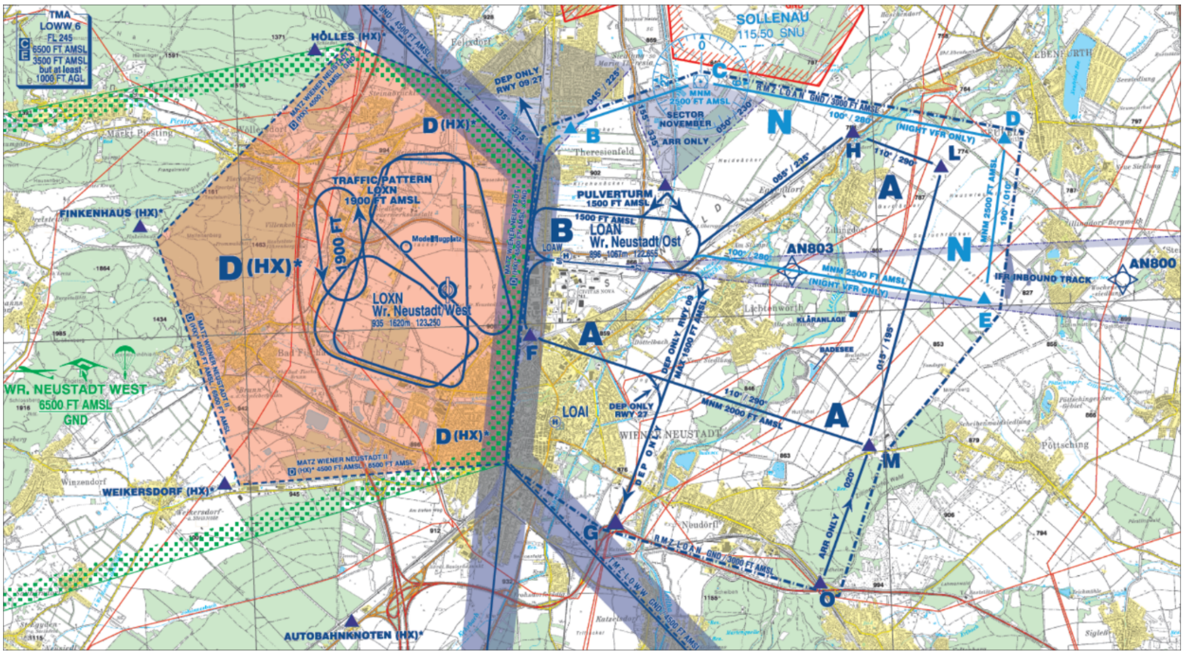
Source: ACG, AIP Austria

Figure 15 LOAN AIP section 2.2.2.3 – Approaches to runway 27

2.2.2.3. Anflüge zur Piste 27	**2.2.2.3. Approaches to RWY 27**
2.2.2.3.1. Aus Richtung Norden Sektor November → Meldepunkt **Pulverturm** (1500 FT MSL) → Platzrunde **B** Schwelle 27.	2.2.2.3.1. From direction north Sector November → reporting point **Pulverturm** (1500 FT MSL) → traffic circuit **B** THR 27.
2.2.2.3.2. Aus Richtung Süden Meldepunkt **O** → Meldepunkt **M** (MNM 2000 FT MSL) → Meldepunkt **L** → Platzrunde **A** Schwelle 27.	2.2.2.3.2. From direction south Reporting point **O** → reporting point **M** (MNM 2000 FT MSL) → reporting point **L** → traffic circuit **A** THR 27.

Source: ACG, AIP Austria

Figure 16 LOAN AIP – Visual flight chart



Source: ACG, AIP Austria

Figure 17 LOAN AIP section 2.22 – Flight procedures

LOAN AD 2.22 FLUGVERFAHREN	LOAN AD 2.22 FLIGHT PROCEDURES
Es existiert ein IFR-Anflug mit VFR-Teil basierend auf RNAV zum Zwecke des Wolkendurchstoßes. Es ist nicht möglich am Flugplatz LOAN nach Instrumentenflugregeln zu landen. Instrumentenanflüge müssen den Instrumentenflugteil des Fluges spätestens beim Erreichen des Fehlanflugpunktes des IAP, sofern möglich, aufheben und den Flug als VFR-Flug beenden, anderenfalls ein Fehlanflugverfahren einleiten. Das Streichen des IFR-Fluges hat gemäß SERA.5015 zu erfolgen.	The IFR approach with VFR part based on RNAV was designed for the purpose of cloud breaking. It is not allowed to land at LOAN as IFR flight. IFR arrivals have to cancel their IFR flight latest at the MAPt if able, otherwise a missed approach must be initiated. IFR cancellation has to be done according to SERA.5015.
Ab Beendigung des IFR-Flugteils muss in das veröffentlichte VFR-Verfahren (LOAN AD 2 MAP 14-2) eingeflogen werden. Wiederholte IFR-Anflüge (Trainingsflüge) dürfen nicht durchgeführt werden.	After IFR cancellation the published VFR procedures (LOAN AD 2 MAP 14-2) shall be joined. Repetitive IFR-approaches (training) are not allowed.

Source: ACG, AIP Austria

In addition, an IFR approach with VFR part based on RNAV exists for the purpose of cloud breaking (Figure 17). At the MAPt[1] (Missed Approach Point) at the latest, the approach must be completed according to visual flight rules or, if necessary, a missed approach procedure must be initiated. According to NOTAM 2926/21, valid from 29.10.2021 to 31.12.2021, this cloud breaking procedure was suspended for the mentioned period (Figure 18).

Figure 18 NOTAM 2926/21

```
B)2110291218  C)2112312359  EST                                          A2926/21
E)IFR CLOUDBREAKING PROCEDURES FROM AND TO LOAN ARE SUSPENDED FOR
ALL FLIGHTS.
REF AIP AUSTRIA LOAN AD 2 MAP 9-1, LOAN AD 2 MAP 13-2-1, AIC A11/21.
```

Source: PIB Flight Information Bulletin Austro Control - Homebriefing

[1] For the ICAO instrument approach procedure (RNP A CAT A / B), the MAPt is the waypoint AN802

1.11 Flight recorders

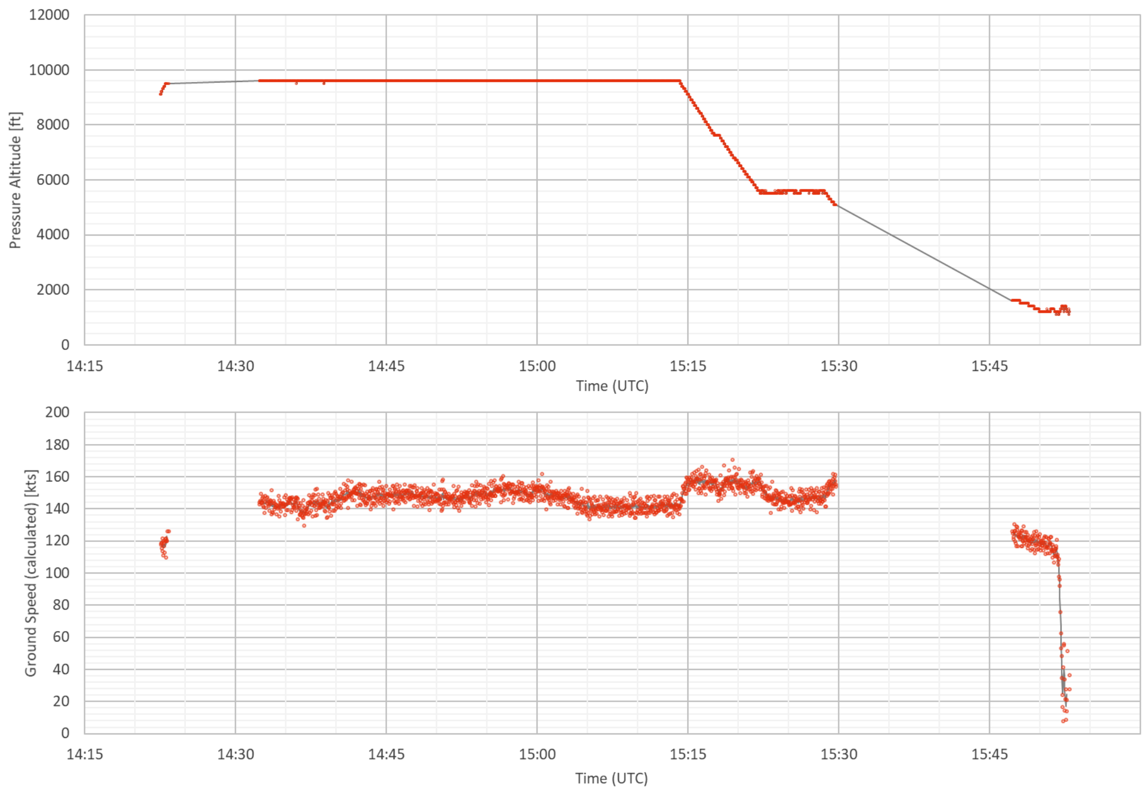
A flight data recorder was not mandatory and not installed. No portable navigation devices, recorders or satellite navigation devices were found in the wreckage that could have been evaluated for the purpose of the investigation.

1.11.1 Radar data

The ADS-B data recorded by Austro Control and the MLAT data recorded by the airfield are shown in Figures 19 and 20.

The recorded altitude data in Figure 19 are shown in red, the gray lines represent areas where no data was available. Gray lines directly connect the recorded data in red. The actual flown altitudes in non-acquired areas may differ from the gray connecting line shown.

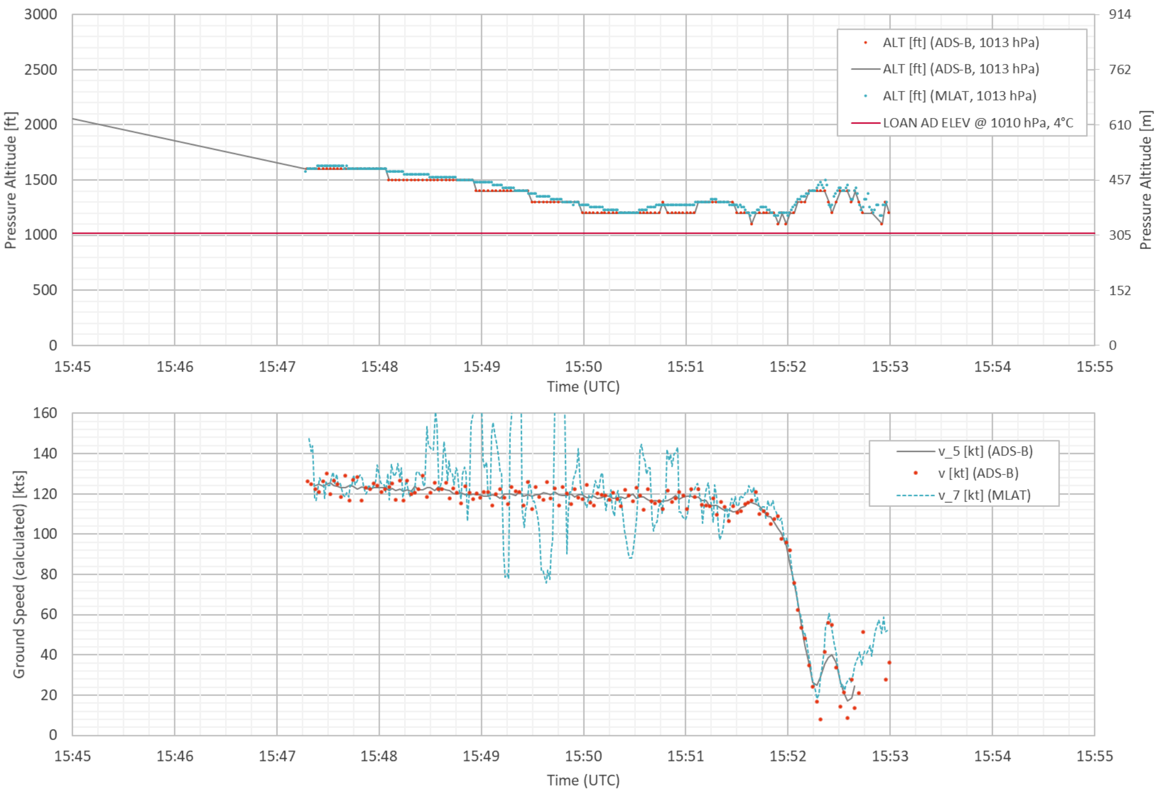
Figure 19 Radar data, altitude and speed, 14:15 to 16:00



Source: SIA

The altitude data in Figure 20 are pressure altitudes[1] and shown as follows: Recorded ADS-B altitude data are shown in red, MLAT data are shown in blue. ADS-B data are additionally connected by a gray line. Furthermore, the airfield elevation - calculated back to a pressure altitude using QNH and temperature current at the time of the accident - is visible as a red horizontal line (pressure altitude of the airfield about 310 m or 1018 ft).

Figure 20 Radar data, altitude and speed, 15:45 to 15:55



Source: SIA

According to the data, the helicopter was flying at an altitude of 200 ft above ground level at about 15:50 when it entered RMZ LOAN (approximately near Neudörfl). At about 15:52:15, the altitude increased temporarily up to 400 ft above ground level as the helicopter passed over runway threshold 27. This altitude gain was accompanied by a reduction in ground speed from 120 kt to between 20 and 60 kt. During the final turns and

[1] Pressure altitude: Altitude in the standard atmosphere with specified atmospheric pressure, based on 1013.25 hPa and 15°C.

hovers over the airfield, the altitude decreased again and remained between 100 and 300 ft above ground (about 30 to 90 m) until the end of the recordings.

1.11.2 Aircraft data recording

Engine data, airframe data or flight data are recorded by multiple devices located in various spots in the helicopter.

1.11.2.1 Rogerson Kratos Display Units

Each of the 3 primary cockpit displays (Rogerson Kratos Display Units) contains a compact flash memory, which is not crash proof. The displays were identified in the wreckage by the Federal Safety Investigation Authority and the condition and ability to read out data was discussed with the helicopter manufacturer and Transportation Safety Board Canada. Based on the condition, there was no doubt that the memory had been completely destroyed by the collision and subsequent fire, making it impossible to read out data.

1.11.2.2 Cockpit voice / flight data recorder

A combined Cockpit Voice/Flight Data Recorder (CV/FDR) is available as an option for this helicopter type, but was not installed.

1.11.2.3 Infrared video camera system

An infrared video camera system Max-ViSEVS EVS-1500 was installed in the nose of the helicopter, but had no recording capability.

1.11.2.4 Aircraft Data Memory Module

The Aircraft Data Memory Module (ADMM) is connected to the Aircraft Data Interface Unit (ADIU) and is located in the rear of the helicopter behind the cabin. On an intact ADMM, the following information is recorded on two channels (CHA and CHB): *aircraft identification, fuel calibration, timers, flight log, exceedance data, chip history, engine identification, weight and balance data, faults* and *counters*.

The area behind the cabin, where the ADIU was installed, was largely unaffected by the fire, so the survival and potential readout of data was considered realistic and possible. The

ADMM was removed by the Federal Safety Investigation Authority personnel and shipped to the manufacturer for readout under TSB Canada supervision. Because the manufacturer had found shorts between pins of the connector during testing of the ADMM, TSB Canada first had to remove the memory chip and install it in a new ADMM. After that, the manufacturer was able to read out data from channel A, which appeared to be intact with a few exceptions. Data from channel B was largely unusable.

The aircraft model, aircraft serial number and engine serial numbers match the rest of the aircraft documentation. No data was recorded for “Chip History” and “Power Assurance”. In “Fault Log” the last data recorded in chronologically correct order was from 2019, after which 5 records were recorded dated 2005. Other timers and counters were recorded according to Table 6 read out.

Table 6 ADMM Timer / Counter

Timer / Counter	Value
AIRCRAFT	[correct serial number of the helicopter].
OP TIME HRS	887.1
AIR TIME HRS	779
TO/LDGS	1379
D/A[1] ZONE 1 TIME	140.9
D/A ZONE 2 TIME	303
D/A ZONE 3 TIME	W_ERROR_0x4727484D
D/A ZONE 4 TIME	49.5
ENG 1 S/N	[correct serial number of engine 1]
ENG 1 HRS	---
ENG 1 STARTS	869
ENG 2 S/N	[correct serial number of engine 2]
ENG 2 HRS	---
ENG 2 STARTS	2853

Source: Manufacturer, ADMM

The AIR TIME HRS listed in Table 6 is in full agreement with the techlog record (Section 1.6 total operating hours). The value for landings and takeoffs (TO/LDGS) is 1379, which is 4 greater than the techlog record.

An exceedance of a limit was recorded:

- X TRQ LIMIT on 11/21/2021 at 15:52:36 with a peak value of 52.6 for a duration of 1.7 seconds.

[1] Density Altitude

Such X TRQ LIMIT exceedance is expected by the manufacturer in the event of collision with the ground in the course of the accident due to the sudden stop of the rotor system.

In the "Flight Log", 3 data records could be assigned to the day before the accident (20 Nov 2021), the last data was recorded as 04 Nov 2021. However, since this was recorded in chronological order after 20 Nov 2021, it can be safely assumed that this record is actually from 21 Nov 2021, the day of the accident. The "flight log" for 20 Nov 2021 is shown in Table 7. Data identified as erroneous are shown in square brackets and italics.

Table 7 ADMM data "Flight Log" from 20 and 21 Nov 2021

DATE	UTC TIME	OP HRS	AIR HRS	TO/LDGS	ENG1 HRS	ENG2 HRS
[04 Nov 2021]	14:10:22	1.7	*[84.2]*	*[P02]*	1.7	1.7
20 Nov 2021	11:06:48	0.5	0.5	1	0.5	*[31.2]*
20 Nov 2021	10:02:58	*[W_ERROR_0x48A3EE31*]	0.8	1	0.9	0.8
20 Nov 2021	08:44:25	1.2	1.1	1	1.2	1.2

Source: Manufacturer, ADMM

1.11.2.5 Data Collection Units

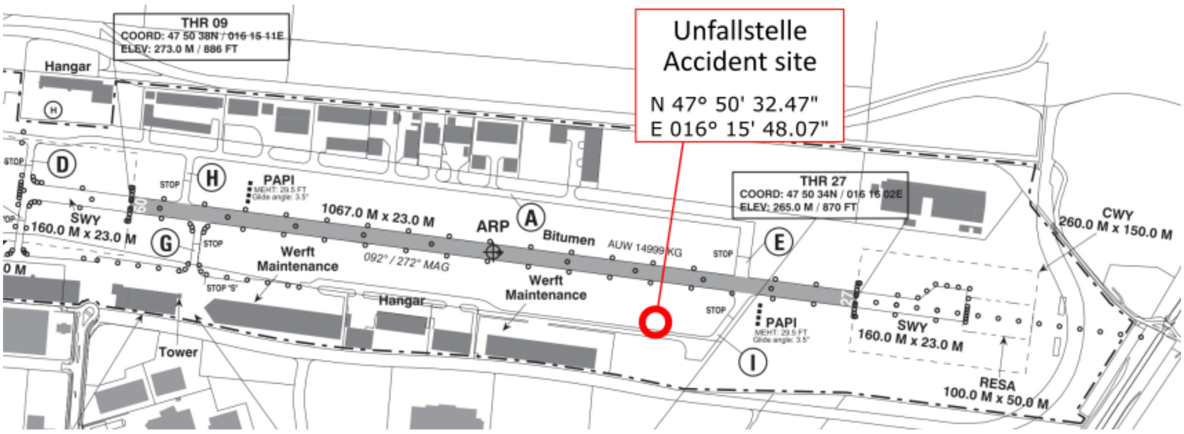
The DCUs (Data Collection Units) are responsible for exchanging data between the engines and the aircraft, and for recording certain parameters. There is one DCU on each engine. The DCUs were damaged by the collision and fire. The two units were removed from the wreckage by Federal Safety Investigation Authority personnel in the investigation hanger and sent to the engine manufacturer to check whether it was still possible to read out data. Eventually, this was not the case anymore due to the severe damage.

1.12 Wreckage and impact information

1.12.1 Site of the accident

The accident site is located at taxiway INDIA of the airfield Wr. Neustadt/Ost (LOAN), refer to Figure 21. Most of the wreckage rested in the adjacent grass field north of the taxiway, with parts of the wreckage also lying on the tarmac. Operating fluids and extinguishing agents were also spread on the tarmac.

Figure 21 Accident site on the aerodrome chart (AIP Austria)



Source: ACG / AIP Austria, SIA

1.12.2 Distribution and condition of the wreckage

The wreckage showed – partly due to the impact, partly due to the subsequent fire – a high level of damage. It was found lying on the right side of the fuselage with an orientation to the west (about 270°), i.e. approximately along the taxiway INDIA. A large amount of wreckage debris (some of which was in burnt condition) was scattered around the main wreckage. The majority of these debris were scattered within a radius of 10-15 m around the main wreckage, a small amount of debris was also scattered significantly further. Parts of the main rotor blades, which were found on the surrounding hangar buildings, were handed over by the police to the Federal Safety Investigation Authority.

The tail was broken into several larger pieces, separated from the fuselage, and was not affected by the fire. The tail rotor blades showed minimal damage. No traces typical of contact under load with the ground or other obstacles were found. The tail rotor shaft showed typical signs of torsional fracture.

The post-impact fire affected the area from the fuselage nose of the helicopter, the cockpit up to the aft of the baggage compartment and cabin (approx. at the level of the engine mount bulkhead and aft lift frame). The fire caused total structural failure in the forward fuselage area, since the matrix material of the carbon fiber composite parts burned completely, leaving only the carbon fibers, and structural parts made of aluminum were liquefied and melted by the high burning temperature. This also resulted in the complete destruction of the cockpit-side electronics, wiring, displays and controls. The Rogerson Kratos display units were also completely destroyed and burned, making it impossible to read out the memory units contained therein.

Two of the four main rotor blades were severely deformed and partially burned, but were still connected to the main rotor mast or blade grip. The other two main rotor blades were bluntly broken off directly at the blade holder and fragmented into several smaller pieces by the rotational energy of the main rotor, the impact and fire. The entire main rotor mast showed clear signs of torsion and corresponding deformation. The blade holder and control rods were partially bent backward against the direction of rotation. The damage is consistent with an impact of the main rotor blades under load. Impact marks of the main rotor blades were also visible on the taxiway directly adjacent to the accident site.

The forward section of the engines were severely damaged from the impact and fire. The DCUs were in their intended position at the front of the engines and were also severely damaged. Data could not be read out from the engine manufacturer (see Section 1.11.2.5). The rear part of the engines – approximately from the engine mount bulkhead – was not directly exposed to the fire. The engines could be partially moved by hand, but not fully rotated. Unless damaged by impact or fire, the rear section of the engines did not exhibit any damage typical of pre-existing engine damage[1] , so that – where discernible – it is safe to assume that the engines were intact at the time of impact.

The electromechanical actuators of the main landing gears were in the retracted position, the landing gear legs thus extended and configured for landing. Nevertheless, the “locked” condition could neither be confirmed nor disproved due to the condition of the wreckage.

[1] These would be e.g. rotational drag marks or damaged or missing engine blades

The landing gear legs exhibited lateral (transverse) deformation, indicating lateral loading. A possible cause could be ground contact during lateral movement of the helicopter. The nose gear electromechanical actuator was in the extended position, thus the landing gear leg was also extended and configured for landing. The “locked” condition could also neither be confirmed nor disproved for the nose gear.

1.12.3 Cockpit and instruments

The cockpit was completely destroyed due to the impact and subsequent fire. The display units were removed from the wreckage in the examination hanger of the Federal Safety Investigation Authority (see section 1.15.1)

1.12.4 Aircraft and equipment - failure, malfunctions

There are no indications of technical defects existing before the accident. Maintenance was performed in a timely manner. The last pages of the techlog were not found. It is likely that these were burned in the wreck. It was therefore not possible to check any current hold items.

1.13 Medical and pathological information

According to the results of the forensic toxicological examination of the liver-, muscle- and brain tissue, no evidence of impairing substances – apart from traces of caffeine – could be obtained by means of chromatographic and mass spectrometric examination methods.

There is no other evidence of any pre-existing mental or physical impairment of the pilot.

1.14 Survival aspects

There is no evidence of fire while the aircraft was still in flight. In particular, no emergency call was made and no corresponding witness statements were made. The data recording also shows no evidence of technical problems with the aircraft or the engines.

The traces present provide a consistent indication of a fire caused by the impact of the aircraft on the ground. The smell of burnt fuel and carbon fiber composite parts was perceptible at the entire accident site. Temperatures were highest at the center of the fire. These were high enough to melt and liquefy aluminum parts. The matrix material of various fiber composite parts, if affected by the fire, was completely burned, leaving only the fibers themselves. The fire subsequently destroyed large parts of the wreckage, so that only aircraft parts that came to rest on the outer edge of the accident site were not completely destroyed.

The required emergency transmitter ELT was on board, was operational and triggered. Due to the difficulty of access to the location in the wreckage, it could not be deactivated until the day after the accident.

1.14.1 Restraint systems

Due to the high degree of damage to the wreck, the condition and functionality of the restraint systems could not be determined.

1.14.2 Evacuation

Not relevant.

1.14.3 Causes of injury

The autopsy concluded that the cause of the pilot’s death were polytraumata with multiple organ ruptures. According to the forensic medical report, the injuries led to immediate death, which could not have been prevented even by medical emergency aid. The injuries were consistent with a very violent blunt force impact corresponding to an impact at high speed, whereby it must be assumed that death had already occurred at the time when the helicopter crashed and began to burn.

The injuries from the crash and impact as well as subsequent fire were not survivable.

1.15 Further investigations

On the day after the accident, the helicopter wreckage was transported by the Wr. Neustadt Fire Department to the investigation hangar of the Federal Safety Investigation Authority for further examination. Subsequently, the condition of the wreckage was documented, data storage devices were removed, sent to the manufacturers for inspection and readout (see section 1.11.2) and the wreck was searched for documents.

1.15.1 Technical investigations

The result of the technical examination at the accident site and in the investigation hangar of the Federal Safety Investigation Authority is given in section 1.12.2 and the following paragraphs.

The Aircraft Data Interface Unit (ADIU) together with the Aircraft Data Memory Module (ADMM) were removed from the rear electronics bay of the main wreckage by the Federal Safety Investigation Authority. Apart from soot on the housing, the two parts appeared undamaged on the outside. Connected cables could be disconnected without problems and were neither fused nor charred. According to the information and instructions of the helicopter manufacturer Bell Textron Helicopters, the ADMM was unplugged from the ADIU and sent to the manufacturer for readout under the supervision of the Transportation Safety Board Canada. The data that was read out is shown in section 1.11.2.4.

The three Rogerson Kratos Display Units (section 1.11.2.1) were identified by the Federal Safety Investigation Authority in their investigation hangar within the remains of the wreckage. Two display units were identified only from their display frames and were in such condition of damage that survival of any installed memory had to be considered impossible. The remaining third display unit was damaged but could be further disassembled. The display unit appeared severely damaged from the outside, with the electronics exposed to intense heat from the fire and destroyed by mechanical force. The case could be opened by removing the screws, which had to be partially drilled out. Circuit boards and components inside were severely mechanically and thermally damaged. Numerous components were desoldered due to the effects of heat. The installed flash memory module could not be identified beyond doubt. A component was found that had similarities to the flash memory module, but was also severely damaged. After sending photos, the helicopter manufacturer and TSB Canada also determined that no more data could be read out from this module.

1.16 Organization and procedures

The helicopter was owned and operated by a company located at the airfield Wr. Neustadt/Ost (OPS and CAMO). The helicopter was listed on the operator's Air Operator Certificate (AOC) from 25 Jul 2017 to 06 Mar 2018, after which the helicopter was no longer used in flight operations as part of the AOC. From then on, the helicopter was available exclusively for flights of the owner. The helicopter was not available for rental or other purposes. As a result, the existence or use of Operation Manuals A through D was no longer required.

The helicopter was primarily flown by the involved pilot. For a limited number of flights, a second pilot acted as a substitute pilot and as an examiner on the helicopter.

2 Analysis

2.1 Meteorological analysis

The accident occurred at the airfield Wr. Neustadt/Ost (airfield altitude 273 m / 896 ft) at about 15:53 (16:53 local time). The time of the accident was therefore about 7 minutes after the end of civil evening twilight[1] . According to aviation definition, the time of the accident was therefore in the night, thus darkness prevailed, which can also be seen on the recordings of a webcam located at the airfield (Figs. 6 to 10).

In the above-mentioned webcam images, the strong reduction in visibility due to fog can be seen as well. In the METAR weather observation for the airfield, a horizontal visibility of about 1500 m was given at 14:00. One hour later at 15:00 the visibility was down to about 400 m. Furthermore, fog, a vertical visibility of about 200 ft and overcast cloud cover were reported.

The TAF weather forecast for the airfield valid at the time of the accident was issued at 11:25 and supplemented twice thereafter. In the initial issue, a horizontal visibility of 2500 m was forecast, which might decrease temporarily to 1800 m from 16:00.

At 13:40, the horizontal visibility was again reported as 2500 m. Temporary reduction in visibility was revised to 3000 m.

The last amendment to the TAF was given at 15:07 and again concerned temporary changes. The horizontal visibility was revised to 400 m with fog and a vertical visibility of about 200 ft.

According to the helicopter’s ADMM record, the engines were started at about 14:10 on the day of the accident. Thus, the pilot could not have been aware of the most recent METAR report and the most recent TAF forecast when commencing the flight.

[1] ECET in Wr. Neustadt at 15:46 (see section 1.7.7)

The latest METAR and TAF data could also not appear on the printouts of the RocketRoute briefing packs that were carried in the cockpit, as these were produced at 08:13 and 08:24 respectively (see section 1.1.1). RocketRoute was able to provide a PDF version of the briefing pack for the flight to the Goldeck Talstation heliport, which was created at 10:58. The briefing pack for the route from Goldeck Talstation to Wr. Neustadt/Ost was only saved as draft, the PDF version transmitted by RocketRoute to the SIA was created by RocketRoute itself after the time of the accident. It is unknown when exactly the pilot last updated the weather data on the briefing pack. If the last update took place before the start of the flight, the METAR and TAF data valid at the time of the accident could not have been included.

The GAFOR chart indicated in the initial version of 11:45 for the route between Kapfenberg and Wr. Neustadt between 14:00 and 16:00 difficult conditions[1] for visual flights with an additional "low clouds" [2] remark. The chart was amended at 13:52, since then the mentioned route was marked with "X" as closed. It was not possible to determine whether the pilot had taken the GAFOR charts into account when assessing the weather. A departure at 14:10 would have allowed retrieval of the amended chart of 13:52.

The passenger stated that the pilot had retrieved weather data enroute via the tablet he was carrying. It could not be determined when and which weather data was retrieved via this tablet. If the pilot had retrieved weather data during the stopover at Semmering, he would have had the most current data available.

The pilot also had telephone contact with the airfield in Wr. Neustadt/Ost before the departure from Semmering. It could not be reliably reconstructed whether weather information was exchanged.

The passenger stated that the weather was discussed with the pilot several times. In this respect, it can be assumed that the pilot was aware of the difficult and changeable weather situation. This implies that the pilot endeavored to obtain up-to-date weather data via both the tablet and the telephone.

[1] "D" = Difficult

[2] "LC" = Low Clouds

2.2 Crew

At the time of the accident, the pilot held a commercial pilot license CPL(H) and the type rating for the Bell 429 model involved in the accident. A night rating for helicopters Night(H) was available and valid. Aeromedical fitness was given and the Medical Class 1 was valid. He had accumulated approximately 2081 hours of total flight experience at the time of the accident. The pilot had not obtained an instrument rating (IR) required for operation under instrument flight rules.

Since the pilot had listed the Bell 429 model as the only multi-engine type in the pilot's license, it can be assumed that those approximately 925 flight hours attributable to multi-engine helicopters were flown exclusively on the accident type. The flight hour record indicates sufficient experience both generally and specifically on the accident type Bell 429.

Furthermore, the pilot had documented several night flights in his flight log. However, these had been made considerably long in the past. The last 3 night landings were recorded on 12 Nov 2020, i.e. a little more than a year before the accident flight. The night landings before that were also about another year ago.

Since night landings were performed this rarely and the last ones were made about a year ago and – even if performed according to the rules – only under night visual flight conditions, it must be assumed – despite the existence of the required night rating – that the pilot was lacking in practice with regard to night landings in general and was not competent to perform flights under instrument flight conditions at night.

2.3 Aircraft

The Bell 429 aircraft was used exclusively for passenger flights by the owner. In addition to the standard equipment, the aircraft was equipped with a retractable wheel landing gear, an articulated landing light, a radar altimeter, an auxiliary fuel tank for range extension and a four-axis autopilot.

Maintenance was properly registered and performed in a timely manner. Mass and center of gravity were within the permissible range for the duration of the entire flight according to the pilot's center of gravity calculation, which was included in the briefing pack. The calculation bases used were correct. The helicopter was almost fully refueled during the stopover in Innsbruck on the day before the accident. According to the pilot's flight plan, there was 1506 lbs of fuel on board. At 8°C fuel temperature, this corresponds to about 850 liters (or 224 US gallons)[1].

An exact calculation of the fuel consumption since the last refueling and the amount of fuel remaining in the tanks at the accident site would only be possible on the basis of fuel consumption records or engine data. However, the values used in the flight planning could be roughly checked on the basis of flight altitudes and speeds (radar data), outside temperatures and flight times. Consequently, the information in the briefing pack is correct, according to which about 503 lbs of fuel was still available in Wr. Neustadt. With this amount of fuel, a further flight time of about one hour or 140 nm in long range cruise (approx. 130 kt) would have been possible under the given conditions (approx. 6000 lbs aircraft mass, 4000 ft flight altitude, 7°C outside air temperature). Both the landing site at Semmering and numerous alternative airfields in the vicinity (e.g. Vöslau, Vienna-Schwechat or Bratislava) would have been reachable.

The wreckage exhibited a high degree of damage due to the impact on the one hand and the subsequent fire on the other. Due to the large amount of fuel on board (about 500 lbs), a large part of the structural components made of carbon fiber composite and aluminum in the cockpit area, in the area of the fuel tanks under the cabin floor, and also in the area of the cabin itself were destroyed by the fire.

[1] Full fueling is equivalent to 256.1 US gallons or 969 liters, see section 1.6.3

The witness marks and deformations on the main rotor and main rotor blades, the drive train and the engines indicate that engine power was present at the time of impact and that the main rotor was powered. The lack of or limited damage to the tail rotor indicates, regardless of the banked attitude of the helicopter at impact, that the initial ground contact of the helicopter did not occur with the tail rotor. Instead, the deformations on the landing gear legs suggest that the initial contact with the ground occurred with the landing gear in what was at least a partial lateral motion.

The fact that only one exceedance message was stored in the ADMM exactly from the time of the accident (X TRQ LIMIT) also shows that no abnormal engine parameters existed and that the helicopter was operated within the approved operating limits up to the time of impact. Had this not been the case, more and different exceedance or warning messages would have been recorded. The presence of an exceedance message in the absence of other messages is consistent with the findings from the damage to the helicopter.

The pilot has not declared an emergency or reported a technical defect.

Based on the conditions of the landing gear actuators, it can be assumed that the landing gear was in the extended condition, although the “locked” condition could not be confirmed either due to the high level of destruction of the wreckage.

For the reconstruction of the accident in the course of the accident investigation, it proved to be disadvantageous that no crash- and fire-proof data storage was installed in the helicopter. The added value of such a recording would be that the pilot’s actions and decision-making processes could be better understood. Crash- and fire-proof data storage is not mandatory for helicopters in such weight class. Much of the existing memory modules was destroyed by the fire. However, semiconductor memories could typically withstand high acceleration forces, such as those that occur in a collision with the ground.

2.4 History of flight and flight operations

The purpose of the flight was to fly the passenger, who was also the owner, from Moritzing near Bolzano to Wr. Neustadt. The day before, the pilot flew from Wr. Neustadt to Bolzano via Innsbruck airport for the very same reason. It is worth mentioning that although the pilot’s flight log recorded a stopover at the Goldeck Talstation heliport, the radar data, which are based on transponder interrogations, only show a flyby near the landing site at about 8000 ft MSL. A little further north between Mühldorf and Obervellach, a 12 minute gap is documented in the radar data, as well as a shutdown and startup of the engines in the ADMM data. This can only be explained by an off-field landing, which again was not recorded in the pilot’s flight log.

Based on the available data, the onward flight to Innsbruck was uneventful. Once there, the helicopter was refueled to near full capacity[1] and the flight continued over the Stubai valley to Bolzano.

There was a five-minute stopover at San Genesio airfield, which was confirmed by the airfield operator but not entered in the pilot’s flight log. The end of the flight at the private heliport in Moritzing was entered by the pilot at 11:46.

In the course of the investigation of the accident, it was noticed that there were deviations between the start and end times[2] in the flight logbook and the flight times recorded by the radar and ADMM for the outbound flight. Thus, for the flight on 20 Nov 2021 from Wr. Neustadt to Innsbruck, the flight log shows a start time of 08:35 and an end time of 11:00. According to radar data, the flight started at 08:45:49 and according to ADMM data, the engines were started at 08:44:25. According to radar data, the aircraft reached the parking position in Innsbruck at 10:54:58 and according to ADMM data, the landing was made at about 10:50:58[3] . This results in a time difference of about 15 minutes. Whether only this flight was affected or whether there was also additional flight time entered in the flight log for other flights cannot be determined due to the lack of radar data from earlier flights.

[1] See also section 2.3

[2] Flight time is the total time from the moment an aircraft starts moving to take off until the moment it comes to a stop at the end of the flight. Thus, flight time = block time.

[3] Calculated from start time near Obervellach (10:02:58) and air time (48 minutes).

On the day of the accident, the return flight was again via San Genesio airfield. The plan was to reach Wr. Neustadt/Ost airfield before ECET. However, pilot and passenger were already discussing whether a landing there would be possible at all due to the weather. Alternatively, the off-field landing site at Semmering was to be approached. Ultimately, the decision was made in flight to drop off the passenger at Semmering. Since the pilot had previously expected the weather to improve during the flight, he then decided to fly the helicopter to Wr. Neustadt without the passenger. It is unknown which weather data were retrieved by the pilot and caused him to come to this assessment. At this time (about 15:40) the latest GAFOR map and the amended TAF forecast were already available, according to which visual flight routes were closed and strong visibility limitations due to fog and low-lying clouds were to be expected.

Before continuing the flight from Semmering, the pilot notified the tower of the airfield Wr. Neustadt/Ost of his intentions by telephone. This prompted the airfield operations to set the runway lighting to the maximum possible brightness.

The airfield Wr. Neustadt/Ost (LOAN) itself is a private airfield without the obligation to operate. The end of operating hours is published in the AIP Austria as 16:00, whereas the pilot was informed via telephone that the airfield would remain in operation until his arrival. In addition, the airfield is without air traffic control (but with traffic information). Landings do not have to be cleared and are at the pilot's discretion. Nevertheless, for night vision flights outside the vicinity of the airfield, a flight plan must be filed and a radiotelephony connection with air traffic service must be established. A flight plan had been created in the system (RocketRoute) but had not yet been filed. A radiotelephony connection with FIC ("Vienna Info") was not established.

In any case, the airfield operator could not have denied a landing. Closure of the entire airfield due to bad weather is basically not envisaged. Since this is a private airfield, an extension or shortening of the operating hours is permissible at any time.

The cloud penetration procedure published in the AIP, which is designed as an IFR approach with VFR part, was temporarily suspended at the time of the accident by means of NOTAM 2926/21. In addition, neither the pilot had the required qualification for an IFR approach, nor were there appropriate weather conditions to perform the VFR portion of the approach.

The helipad of the Christophorus Flugrettungsverein (LOAW), which is also located at the airfield, was not manned at the time of the accident due to the weather conditions.

After an interruption of radar tracking, the helicopter was captured again by radar at 15:47:18 west of Bad Erlach. At the time of dusk (ECET), the helicopter was approximately between Neunkirchen and Breitenau am Steinfelde ca. 9 nm south-west of the airfield. From this point on, according to the AIP, only the NOVEMBER traffic pattern was to be used for night VFR flights. The pilot nevertheless decided to approach via VFR point GOLF and the Departure Only route (Figure 1). The exact reasons for this are unknown, but the most plausible reason seems to be a possible time saving.

As shown in the radar data (Figs. 1 and 2), after the last left turn from the base leg into the final approach, the runway centerline was overshot several times. This together with the last flight maneuvers, during which direction and altitude were changed several times, are both strong indications that the pilot had no visibility to the ground and was looking for visual reference points. A possibly powered landing light might not have led to an improvement of the visibility to the ground in the given fog, but rather resulted in blinding effects due to backscattering of the light. Whether the pilot was using the infrared camera for the purpose of navigating through the fog cannot be ascertained. In any case, based on the recorded flight track and the number of changes in direction and altitude, the use of the autopilot can be ruled out. The above factors are a clear indication that spatial disorientation (see Sect. 2.4.2) of the pilot had occurred.

According to the standardised european rules of the air (SERA.5001) and the Luftverkehrsregeln 2014 (national rules of the air) (§ 23), a minimum visibility and a minimum distance to clouds of 800 m is required for visual flights with helicopters. According to the weather data and webcam images, a considerably lower visibility was prevailing. Operation of the helicopter under such conditions would not have been permissible.

The exact altitude at which the pilot finally had visual contact with the ground is difficult to determine. At the time of overflying the runway (15:51:59 to 15:52:15), the altitude above ground was between 70 and 16 m. Since the pilot – already above the runway – made another turn of about 130 degrees to the left, it must be assumed that he was unable to recognize the runway at this altitude, despite the fully lit runway lighting. The subsequent “search flight” caused him to fly onto the southern taxiway INDIA, which is not lighted and therefore even more challenging to detect. It is as well possible that the pilot tried to descend to the ground in a hover and drifted off to the south towards taxiway INDIA.

Regardless of how the pilot attempted to reach the ground, it must be assumed that the altitude above the unlighted taxiway was probably only a few tens of feet when he then must become aware of his location. Any pilot in this situation would likely have been surprised by the sudden recognitions of the taxiway. In aviation psychology, the reaction to sudden events is known as startle effect and is described in more detail in section 2.4.1. This would explain a short disruption or a reaction of the pilot, which he would not have set under other circumstances and which would have led to the crash of the aircraft. The fact that the pilot was surprised or startled despite the availability of a radar altimeter could be explained by the fact that there was probably no scanning of the instruments as is usual in instrument flying (see 2.4.2) and the focus of concentration was probably outside the cockpit and thus also away from the radar altimeter.

The fact that the landing gear shows traces of lateral loading is also an indication that the pilot had misjudged the direction of flight or the movement of the helicopter relative to the ground and must have been surprised and startled.

2.4.1 Human factors

The startle reflex[1] is the first response to a sudden, intense stimulus. It triggers an involuntary physiological reflex, such as blinking of the eyes, increased heart rate, and increased tension of the muscles. The latter are necessary to prepare the body for the fight-flight response (Koch[2] , 1999). The startle response is accompanied by an emotional component, which in large part influences how a person responds to the unexpected event (Lang, Bradley, & Cuthbert[3] , 1990).

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[1] EASA. (2018). "Startle Effect Management"
[2] Koch, M. (1999). "The neurobiology of startle". Progress in Neurobiology, 59, 107-128.
[3] Lang, P., Bradley, M., & Cuthbert, B. (1990). "Emotion, attention, and the startle reflex". Psychological Review, 97(3), 377-395.

The duration of the startle reflex depends on the severity of the reflex. A mild reflex lasts less than a second, while a high-intensity response can last up to 1.5 seconds. Startle reflexes are more severe during very low or very high arousal levels. In addition to involuntary physiological reflexes, startle inhibits the muscular activity, thus a startled person stops doing what he or she was doing (Koch, 1999). The disruption can last from 100 milliseconds to 3 seconds for simple tasks and up to 10 seconds for more complex motor tasks (Rivera et al.[1] , 2014).

On the flight deck, the disruption caused by the startle reflex can have detrimental effects, particularly when the startle is elicited when the pilot is performing flight essential tasks. A pilot can lose part of the situational awareness, due to the distraction which might cause cognitive tunneling. And pilots might be interrupted in a difficult cognitive process, such as making a decision (Rivera, et al., 2014).

Cognitive and psychophysiological burdens (stress) have a direct impact on perception, memory, thought processes, and decision making. Toward the end of the flight, the pilot experienced several factors that contributed to the increase in stress. This included the pilot being under a certain amount of pressure simply due to his planned late arrival at the destination airfield and the need to coordinate with the airfield by telephone. This subjective time pressure also manifested in the further course of the flight by the fact that the approach to the airfield was via the departure-only route (VFR point GOLF), which was not permitted for these purposes, instead of via the somewhat longer and more easterly traffic pattern (OSCAR and MIKE) or via the night-VFR traffic pattern (via point ECHO).

The late arrival was likewise accompanied by the onset of darkness. This deterioration in visibility due to darkness was further exacerbated by low clouds and fog. TAF weather forecasts for the destination airfield indicate that the pilot was confronted with a deteriorating weather situation as the flight progressed. On departure from Bolzano, according to the TAF, a landing did appear possible, while with the last amendment of the TAF (at 15:07), a landing was no longer realistic and not permitted (horizontal visibility 400 m, fog and vertical visibility 200 ft).

[1] Rivera, J., Talone, A., Boesser, C., Jentsch, F., & Yeh, M. (2014). “Startle and surprise on the flight deck: similarities, differences, and prevalence”. Proceedings of the Human Factors and Ergonomics Society 58th Annual Meeting, (pp. 1047-1051).

In addition, no alternate aerodromes were listed on the flight plans [1]. The pilot does not seem to have seriously considered the possibility of not being able to land at the destination airfield. This may be due to the fact that it is easier to find an emergency landing area with a helicopter than with a fixed-wing aircraft. However, at night or in poor visibility at the latest, such strategy poses a high level of risk. Preparing and seriously considering a landing at an alternate airfield can significantly reduce the stress on a pilot in flight, since decisions in this regard can be made before the flight and, in a potentially stressful situation, a pre-planned procedure can be followed.

The additive effect of the preceding stress factors partly explains the pilot's behavioral pattern, in which automated, skill-based behavior is applied instead of analytical and knowledge-based behavior as well as rule-based behavior (Rassmussen, 1983). Even if the pilot was aware of the principles of instrument flying it must be assumed that under the given circumstances a relapse to intuitive behavior patterns – e.g. regarding different scanning of the instruments or reliance on the senses of the vestibular apparatus – must have occurred. Once there, a pilot does not recognize whether his or her actions are based on incomplete knowledge, are insufficiently trained, or are applied inappropriately (see error types according to REASON, 1994).

The pilot seems to have followed the need to quickly end the situation with a landing. It is conceivable that the additional equipment of the helicopter (radar altimeter, infrared camera, four-axis autopilot) gave the pilot an additional feeling of perceived safety. It is possible that aborting the landing attempt would have occurred earlier without the perceived safety provided by this additional equipment.

[1] (1.) From Bolzano (LIGT) to Goldeck Talstation (LOKO) and (2.) from LOKO to Wr. Nesutadt/Ost (LOAN)

2.4.2 Spatial disorientation

Spatial disorientation is a state characterized by an erroneous sense of one's position and motion in relation to the earth's surface. [1]

A number of studies have been conducted on the fact that pilots who are untrained in instrument flying lose their orientation and misjudge their own flight attitude within a few minutes. The University of Illinois, in their 1954 "180-Degree Turn Experiment", found that pilots untrained in instrument flying had the wrong understanding of the principles of instrument flying, which they believed to be similar to a visual flight. Although in both cases the number of orientation points is reduced and visibility is greatly degraded, this comparison is incorrect because in night visual flight (just as in daytime visual flight) the primary orientation points for flight attitude lie outside the cockpit (e.g. lights on the ground), whereas in instrument flight orientation is based exclusively on the cockpit instruments. It was found that pilots who usually operate in visual flight are trained to rely mainly on the altimeter and airspeed indicator as well as the natural horizon for estimating their attitude. However, these instruments are, especially during night, not sufficient for a reliable assessment of the attitude of the aircraft. Once the pilot has a false mental image of the attitude, he or she will eventually apply wrong control inputs, which may further aggravate the situation.

The United States Helicopter Safety Team (USHST) published a document titled "Unintended Flight in Instrument Meteorological Conditions" in 2021. According to this document, 15% of all helicopter fatal accidents in the United States from 2009 to 2018 are caused by continuation of a visual flight in instrument meteorological conditions. For this document, of 31 fatal helicopters accidents, the time between entry into instrument meteorological conditions and the accident was evaluated. The median was 56 seconds. This means that pilots who were untrained in instrument flight had crashed on average about 56 seconds after losing visual contact with the ground.

"Spatial Disorientation Induced by a Degraded Visual Environment"[2] (also published by the United States Helicopter Safety Team), published in 2020, states that spatial disorientation as a result of visual impairment[3] occurs regardless of pilot experience or type of flight

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[1] See also Benson, A. J. (1978) "Special senses, work and sleep", in: Ernsting, J, Ed. "Aviation medicine, physiology and human factors" or FAA "Introduction To Aviation Physiology".

[2] Recommended Practice, Helicopter Safety Enhancement No. 127A Output No. 2

[3] DVE (Degraded Visual Environment) induced Spatial Disorientation

operation (helicopter emergency medical services, police, business, military, aerial work, private, etc.) and is often a result of failed planning, lack of understanding, or poor decision-making. Based on FAA and NTSB investigation data of accidents between 2009 and 2019, the average age of pilots involved in such accidents is approximately 48 years with an average total flight experience of 2673 hours. It is notable that the pilot in the present accident is about average with 50 years of age and 2081 hours of total flight experience.

A person's sense of orientation (vestibular apparatus) is perceived via sensory cells in the inner ear. Under normal circumstances, the dominant part for spatial orientation is achieved via the visual apparatus (the eyes). If the visual system is suppressed (e.g. because nothing can be seen to orient oneself), the vestibular apparatus takes over entirely. However, due to its physiological structure, the vestibular apparatus can easily be deceived.

An unintended bank attitude or lean is one of the most common effects caused by a vestibular illusion (USHST 2020). Gradual and prolonged turns (usually less than 2 degrees per second) remain unnoticed by the pilot and his of her vestibular apparatus (sub-threshold acceleration, see FAA “Introduction To Aviation Physiology”). A then sudden return to level flight (e.g. after checking the instruments and correcting attitude) will cause a strong sensation of rolling to the opposite side. An untrained pilot may put the aircraft back into the initial roll because that “feels normal”. Similarly, following a known sustained duration turn (20-25 seconds and longer) and attempting to return to level flight, pilots may feel turning in the opposite direction (see USHST 2020) This can cause pilots to return the aircraft to its original turn. As the aircraft turns without an increase in lift it causes the aircraft to descend. If the pilot then only focuses on the variometer and altimeter and makes an aft input into the flight controls the aircraft turn will tighten, “corkscrewing” into the ground (Graveyard Spiral).

In the same way, a nose-up attitude can be mistaken for an acceleration of the aircraft, and a nose-down attitude can be mistaken for a deceleration (USHST 2020), leading to incorrect control inputs by the pilot to counteract the supposedly incorrect attitude.

The March 2021 issue of ROTOR (Helicopter Association International) also covers the topic of “Inadvertent Entry Into Instrument Meteorological Conditions” (IIMC). It explains several methods for either avoiding such a situation or minimizing the risk if one has already entered instrument flight conditions. Consequently, good flight planning and preparation is of utmost importance. Thus, in addition to conducting a risk assessment (e.g. using a flight risk assessment tool), establishing Enroute Decision Points (EDP) is critical. One problem in deciding whether to abort a flight is that criteria for poor visibility are difficult to pin down. Typically, distances to clouds or fog are hard to determine (Is a cloud layer 1300 or 1700 m away?) and change continuously rather than abruptly while the flight proceeds. It is tempting to continue the flight for a period of time, since no clear criterion for instrument flight conditions has been exceeded. EDP can help to relieve the pilot of this decision during the flight by defining clear decision criteria prior to the flight based on flight data such as minimum altitude or speed. When an EDP is reached, a pilot must then decide whether to turn around, take evasive action or land is the best alternative.

3 Conclusions

3.1 Findings

- The pilot held the required medical certificate.
- The pilot held the type rating for the accident type Bell 429.
- The pilot held a VFR license with including a night rating for helicopters. An instrument rating was not held.
- Given the pilot's licenses and ratings, the flight was permissible (even after ECET in the context of a night VFR flight) until entering clouds or fog.
- The pilot had sufficient flight experience both on the accident type with approximately 925 hours and in total including other helicopter types (approximately 2081 hours).
- The pilot had little experience with night landings, the last three recorded night landings having occurred over a year ago.
- There are no indications of impairing substances (apart from traces of caffeine) in the pilot's body. Likewise, there are no indications of psychological or physical impairment.
- The time of the accident was after ECET hence darkness prevailed.
- At the time of the accident, visibility at the airfield Wr. Neustadt/Ost was severely impaired by clouds and fog. According to METAR, the visibility was about 400 m.
- The required VMC minimum distances for helicopters according to SERA.5001 and Luftverkehrsregeln 2014 (national rules of the air) § 23 could not be met under the given conditions.
- At the time of departure, weather information was available (in particular the TAF of 11:25), according to which the approach and landing at the destination airfield seemed possible.
- At the time of the accident, a landing at the airfield Wr. Neustadt/Ost was not permissible due to the limited visibility even if an instrument rating was available, since the last part of a cloud penetration procedure – suspended by NOTAM at the time of the accident – would have to be executed as VFR part.
- At the time of the accident (past ECET), an approach and landing is only permitted via the NOVEMBER traffic pattern, which must be used for all night VFR flights.

- The pilot did not comply with the NOVEMBER aerodrome traffic pattern for approach and landing, which must be used for night VFR flights according to AIP, but shortcutted the approach via the "DEP ONLY RWY 09" route, which is exclusively designated for departures.
- The helicopter was available for owner's flights only via an operator organization and had been removed from the AOC by March 2018.
- Maintenance was properly documented and performed in a timely manner.
- The helicopter was equipped with a retractable landing gear, which was configured for landing.
- In addition to the basic equipment, the helicopter was equipped with an infrared camera system, an articulated landing light, a four-axis autopilot and a radar altimeter.
- At the time of the accident, enough fuel was available for a flight time of about one hour or 140 nm in long range cruise. Thus, several alternate airfields were available.
- Apart from an X TRQ LIMIT exceedance, which was triggered during the collision or by an abrupt flight maneuver a few seconds earlier, no engine parameter exceedances were recorded.
- There are no indications, reports, notifications or records of pre-existing technical defects or malfunctions on the helicopter. The damage pattern on the helicopter wreckage indicates that the engines were supplying power to the main rotor up to the time of impact.
- There are no indications that an in-flight fire had broken out prior to the collision with the ground. A post-flight fire broke out as a result of the collision.
- Based on the traces, it can be concluded that the landing gear was subjected to lateral loads at the time of ground contact. This indicates an uncontrolled flight maneuver at the time of ground contact.
- The pilot probably retrieved current weather information during the flight or during the stopover at Semmering and was aware of the difficult weather conditions for the onward flight and landing at Wr. Neustadt/Ost airfield.
- The destination airfield Wr. Neustadt/Ost is a private airfield without operating obligation and without air traffic control. Operating hours are published in the AIP.
- The pilot informed the airfield Wr. Neustadt/Ost by telephone of his intention to land before departure after the stopover at Semmering. The airfield in turn agreed to extend the operating hours until landing, if necessary.
- The flight plan, which was filed for the flight from Bolzano to the Goldeck Talstation heliport, was closed in flight shortly before reaching the heliport. A landing there did not take place.

- A second flight plan from Goldeck Talstation to Wr. Neustadt/Ost was saved in the system (RocketRoute) as a draft, but not activated or filed.
- No alternate aerodrome was specified on the flight plans in case the destination aerodrome could not be reached.
- A flight after ECET would have required the filing of a flight plan and a radiotelephony communication with air traffic service.
- Due to the uncertainty whether a landing in Wr. Neustadt/Ost was possible, the only passenger had himself dropped off at the off-field landing site at Semmering.
- The pilot adequately prepared for the flight, with the exception of the lack of alternate aerodromes on the flight plans.
- The flight track during the approach to the airfield and across the airfield area as well as the circumstances of the collision with the ground strongly indicate a spatial disorientation of the pilot. The flight track is not attributable to other circumstances.
- The runway lighting was set to the maximum brightness level. Based on the flight track, it can be assumed that the pilot was nevertheless unable to establish visual contact with the ground when flying over the runway.
- Taxiways at Wr. Neustadt/Ost airfield are not lighted.
- It must be assumed that in the given darkness and impaired visibility due to fog, recognition of the unlighted taxiway occurred very late and the pilot was surprised and startled by the sudden recognition of the obstacle.

3.2 Probable causes

- Continuation of a visual flight under instrument meteorological conditions
- Spatial disorientation

3.2.1 Probable factors

- Non-compliance with visibility and distance from cloud minima according to SERA and LVR
- Non-compliance with approach procedure
- Little experience regarding night landings
- Lack of or no experience in instrument flight

4 Safety recommendations

None.

5 Consultation

Pursuant to Art. 16 (4) Regulation (EU) No. 996/2010, the Federal Safety Investigation Authority solicited comments from the authorities concerned, including EASA, and, through them the certificate holder for the design, the manufacturer and the operator concerned prior to publishing the final report.

In soliciting such comments, the Federal Safety Investigation Authority follows the international standards and recommendations regarding investigations of aviation accidents and incidents as approved under Article 37 of the Chicago Convention on International Civil Aviation.

Pursuant to article 14 para. 1 of the UUG [*Accident Investigation Act*] 2005 as amended, the Federal Safety Investigation Authority gave, prior to the completion of the final report, the manufacturer, the companies concerned, the aircraft operators, the pilots as well as the competent authorities the opportunity to comment in writing on the facts and conclusions relevant to the incident under investigation ("Stellungnahmeverfahren").

Feedback without comments was received from EASA, TSB Canada and the aircraft manufacturer. The operator submitted a statement that was considered and incorporated in the investigation report.

List of Tables

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Federal Aviation Act of 2 December 1957 (**Aviation Act** [***Luftfahrtgesetz – LFG***]), Federal Law Gazette [*BGBl. I*] No. 253/1957 as amended by Federal Law Gazette [*BGBl. I*] No. 151/2021

Federal Act on the Independent Safety Investigation of Accidents and Incidents (**Accident Investigation Act** [***Unfalluntersuchungsgesetz – UUG***]), Federal Law Gazette [*BGBl. I*] No. 123/2005 as amended by Federal Law Gazette [*BGBl. I*] No. 231/2021

Ordinance of the Federal Ministry of Transport and Electricity of 26 February 1962, concerning the operation of civil airfields [***Zivilflugplatz-Betriebsordnung – ZFBO***], Federal Law Gazette [*BGBl.*] No. 72/1962 as amended by Federal Law Gazette [*BGBl. II*] No. 209/2019.

Ordinance of the Federal Minister of Transport, Innovation and Technology and the Federal Minister of Defence and Sport on the Rules of the Air 2014 (**Rules of the Air** [***Luftverkehrsregeln 2014 – LVR 2014***]), Federal Law Gazette [*BGBl. II*] No. 297/2014 as amended by Federal Law Gazette [*BGBl. II*] No. 174/2020

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 repeal of Directive 94/56/EC.

Commission Implementing Regulation (EU) No. 923/2012 of 26 September 2012 laying down common rules of the air and operational provisions regarding services and procedures in air navigation and amending Implementing Regulation (EU) No 1035/2011 and Regulations (EC) No 1265/2007, (EC) No 1794/2006, (EC) No 730/2006, (EC) No 1033/2006 and (EU) No 255/2010. (**SERA**)

Abbreviations

ACG	Austro Control GmbH
ADMM	Aircraft Data Memory Module
ADIU	Aircraft Data Interface Unit
ADS-B	Automatic Dependent Surveillance - Broadcast
AFTN	Aeronautical Fixed Telecommunication Network
AIP	Aeronautical Information Publication
AIS	Aeronautical information service(s)
ANSP	Air Navigation Service Provider
ARO	Air traffic services reporting office
BMVIT	Bundesministerium für Verkehr, Innovation und Technologie (Federal Ministry for Transport, Innovation and Technology) (until 2020)
CAMO	Continuing Airworthiness Management Organization
CPL(H)	Commercial Pilot License, Helicopter
CV/FDR	(Combined) Cockpit Voice and Flight Data Recorder
DCU	Data Collection Unit
EASA	European Aviation Safety Agency
ECET	End of Civil Evening Twilight
EDP	Enroute Decision Point
ELT	Emergency Locator Transmitter
EU	European Union
FAA	Federal Aviation Administration
FI(H)	Flight Instructor - Helicopter
FIC	Flight Information Center
FIR	Flight information region
GAFOR	General Aviation Forecast
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IIMC	Inadvertent Entry Into Instrument Meteorological Conditions
IR	Instrument Rating

LOAN	ICAO designation of the aerodrome Wr. Neustadt/Ost
LOAW	ICAO designation of the heliport ÖAMTC/Wr. Neustadt
LOKO	ICAO designation of the heliport Goldeck Talstation
LOWI	ICAO designation of Innsbruck airport
LOVV	Designation of the Flight Information Region (FIR) Vienna
LIGT	ICAO identifier of airfield San Genesio
MAPt	Missed Approach Point
METAR	Meteorological Aerodrome Report
CET	Central European Time
MLAT	Multilateration
NAV	Navigation
NGT VFR	Night VFR
NOTAM	Notice(s) to Airmen
NTSB	National Transportation Safety Board
OPS	Operation(s)
PAPI	Precision Approach Path Indicator
PPL	Private Pilot License
RMZ	Radio Mandatory Zone
RNAV	Area Navigation
RNP	Required Navigation Performance
SIG Wx	Significant Weather Chart
TAF	Terminal Aerodrome Forecast
TAWES	Teilautomatisches-Wetter-Erfassungs-System (Semi-automatic weather acquisition system)
TSB Canada	Transportation Safety Board Canada
USHST	United States Helicopter Safety Team
UTC	Coordinated Universal Time
VAMES	Voll-Automatisches-Meteorologisches-Erfassungs-System (Fully automatic meteorological acquisition system)
VFR	Visual Flight Rules
X TRQ LIMIT	Cross Torque Limit

ZAMG	Zentralanstalt für Meteorologie und Geodynamik (Central Institute for Meteorology and Geodynamics)
ft	Feet (1 ft = 0.3048 m)
kt	Knots (1 kt = 0.514444 m/s)
lbs	Pounds (1 lbs = 0.453592 kg)
nm	Nautical mile (1 nm = 1852 m)

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