Statens haverikommission

Accident involving an aircraft of the model Antonov AN-2

The Swedish Accident Investigation Authority has investigated an accident at Vårgårda, Västra Götaland county, on 08 July 2023

19 June 2024

Final report
SHK 2024:10e

About Swedish Accident Investigation Authority

The Swedish Accident Investigation Authority (SHK) investigates accidents and incidents from a safety perspective regardless of whether they occurred on land, at sea or in the air. The authority's accident investigations are intended to disseminate knowledge and provide a basis for actions by authorities, companies, organizations, and individuals that improve safety and reduce the risk of accidents. The activities should also contribute to people feeling secure and having trust in society's institutions and the confidence in transportation systems. The mission also includes assessing the efforts made by the rescue services in connection with an accident. However, the investigations should not assign blame or liability, whether criminally, civilly, or administratively.

The investigations by SHK aim to answer three questions:

- What happened?
- Why did it happen?
- How can a similar accident/incident be avoided in the future?

Investigations of aviation accidents and incidents are primarily regulated by Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and the Act (1990:712) on the investigation of accidents. The investigations are conducted in accordance with Annex 13 of the Chicago Convention.

The report is also available on the Swedish Accident Investigation Authority's website: www.shk.se.

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Content

Summary

The flight, which was a private flight, was the third of the day. The pilot had landed on a field at Tumberg just north of Vårgårda and after a ground stop they planned to take off from the field. On board were one pilot and four passengers.

The pilot decided to take off from the field in an easterly direction because there were obstacles in the form of buildings and lamp posts in the westerly direction. There were trees at the end of the field to the east, but the pilot assessed that these did not pose a problem and that the field was long enough for a take-off in an easterly direction. No precise calculations were made to determine the required take-off distance.

The pilot initiated the take-off and set the engine controls to full take-off power. According to the pilot and the passenger in the right front seat, the indicated values for engine rpm and manifold pressure were normal. The acceleration of the aircraft was also perceived as normal.

At lift-off, the aircraft rolled to the right and the pilot felt that the aircraft did not climb as expected. The pilot pulled hard on the control yoke and tried to climb over the trees at the end of the field. However, he failed to manoeuvre the aircraft away from the trees and as a result the aircraft collided with the trees.

No one was injured in the collision but the aircraft sustained significant damage.

The investigation has shown that under the prevailing conditions, the required distance for a take-off exceeded the available distance. A safe take-off was therefore not possible in the chosen take-off direction.

Causes/Contributing Factors

The accident was caused due to the fact that a robust method for performance calculation of the required take-off distance was not applied. This in term led to the commencement of the flight in spite of the lack of conditions for a safe start in the chosen direction.

Safety recommendations

None.

Uppgifter	
Aircraft:	Registration, type: SE-KCE Model: Antonov-AN2 Class, Airworthiness: Annex 1, National Permit to Fly Serial number: 1G18959 Owner: Private
Time of occurrence:	8 July 2023, 15.33 hrs. in daylight Note: All times are given in Swedish daylight saving time (UTC[1] + 2 hours)
Place:	Vårgårda, Västra Götalands County, (position 5802N 01249E, 100 metres above mean sea level)
Type of flight:	Private
Weather:	According to SMHI's analysis of the general weather conditions in the area: wind was from the west or northwest at 3–7 knots, gusts 16 knots, visibility was more than 10 kilometres, Cumulus clouds with base between 5,000–6,000 feet, temperature/dewpoint 24/12°C, QNH[2] 1021 hPa
Persons on board:	In total: 5 Crew members: 1 Passengers: 4
Injuries to persons:	None
Damages:	Damage to aircraft: Substantially damaged Other damage: Some environmental damage in the form of fuel leaks and damage to trees
Pilot in command:	Age: 77 years License: PPL(A) [3] Total flying hours: 1,778 hours Flying hours previous 90 days: 17 hours Number of landings previous 90 days: 39

[1] UTC (Coordinated Universal Time).

[2] QNH (The atmospheric pressure adjusted to the mean sea level).

[3] PPL(A) (Private Pilot License Aeroplane).

The investigation

SHK was informed on 8 July 2023 that an accident involving one aircraft with the registration SE-KCE had occurred at Vårgårda, Västra Götaland County, on the same day at 15.33 hrs.

The accident has been investigated by SHK represented by Mrs Jenny Ferm, Chairperson, Mr Ola Olsson, Investigator in Charge and Mr Gideon Singer, Operations Investigator.

SHK has been assisted by Magnic AB as an expert in audio-visual analysis.

Mr Oleksandr Babak has participated as accredited representative of Ukraine and Mr Krzysztof Błasiak has participated as accredited representative of Poland.

The investigation was followed by Mr Ola Johansson of the Swedish Transport Agency and by Mr Simon Sheldon of the European Aviation Safety Agency (EASA).

The following organisations have been notified: International Civil Aviation Organisation (ICAO), EASA, EU-Commission, The Swedish Transport Agency and the authorities for safety investigations in Ukraine and Poland respectively.

Investigation material

Interviews have been conducted with the pilot and the passengers.

The accident site has been examined.

The aircraft's technical documentation has been examined and analysed.

Image and sound from video films and registered data from tablets with navigation applications have been obtained and analysed.

Meteorological information has been obtained.

The investigation has been limited in terms of certain technical aspects about the aircraft as well as information that was not found relevant to the incident.

A fact-finding presentation meeting with the interested parties was held on 1 February 2024. At the meeting SHK presented the facts discovered during the investigation, available at the time.

1. Factual Information

1.1 History of the flight

1.1.1 Circumstances

During the day, the pilot and four passengers completed a flight from Kattleberg to a field at Tånga Hed, Vårgårda.

A decision was then made to continue on a short flight to a field at Tumberg just north of Vårgårda. Before the flight, the pilot visited the field to inspect the conditions there, which the pilot judged to be suitable.

The short flight from Tånga Hed ended with a landing in a westerly direction on the field at Tumberg.

The flights were private flights with passengers. The passenger in the right front seat was also a pilot holding a rating on the class, but had no role as a crew member during these flights.

1.1.2 Sequence of events

After a ground stop in Tumberg, the take-off from the field was being prepared. The pilot stated that he noted that the wind was light and variable. He decided to take-off from the field in an easterly direction because there were obstacles in the form of buildings and lamp-posts in the westerly direction. There were trees at the end of the field to the east, but the pilot assessed that these did not pose a problem and that the field was long enough for a take-off in an easterly direction. According to one of the passengers, there was a light tail-wind in the aircraft's intended take-off direction. No precise calculations were made to determine the required take-off distance.

Actions were taken according to the checklist and the aircraft was taxied to the western part of the field. The far end of the field to the west was considered unsuitable for use because the ground was marshy and had a steep slope. The wing flaps were set to 15 degrees for take-off.

The pilot initiated the take-off and set the engine controls to full take-off power. According to statements from the pilot and the passenger in the right front seat, the indicated values for engine rpm and manifold pressure were normal. The acceleration of the aircraft was also perceived as normal. The aircraft passed over the highest point of the field and the lift-off began soon after.

At lift-off, the aircraft rolled to the right and the pilot felt that the aircraft did not climb as expected. The pilot stated that he increased the throttle lever further and adjusted the control for the propeller pitch. He pulled hard on the control yoke, and tried to get the aircraft to climb over the trees at the end of the field.

The aircraft collided with the trees, descended, and came to rest between trees and branches at a height of about two metres above the ground.

No one was injured after the collision. The pilot turned the ignition and electrical power switches to off. As fuel was leaking from the left wing, everyone helped each other to evacuate the aircraft as quickly as possible.

The accident occurred at position 5802N 01249E, 100 metres above mean sea level.

1.1.3 Sequence of events based on video films

SHK has gained access to two video films taken with mobile phones by witnesses on the ground who captured the sequence of events.

The films show the aircraft taxiing towards the position for take-off and car traffic passing on the road directly adjacent to the field. The aircraft is seen to initiate the take-off in an easterly direction. Evidence observed from the wind on trees, branches, grass and flagpoles, indicates that the wind is westerly, i.e. tailwind in the aircraft's take-off direction. At lift-off, the aircraft is seen to roll to the right and an upward deflection can be seen on the right aileron, (see Figure 2).

Figure 1. The aircraft at take-off position. Photo: Private.

Figure 2. Roll to the right in connection with the lift-off. Markings inserted by SHK. Photo: Private.

The aircraft's roll angle to the right and pitch angle upwards gradually increase and it can be observed that the rudder has a deflection to the right. The aeroplane collides with the trees, turns to the left and falls between them (see Figure 3).

Figure 3. The left image shows the aircraft the moment before the collision with the trees. The right image shows the collision with the trees. Photo: Private.

1.2 Injuries to persons

None.

1.3 Damage to aircraft

Substantially damaged.

1.4 Other damage and environmental impacts

Damage to trees and vegetation and leak of approximately 100 litres of aviation fuel.

1.5 Qualifications of the pilot

The pilot held a PPL(A) with an Annex I endorsement[4] and with valid operational authorisation and a valid medical certificate.

Total flying hours: 1,778 hours

Flying hours on the type: 1 600 hours

Flying hours latest 90 days: 17 hours, all on the type

Number of landings previous 90 days: 39

Latest refresher training on the SEP (land)[5] class was conducted on 26 September 2021.

1.6 Aircraft information

The Antonov AN-2 is a single-engine biplane made of metal with canvas-covered wings. It is 12.7 metres long and has a wingspan of 18.2 metres. The engine is a nine-cylinder radial engine developing 980 hp.

The model was designed in Ukraine in the former Soviet Union during the 1940s. SE-KCE was manufactured under licence by PZL/Poliskie Zaklady Lotnicze in Poland. The maximum number of people allowed on board is 12, including one pilot.

[4] Annex I endorsement – privilege to operate SE-registered aircraft according to Annex I.

[5] SEP (land) – Privileges for single-engine piston aeroplanes-land.

Figure 4. The aircraft SE-KCE on the field before the take-off. Photo: Private.

The aircraft is a so-called Annex I aircraft. This means that it is not covered by the regulation in the European Parliament and Council Regulation (EU) No 2018/1139[6] but instead by national regulations. Annex I aircraft include, among other things, historic aircraft constructed before 1955, experimental, home-built and ultralight aircraft.

1.6.1 Airplane

Airplane	
TC-holder	Antonov Company
Model	Antonov AN-2
Serial number	1G18959
Year of manufacturer	1980
Gross mass, kg	Max take-off/landing mass 5,500 Actual 4,312
Centre of gravity	Within limits
Total flying time, hours	5 150
Flying time since latest inspection	19

Engine	
Engine type	Shvetsov ASZ-62 IR
Serial number	K1648843

Propeller	
Propeller type	PZL-MIELEC AW-2 ser 02
Serial number	H038420085

The aircraft had a valid National Permit to Fly. There were no deferred remarks.

[6] REGULATION (EU) 2018/1139 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91.

1.7 Meteorological information

According to SMHI's analysis of general weather conditions in the area the wind was from the west or northwest at 3–7 knots, gusting 16 knots and the visibility was more than 10 kilometres, Cumulus clouds were present with base between 5,000–6,000 feet, temperature/-dewpoint 24/12°C, QNH 1021 hPa.

The topography around the accident site is not considered to have had any direct effect on the wind.

The wind conditions

SMHI has analyzed the video films that captured the sequence of events. Using the video material, it is estimated that the wind at the location and time of the accident had a direction of 270 to 310 degrees with a strength of 4 to 12 knots. An average value of the wind is 290 degrees and 8 knots (15 km/h or 4 m/s). The variation in both direction and strength that occurred according to the video material was probably caused by thermals in the area, which gave a certain influence on the wind.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

There were no flight and voice recorders installed on the aircraft. Such equipment is not required for this type of aircraft.

SHK has read out GPS data from two tablets with navigation applications that were on board.

Recorded data shows the flight track and ground speed. The data shows that the take-off direction was 110 degrees. The highest recorded speed was 106 km/hour and was reached around the position at which the aircraft, according to the films, lifted off. Thereafter, the speed decreased until the position where the collision with the trees occurred, (see Figure 5).

Figure 5. Recorded data from one of the navigation applications with the ground speed. Markings inserted by SHK. Image: Google Earth.

1.12 Accident site and aircraft wreckage

The field was about 400 metres long. In the western part, the ground was marshy and sloped towards a ditch, making part of the field unsuitable for a take-off. The ground consisted of soil and was covered with grass 20–30 cm high. The western part of the field was close to buildings, poles and roads. The southern part was directly adjacent to road 181. In the direction of take-off at the eastern part of the field there was a patch of forest with trees rising to a height of about 20 metres.

The field had a varying slope. The take-off position height was 105 MSL (mean sea level). The highest point along the take-off run was 108 MSL and the height at the end of the field was 101 MSL. The average slope ratio was 0.011 = 0.63 degrees downhill, (see Figure 6).

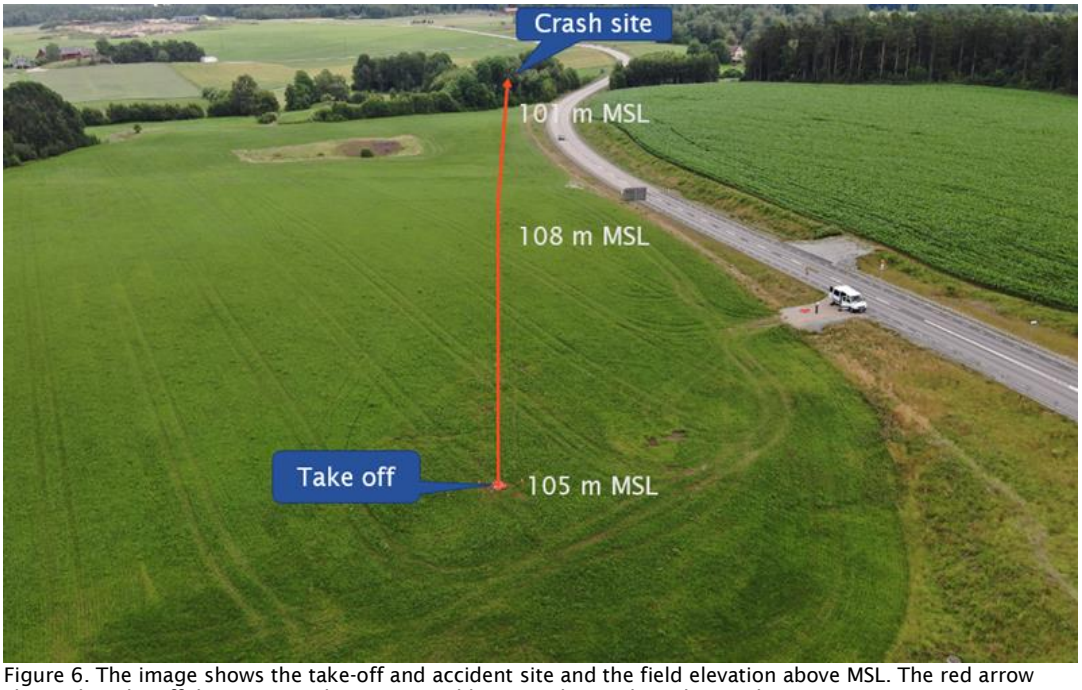


Figure 6. The image shows the take-off and accident site and the field elevation above MSL. The red arrow shows the take-off direction. Markings inserted by SHK. Photo: The Police Authority.

There were clear tracks in the grass from both the main wheels for a distance of 220 metres. After 250 metres there was a short track which was probably from the right main wheel. The total distance from the take-off position to the trees at the end of the field was 360 metres, (see Figure 7).

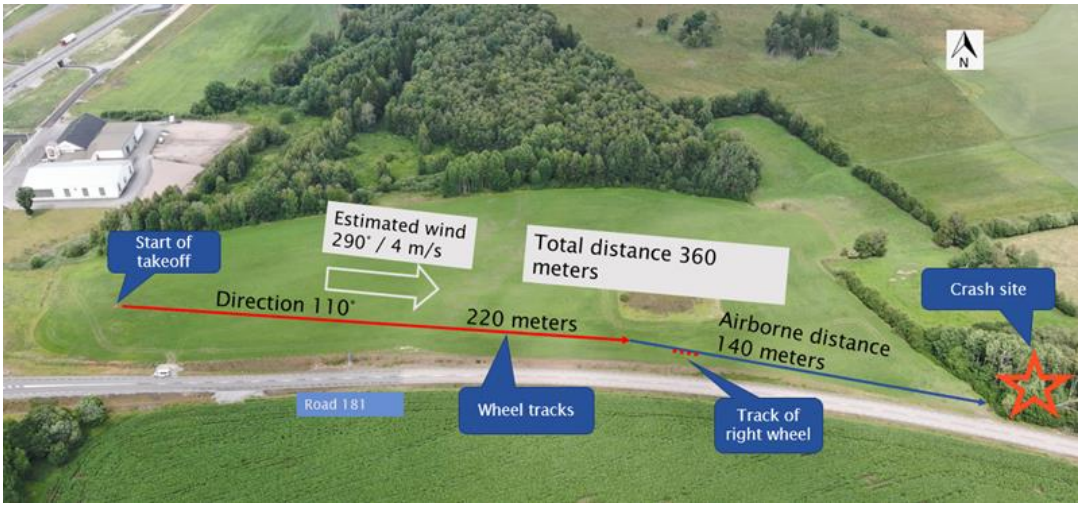


Figure 7. Tracks in the terrain. Markings inserted by SHK. Photo: The Police Authority.

The crash site was in a patch of forest at the eastern end of the field. Large tree trunks were broken off as a result of the collision, (see Figure 8).

Figure 8. The crash site. Markings inserted by SHK. Photo: The Police Authority.

The aircraft sustained substantial damage, mainly to the wings. The cabin received relatively minor damage, (see Figure 9).

Figur 9. The aircraft at the crash site. Photo: Alingsås and Vårgårda rescue services association.

1.13 Medical information

There is nothing to indicate that the mental or physical condition of the pilot was impaired before or during the flight.

1.14 Fire

No fire broke out.

1.15 Rescue operation

An alarm call from a witness was received by SOS Alarm at 15.34 hrs.

Units from Alingsås and Vårgårda rescue service association and ambulances were alerted. The police and JRCC[7] were informed. An ambulance helicopter was alerted but was not deployed.

The exact accident position could not be determined initially, which meant that the rescue services did not find the accident site immediately. The first ambulance arrived at the correct position immediately and was able to guide the rescue service. This led to a delay of a minute or so.

Paramedics examined the pilot and passengers but no one was injured.

To reduce the risk for a fire the rescue services drained the fuel tanks into other containers with the help of the people on board the aircraft. An estimated 100 litres of fuel that had already leaked onto the ground could not be salvaged. Trees were cut down to be able to salvage the aircraft. No other rescue service measures had to be taken and the rescue operation was terminated at 23.30 hrs. An environmental inspector from Vårgårda municipality was on site to assess any continued clean-up work.

[7] JRCC (Joint Rescue Coordination Centre).

The aircraft ELT[8] was not activated during the accident.

1.15.1 Position of crew and passengers and the use of seat belts

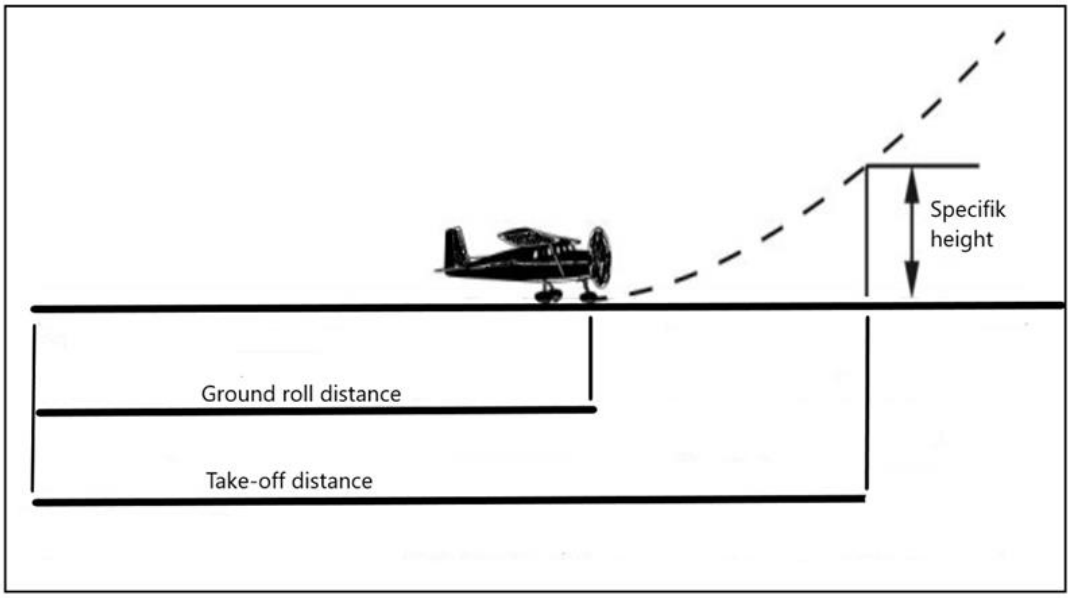
The pilot occupied the left front seat and one passenger occupied the right front seat. The other passengers were seated in the passenger cabin. All were using the installed seat belts and escaped without physical injury.

1.16 Tests and research

1.16.1 Performance calculation of take-off distance

Using the aircraft flight manual (AFM) and material from the Type Certificate Holder, SHK has made a calculation of the required take-off distance.

The total take-off distance of an aircraft consists of the horizontal distance it rolls on the ground before lift-off (ground roll) and the climb distance required to reach an obstacle clearance height or a specific height, usually 50 feet (15 metres), (see Figure 10).



Figur 10. Illustration of ground roll and take-off distances.

The AFM contains graphs for calculating the ground roll distance for a take-off. Factors included in the calculation are atmospheric pressure, air temperature, wind conditions, runway slope, runway condition, take-off mass, flap position and engine power settings.

The AFM further describes i.a. the following applicable performance factors:

- There are two power settings for take-off. One is "Take-Off" with an engine speed of 2,200 rpm and a manifold pressure of 1,050 mm/hg, and the other is "Rated" with engine speed 2,100 rpm and a manifold pressure of 900 mm/hg.
- Flap positions for take-off are flaps up, flaps lowered to 25 degrees or flaps lowered to 30 degrees.
- The lift-off speed is 85–90 km/hrs.

[8] ELT (Emergency Locator Transmitter).

- Rate of climb close to ground is 3 m/s.
- After lift-off, a gradual climb should be performed with a speed increase to 120 km/h.

In the calculations, the current operational conditions and factors at the event have been used. Current wind has been assumed to be the average wind of the estimated wind from the video films, i.e. 290 degrees and 15 km/h. This gives, in relation to the take-off direction, a tailwind component of 15 km/h (4 m/s). There is no calculation conditions in the AFM for flaps lowered to 15 degrees. Interpolation has therefore been made between flaps up and flaps lowered to 30 degrees in the graphs.

The calculations according to the graphs show that the ground roll distance is 225 metres.

With a lift-off speed of 85 km/h and a tailwind of 15 km/h, the ground speed is 100 km/h (28 m/s). To climb to a height of 20 metres with a rate of climb of 3 m/s, an airborne distance of 186 metres is needed.

The total take-off distance (ground roll distance + distance in the air) to reach a height of 20 metres, i.e. the height the aircraft would have had to reach to climb above the trees, is therefore 225 +186 metres = 411 metres.

The calculation is made without any performance-related safety margin. Common practice is to plan and calculate with a safety factor so that all obstacles can be passed with at least a 15 meter margin.

1.16.2 Calculation of engine speed

An audio analysis of the video footage that captured the sequence of events has been carried out in order to calculate the engine speed during the take-off and to identify any malfunctions of the aircraft.

In a spectrogram, the frequency from the propeller has been determined. Calculations, which included the gear ratio between engine and propeller and compensation for the Doppler effect, shows that the engine speed was stable at 2,150 rpm during take-off until the aircraft lifted off. It can also be deduced that the engine speed dropped slightly during the last seconds before the aircraft collided with the trees. This can probably be explained by the fact that the pilot at that stage adjusted the control for the propeller pitch and as a result the rpm was changed. When analysing the films, nothing has been identified that indicates an abnormal function of the engine, propeller or aircraft.

1.16.3 Estimation of angle of attack

The video footage of the event shows that the aircraft had a significant roll and pitch angles at the moment before the collision, (see Figure 3).

The angle of attack of an aeroplane is basically the difference between its pitch angle (attitude) and the vertical flight path angle.

From the investigation material it can be concluded that the angle of attack of the aircraft just before the collision with the trees was high. This meant that the induced drag was high and that maximum engine power was probably no longer sufficient to maintain a climb.

1.17 Organisational and management information

Not applicable.

1.18 Additional information

Not applicable.

1.19 Special methods of investigations

Not applicable.

2. Analysis

There is no indication that any technical failure or abnormal functioning of the aircraft contributed to the accident. The audio analysis of the video footage that captured the event shows that the engine speed was 2,150 rpm during the take-off sequence. According to the AFM, normal rpm for take-off is 2,100–2,200 rpm depending on the selected power setting.

According to SMHI's observations and forecast material, the wind at the time of the accident was west or northwest 3-7 knots with gusts of 16 knots. The pilot perceived the wind to be light and variable prior to takeoff. The video footage that captured the aircraft during taxiing and takeoff shows that the wind was light to moderate and that there was a tailwind in the direction of the aircraft's takeoff. It is possible that the wind changed direction and strength after boarding the aircraft and it may have been difficult for the pilot to assess the wind from inside the aircraft after engine start and during taxiing.

Read-out GPS data shows that the aircraft's maximum ground speed was 106 km/hour. As the tailwind was estimated to be 15 km/h, this meant that the maximum airspeed was around 90 km/h, which corresponds to a normal lift-off speed according to the AFM. Thereafter the speed decreased until the collision. The AFM describes that the initial climb should be done while increasing speed.

At lift-off the pilot experienced that the aircraft did not climb as expected. It cannot be excluded that that thermals in the area affected the wind and further increased the tailwind component and thereby reduced the airspeed.

The aircraft's roll angle to the right gradually increased after lift-off and the pilot has stated that he pulled hard on the control just before the collision. It is likely that the pilot perceived that the trees became a threatening obstacle and that he therefore tried to steer the aeroplane to the right away from the trees while pulling the control stick strongly backwards. In the final phase, however, the aircraft's airspeed had become low with a high angle of attack, which probably led to that the flight control effectiveness was not sufficient to manoeuvre the aircraft away from the trees.

The field had, in the chosen take-off direction, an available take-off distance of 360 metres. At the end of the field there were obstacles in the form of 20 metres high trees. SHK's performance calculations show that the required take-off distance to reach a height of 20 metres in the prevailing conditions was over 410 metres. The required distance thus exceeded the available take-off distance. Therefore, a safe take-off was not possible in the chosen take-off direction.

The pilot estimated that the field length was sufficient for a take-off. No performance calculation of the required take-off distance from the AFM with the prevailing conditions had been made. However, relying on an estimation is not reliable without performing calculations due to the varying operational conditions, such as wind, runway conditions, obstacles, etc., that strongly affects the required distance for a take-off.

The accident highlights the importance of making performance calculations before each flight. Such calculations should consider the operational conditions and factors affecting the performance.

The rescue operation was limited in scope and was carried out without major delays. SHK has had therefore no reason to further analyse the rescue operation.

3. Causes/Contributing factors

The accident was caused due to the fact that a robust method for performance calculation of the required take-off distance was not applied. This in term led to the commencement of the flight in spite of the lack of conditions for a safe start in the chosen direction.

4. Safety recommendations

None.

On behalf of the Swedish Accident Investigation Authority,

Jenny Ferm Ola Olsson