Bundesstelle für
Flugunfalluntersuchung

German Federal Bureau of
Aircraft Accident Investigation

Investigation Report

Identification

Type of Occurrence:	Accident
Date:	2 August 2016
Location:	Oberschleissheim Special Airfield
Aircraft:	Helicopter
Manufacturer / Model:	Agusta S.p.A. / A 109E
Injuries to Persons:	One person suffered minor injuries
Damage:	Aircraft severely damaged
Other Damage:	None
State File Number:	BFU16-1082-3X

Factual Information

History of the Flight

On the day of the accident the crew, consisting of two pilots, wanted to conduct a training flight with an Agusta A 109E helicopter. At 1453 hrs[1] they took off from Ottobrunn Helicopter Special Airfield (EDMR) and flew west around Munich to Oberschleissheim Special Airfield (EDNX). In Oberschleissheim three southern traffic circuits (glider traffic circuit) were conducted with simulated one engine inoperative (OEI) in approach direction to runway 26. The crew stated that during the

[1] All times local, unless otherwise stated.

approaches the nose wheel lock had been engaged and the main rotor rpm selected to 102%.

The two pilots stated that during the first single-engine approach a rolling landing had been conducted with approximately 25 kt horizontal velocity on runway 26. During the second approach the intent was to conduct a CAT A approach to a limited space in front of the runway. The Type Rating Instructor (TRI) had simulated the one-sided engine failure prior to the Landing Decision Point (LDP). The pilot flying aborted the approach and conducted a single-engine go-around. During the following approach, the TRI simulated the one-sided engine failure after the LDP. The pilot flying conducted the approach with released parking brake with approximately 20 kt and a rate of descent of less than 300 ft/min to the intended touch-down in front of runway 26. By adhering to the maximum allowable single-engine power he touched down with low horizontal velocity, reduced the pitch speedily, and selected the main rotor rpm to 100%.

After the helicopter had stood firmly on the ground and the TRI deactivated the OEI training mode, the helicopter suddenly began to swing vertically. Both pilots concluded it had to be ground resonance. The TRI wanted to stop it and therefore pulled the pitch. But the helicopter responded with increased vertical oscillations and added horizontal rocking motions. Finally the helicopter sprang from the left to the right main landing gear and back again. Due to the resulting tilting the main rotor had ground contact. Subsequently, the fuselage yawed and at about 1515 hrs the helicopter reached its final position lying partly on the fuselage after the engines had been shut off by emergency shut-down. The left main landing gear had been torn off.

Both pilots were able to leave the severely damaged helicopter unaided. During the accident the TRI suffered a cut at the back of his head.

Overview: damages on the helicopter Photo: BFU

Personnel Information

Pilot with TRI

The 53-year-old pilot, seated in the left-hand seat, held an Airline Transport Pilot's Licence Helicopter (ATPL(H)) issued in accordance with Part FCL. The license listed the entries: type rating as Pilot in Command (PIC) on AS350/EC130, AW109, BK117, EC135/635, and EC145(BK117). In addition, he held the instructor rating for flight training (FI(H)) and the instructor rating (TRI) for twin-engine helicopter. He held a class 1 medical certificate with restriction (TML) valid until 20 October 2016. He had a total flying experience of 9,021 hours, of which approximately 450 hours had been flown on type.

Pilot Flying

The 62-year-old pilot, seated in the right-hand seat, held an Airline Transport Pilot's Licence Helicopter (ATPL(H)) issued in accordance with Part FCL. The license listed the entries: type rating as Pilot in Command on AS350/EC130, AW109, and EC135/635. He held a class 1 medical certificate with restriction (VDL) valid until

12 November 2016. He had a total flying experience of 10,340 hours, of which approximately 840 hours had been flown on type.

Aircraft Information

The twin-engine helicopter Agusta A 109E manufactured by Agusta S.p.A., currently Leonardo S.p.A. Helicopters, is a lightweight multi-purpose helicopter for up to eight occupants. It was certified in 1993 in accordance with FAR/JAR Part 27 and partly Part 29. The helicopter is equipped with two Pratt & Whitney Canada PW206C engines, a four-blade main rotor, a fully articulated rotor head with elastomers, a retractable tricycle landing gear, and a tail rotor for anti-torque. Maximum take-off mass is 2,850 kg.

The helicopter can meet flight performance class 1 by adhering to CAT-A procedures. This means it can land safely or continue the flight with the remaining engine in case of engine failure during take-off or landing. For training of the CAT-A procedures the helicopter type is equipped with a training mode, which simulates one engine inoperative. In training mode the N2 power of the selected engine is reduced to 90% and the display in the cockpit indicates simulated engine failure. During training mode maximum allowable exhaust gas temperature and N1 rpm of the remaining engine is reduced to preserve the engine and prevent damage. In case of a real emergency or reduced main rotor rpm below 87% the training mode would be deactivated automatically and normal engine and emergency power be available.

Due to the reduced power in training mode the maximum allowable take-off mass is reduced depending on the landing site (Clear Area, Short Field, and Ground Based Helipad). At the day of the accident outside air temperature was 21°C and Pressure Altitude (PA) approximately 1,450 ft AMSL. Therefore, maximum take-off mass for Clear Area would have been about 2,740 kg, for Short Field about 2,655 kg, and for Ground Based Helipad about 2,525 kg.

Up until the end of 2016, 764 Agusta A 109E, S, SP, and the military type A 109LUH, with the same landing gear and a very similar rotor head design, were manufactured. The manufacturer estimates the total operating hours of the entire fleet with approximately 1.5 million flight hours.

The manufacturer stated that in the past events involving ground resonance had occurred with A 109E and S helicopters:

Date	Type	Location	Findings
08.11.2005	A 109E	USA	Uncontrolled landing
19.01.2006	A 109E	USA	Sudden braking during ground taxiing turn
22.08.2009	A 109E	Saudi Arabia	Main Rotor FOD
18.09.2009	A 109E	Kazakhstan	Hard landing
20.11.2009	A 109E	Poland	Asymmetrical hard landing
09.07.2012	A 109S	Germany	Instability during taxi turn
03.10.2015	A 109E	Iran	Improper manoeuvre during lifting up the helicopter nose

Part 2 Normal Procedures of the Flight Manual contained the caution:

CAUTION

The helicopter is free of ground resonance.
However if, for some reason, ground resonance should occur, lift the helicopter free of the ground immediately. If unable to become airborne, lower collective and shut-down engines.

The accident helicopter was built in 1998 and had the manufacturer's serial number 11014. The last airworthiness inspection was conducted on 24 September 2015. The last release to service was issued on 8 July 2016 at total operating time of 1,951 hours and 3,661 landings. At the time of the accident, the helicopter had a total flight time of about 1,966 hours and 3,700 landings. According to the weight report of 10 September 2015 the empty mass was 2,002 kg. At the time of take-off in Ottobrunn the helicopter had 430 kg fuel on board. The take-off mass was about 2,612 kg. The helicopter had a German certificate of registration and was operated by a German operator.

Meteorological Information

Approximately five minutes after the accident the corresponding aviation routine weather report (METAR) of 1520 hrs at Munich Airport ((EDDM), located about 11 Nautical Miles (NM) away, reported the following weather conditions:

The wind was 280°/6 kt. Ground visibility was more than 10 km; slight precipitation, few clouds in 3,300 ft, and scattered clouds in 5,500 ft. The air temperature was 21°C, dewpoint 11°C, and barometric air pressure (QNH) 1,018 hPa.

Aids to Navigation

An iPad® with two installed Apps for navigation (Air Nav Pro® und Jeppesen Mobile FD®) was found in the helicopter's cockpit, which was equipped with substantial avionics. The Air Nav Pro – Logbook had stored the accident flight with take-off and landing times and location. But neither the Air Nav Pro nor the Jeppesen Mobile FD had stored any flight path data.

Radio Communications

Radio transmissions with the Flugleiter (A person required by German regulation at uncontrolled aerodromes to provide aerodrome information service to pilots) at Oberschleissheim Special Airfield were not recorded.

Aerodrome Information

Oberschleissheim Special Airfield (EDNX) is located north of Munich. It has one asphalt runway oriented 08/26 with a length of 808 m and a width of 15.6 m. South of the main runway the towrope pull-out area and two grass strips, which are 250 m long and 30 m wide, for gliders are located. The traffic circuit for powered airplanes is located north and the one for gliders south of the runway. Aerodrome elevation is 1,596 ft AMSL. At the time of the accident the density altitude at Oberschleissheim was approximately 2,700 ft AMSL.

In front of runway 26 parts of the concrete runway surface of the old military airfield still remain. The surface is firm but covered with loose stones, weeds, and larger moss areas, and its surface is slightly rippled.

Overview: Start runway 26, intended touch-down point, accident site Image: BFU/ Google earth™

Flight Recorder

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

Due to the software version of the units (year of manufacture 1998) the analysis of the Data Collecting Units (DCU) of the two engines did not reveal any information regarding the engine parameters during the approach or the accident.

Wreckage and Impact Information

The accident site was located approximately 100 m in front of runway 26 of Oberschleissheim Special Airfield. The helicopter stood upright slightly tilting left towards approximately 320°. The retractable landing gear was extended. The parking brake had been released. The left main landing gear had collapsed outward. The nose landing gear had been twisted to the left. The pin of the nose wheel centre mechanism was not engaged. After the accident, the lever for the nose wheel locking in the cockpit was not completely in the “Lock” position.

Position helicopter, start runway 26, landing area surface Photo: BFU

The nose was damaged. Individual electronic equipment had been torn out. The right side of the Plexiglas cockpit top was damaged; the pitot tubes on the roof were bent towards the rotation direction of the main rotor. The bracket of the main gear box had penetrated the roof of the cabin. All four main rotor blades and the rotor head were damaged. The four mounting rods of the main gear box on top of the fuselage were fractured. The hydraulic lines of the control servos essentially held the main gear box in place. The tail rotor drive shaft had been torn off the main gear box in the area of the rotor brake. The leading edge of one blade tip of the tail rotor showed an egg-sized spherical indentation.

On board a folder with papers, which included flight order for a VFR check flight with hand-written changes of the instructor and flight purpose and pre-flight preparation including flightlog, fuel and mass calculations, meteorological flight briefing and AIS-NOTAM information was found for the route: Ottobrunn, Oberschleissheim, Ottobrunn, destination Innsbruck (LOWI).

The helicopter was salvaged and further examined with the help of a maintenance organisation certified in accordance with Part-145. The visual inspection did not reveal any causal technical defects on the rotor head or the landing gear as cause for the ground resonance.

The air pressure of the wheels was measured as was the gas pressure and the oil level of the landing gear dampers.

The four main rotor blade led/lag-dampers and the three landing gear shock absorbers including the nose-wheel-lock were removed for further examination at the manufacturer.

The main landing gear dampers and the led/lag dampers were x-rayed. No inner damages, indications of loose screw connections, etc. were found. On all four led/lag dampers the ball head for the mounting to the blade grip on the piston rod was fractured. The BFU tasked the Technischen Universität Braunschweig, Institut für Füge- und Schweißtechnik (ifw) with the examination of the fractures. They were clearly classified as secondary accident damage.

In October 2016, further examinations were conducted in the presence of experts of the helicopter manufacturer and the BFU at the facilities of the respective damper supplier in Italy. They revealed no technical malfunction of the dampers, the nose-wheel-lock mechanism, or the four led/lag dampers.

Fire

There was no fire.

Additional Information

Ground Resonance

Excerpt from the Rotorcraft Flying Handbook of the Federal Aviation Authority (FAA):

Ground resonance is an aerodynamic phenomenon associated with fully-articulated rotor systems. It develops when the rotor blades move out of phase with each other and cause the rotor disc to become unbalanced. This condition can cause a helicopter to self-destruct in a matter of seconds. However, for this condition to occur, the helicopter must be in contact with the ground.

If you allow your helicopter to touch down firmly on one corner (wheel type landing gear is most conducive for this) the shock is transmitted to the main rotor system. This may cause the blades to move out of their normal relationship with each other. This movement occurs along the drag hinge.

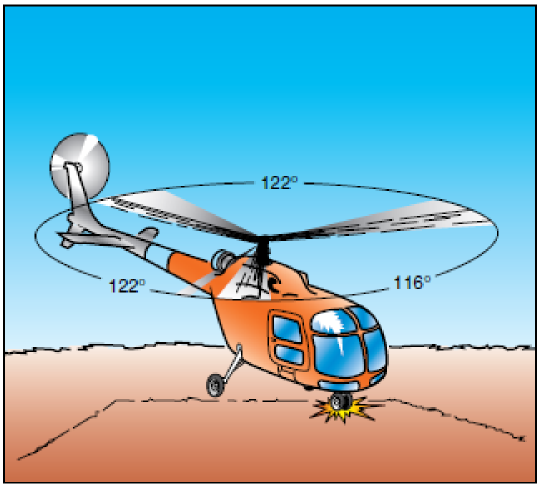

Figure 11-5. Hard contact with the ground can send a shock wave to the main rotor head, resulting in the blades of a three-bladed rotor system moving from their normal 120° relationship to each other. This could result in something like 122°, 122°, and 116° between blades. When one of the other landing gear strikes the surface, the unbalanced condition could be further aggravated.

If the r.p.m. is low, the corrective action to stop ground resonance is to close the throttle immediately and fully lower the collective to place the blades in low pitch. If the r.p.m. is in the normal operating range, you should fly the helicopter off the ground, and allow the blades to automatically realign themselves. You can then make a normal touchdown. If you lift off and allow the helicopter to firmly re-contact the surface before the blades are realigned, a second shock could move the blades again and aggravate the already unbalanced condition. This could lead to a violent, uncontrollable oscillation.

This situation does not occur in rigid or semirigid rotor systems, because there is no drag hinge. In addition, skid type landing gear are not as prone to ground resonance as wheel type gear.

Excerpt Final Report, Occurrence 995/09, Agusta A 109E helicopter, SP-HXA, 20. November 2009:

There are several causes which may trigger ground resonance. The list of possible causes divided into two groups is given below:

Technical causes: incorrect pressure in tires, incorrect performance of wheels shock absorbers, damage to the main rotor damper, delamination of the composite blade, inadequate tracing of the main rotor blades, other damage.

Pilotage causes: asymmetrical landing, landing on a slope, hard landing, an impact during taxiing of the helicopter after touchdown, any actions causing rapid change of engine parameters.

It should be noted that the complete elimination of the possibility of ground resonance is impossible.

Analysis

During a training flight, OEI- landing outside the runway in use, ground resonance occurred after ground contact. Within a few seconds the helicopter was severely damaged and the pilot with instructor rating suffered minor injuries.

The pilot with instructor rating (TRI) and the pilot flying held the aeronautically required licences and ratings to conduct the training flight. Both have to be viewed as very experienced in regard to total flying and type experiences. In light of the high flying and type experience of the pilot flying in the right-hand seat, the BFU considers the training flight with the resulting cost for the owner as remarkable. Originally the flight order listed a different instructor who was a type rating examiner. The TRI in the left-hand seat was, however, not a type-rating examiner and subsequently this flight could not have been used for the revalidation of the type rating or as commercial operator proficiency check.

In accordance with aeronautical regulations, the helicopter had been continuously maintained. Centre of gravity and take-off mass were within the prescribed limits. Neither the technical examination of the helicopter after the salvage operation, nor the examination of the led/lag and landing gear dampers and the nose-wheel-lock mechanism at the respective manufacturer revealed any technical malfunctions which would explain the ground resonance. Wheels, wheel rims, braking system and tail skid did not show any indications of hard landing. For decades, this helicopter type has been used in private, commercial, and military operations. Ground resonance occurrences in the past with this helicopter type had mostly operational causes.

For the planned flight the weather was good. It only limited the training flight and the CAT-A procedure in regard to the adherence to the Pressure Altitude (PA) and the temperature. The headwind component of wind direction 280° positively supported the OEI- approach to runway 26 in regard to needed engine thrust.

For OEI- approach or landing exercises runway 26 and its markings showed numerous locations for clear target announcement for the simulation of a limited landing site. Considering mass limitations and reduced engine thrust in training mode, on the runway all landing site options (Clear Area, Short Field und Ground Based Helipad) would have been possible under comparably safe conditions. According to the statements of the two pilots the landing site had explicitly been chosen. The BFU does not understand this location ahead of runway 26 at Oberschleissheim. The BFU is of the opinion that, due to loose stones, grass and mossy areas, and being slightly rippled, the surface in this area was not suitable for simulated emergency landing during a training flight. Especially since touch-down without any horizontal velocity with the simulated engine emergency thrust in training mode was almost impossible. At the time of the accident, after approximately 22 minutes of flight time, aircraft mass was about 2,530 kg. For a Ground Base Helipad OEI-landing in training mode the mass was at the upper limit.

The surface also posed the risk of foreign object damage, e.g. on the tail rotor, caused by stones raised by downwash or landing gear wheels. The egg-sized spherical indentation at one of the tail rotor blades could have been caused by a stone. This stone could then have been thrown upward and caused main rotor blade damage. Main rotor damage could have triggered ground resonance. Due to the number of damages on the main rotor blades this could neither be proven nor ruled out.

The American aviation authority describes in their Rotorcraft Flying Handbook in a short summary how generally ground resonance with helicopters with fully articulated rotor heads arises. Ground resonance without technical malfunctions arises through outer causes, e.g. unbalanced touch-down, hard landing, strong deceleration, uneven surface during taxiing, etc. The normal emergency procedure, as it was described in the manual of the helicopter involved, is the immediate lifting of the helicopter into hover to end the ground resonance. The ground resonance phenomena can technically not be entirely prevented, past occurrences document that helicopter types with fully articulated rotor heads and landing gears are more susceptible than other technical designs.

The BFU is of the opinion that it is highly likely that the rotor blade relationship had become unbalanced by some input and triggered the ground resonance. The reasons for the input could be: the simulated OEI- landing, the subsequent short rollout on the uneven surface, the deceleration to stand-still, the swift pitch down and the reduction of the rotor rpm from 102% to 100%. It cannot be ruled out, however, that a sudden main rotor blade damage, e.g. by a stone thrown up by the tail rotor, was the cause. Only immediate recognition of the situation and the lifting of the helicopter into hover could have prevented the accident.

It was not possible to determine causal technical damages on the helicopter or the dampers.

Conclusions

The accident and the severe damages on the helicopter were caused by ground resonance subsequent to a simulated OEI-landing on an unsuitable surface outside the runway in use.

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