Statens haverikommission
Swedish Accident Investigation Authority

Final report RL 2021:10e

Accident at Skövde Airport, Västra Götaland County, on 19 December 2020 involving the aeroplane SE-MDN of the model Cessna 172N, operated by Skövde Aeroclub.

File no. L-97/20

15 December 2021

SHK investigates accidents and incidents from a safety perspective. Its investigations are aimed at preventing a similar event from occurring in the future, or limiting the effects of such an event. The investigations do not deal with issues of guilt, blame or liability for damages.

The report is also available on SHK´s web site: www.havkom.se

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This document is a translation of the original Swedish report. In case of discrepancies between this translation and the Swedish original text, the Swedish text shall prevail in the interpretation of the report.

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Content

General observations

The Swedish Accident Investigation Authority (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended to clarify, as far as possible, the sequence of events and their causes, as well as damages and other consequences. The results of an investigation shall provide the basis for decisions aiming at preventing a similar event from occurring in the future, or limiting the effects of such an event. The investigation shall also provide a basis for assessment of the performance of rescue services and, when appropriate, for improvements to these rescue services.

SHK accident investigations thus aim at answering three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any supervisory role and its investigations do not deal with issues of guilt, blame or liability for damages. Therefore, accidents and incidents are neither investigated nor described in the report from any such perspective. These issues are, when appropriate, dealt with by judicial authorities or e.g. by insurance companies.

The task of SHK also does not include investigating how persons affected by an accident or incident have been cared for by hospital services, once an emergency operation has been concluded. Measures in support of such individuals by the social services, for example in the form of post crisis management, also are not the subject of the investigation.

Investigations of aviation incidents are governed mainly by Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and by the Accident Investigation Act (1990:712). The investigation is carried out in accordance with Annex 13 of the Chicago Convention.

The investigation

SHK was informed on 19 December 2020 that an accident involving one aircraft with the registration SE-MDN had occurred at Skövde Airport, Västra Götaland County, the same day at 10:56.

The accident has been investigated by SHK represented by Mr Jonas Bäckstrand, Chairperson until 7 April 2021, subsequently Ms Kristina Börjevik Kovaniemi, Mr Mats Trense, Investigator in Charge, Mr Johan Nikolaou, Operations Investigator, Mr Ola Olsson, Technical Investigator (aviation) and Mr Alexander Hurtig, Investigator Behavioural Science.

Mr Matthew Hilscher has participated as an adviser on behalf of European Union Aviation Safety Agency (EASA).

Mr Magnus Axelsson and Mr Mahmoud Mostafa has participated as advisers on behalf of the Swedish Transport Agency.

The following organisations have been notified: EASA, the European Commission, National Transportation Safety Board (NTSB) and the Swedish Transport Agency.

Investigation material

- Interviews have been conducted with the instructor, the student, a witness and the AFIS[1]-officer.
- Sensor data from Flightradar24[2] and an application in the Head of Training's smartphone.
- The aircraft and the accident site have been examined and documented.
- The radio transmissions from the aircraft has been obtained from ATS Skövde.
- Reference flights with an aircraft of the same type has been performed.
- The flight school's training materials have been reviewed.
- Training materials from the instructor's flight instructor training have been reviewed.
- Pictures from the Police Authority, the Head of Training and the AFIS-officer have been obtained.
- Information from meetings with EASA and the Swedish Transport Agency.

A meeting with the interested parties was held on 20 May 2021. At the meeting SHK presented the facts discovered during the investigation, available at the time.

[1] AFIS (Aerodrome Flight Information Service).
[2] Flightradar24 (website that uses the aircraft's transponder information to determine the aircraft's position, altitude, speed etc.)

Final report RL 2021:10e

Aircraft:	
Registration, type	SE-MDN, Cessna 172 Series
Model	172N
Class, Airworthiness	Normal, Certificate of Airworthiness and Valid Airworthiness Review Certificate (ARC)[3]
Operator	Skövde Aeroclub
Time of occurrence	19 December 2020, 10:56 hrs in daylight Note: All times are given in Swedish standard time (UTC[4] + 1 hour)
Place	Skövde Airport, Västra Götaland County, (position 58°27N 013°58E, 99 metres (feet) above mean sea level)
Type of flight	Schooling
Weather	According to SMHI's analysis: wind south 5 to 8 knots, visibility; > 10 km, no significant clouds, temperature/dewpoint; +06/+04°C, QNH[5] 1014 hPa
Persons on board:	3
crew members including cabin crew	3
passengers	0
Injuries to persons	None
Damage to aircraft	Substantially damaged
Other damage	None
Instructor:	
Age, licence	65 years, PPL[6]
Total flying hours	802 hours, of which 400 hours on type
Flying hours previous 90 days	23 hours, of which 23 hours on type
Number of landings previous 90 days	87
Student:	
Age, licence	31 years, during training for LAPL[7]
Total flying hours	11, of which all hours on type
Flying hours previous 90 days	6
Number of landings previous 90 days	17

[3] ARC (Airworthiness Review Certificate).
[4] UTC (Coordinated Universal Time).
[5] QNH (Question Nil Height) – Barometric pressure reduced to mean sea level.
[6] PPL (Private Pilot License).
[7] LAPL (Light Aircraft Pilot Licence).

SUMMARY

An accident with a smaller aircraft occurred on 19 December 2020. The accident occurred during a school flight carried out by Skövde Aeroclub. Three people were involved in the accident, a student, a flight instructor and the Head of Training. During the flight, the student would be approved for solo flight.

As part of the training, a so-called touch and go would be performed. When the student tried to take off from the runway, the plane did not lift off. The student pointed out that something was wrong and the instructor took control of the aircraft and aborted the take-off at high speed. The remaining runway length was not sufficient for the aircraft to stop. The aircraft continued on the runway extension and ended up on its back 175 metres after the runway end. All three were able to get out of the plane themselves.

After the accident, it has been established that the aircraft's trim position deviated from the normal position for take-off. At the abortion of the take-off, the speed significantly exceeded the rotational speed specified in the flight manual.

According to the flight school's procedure for take-off, the student should allow the aircraft to lift off by itself when the aircraft had the correct speed. The airspeed indicators were not used as a reference.

The cause of the accident was that the flight school's procedures for take-off were not appropriate. This resulted in that the speed became considerably higher than the rotational speed without being noticed. When the instructor aborted the take-off, the speed was so high that it was not possible to stop the aircraft on the remaining runway length.

Contributing causes of the accident was that the instructor had an incorrect picture of the course of events and took over the controls in a late stage of the take-off. The long runway and the aircraft's flight characteristics gave the pilots a false assurance that the margins were large. Furthermore, the flight school's training material did not describe the impact of the speed and required braking distance in relation to the decision point designated at take-off.

The training was performed by a training organization (DTO). The Safety Management System in this type of organization lacks the structure to proactively identify risks. EASA is responsible for the regulations. EASA does not describe in guidance material how training should be performed for a DTO. This has been identified as a deficiency at a system level.

Safety recommendations

The EASA is recommended to:

- Evaluate the benefit of a review of the exercises contained in the training programmes that may pose a safety risk and to decide on the best course of action to make the training organisations aware of these risks, either through dedicated safety promotion, development of best practises or developing guidance material to the existing requirements. *(RL 2021:10 R1)*

1. FACTUAL INFORMATION

1.1 Description of the course of events

1.1.1 Prerequisites

The accident occurred during a school flight. The flight was part of the student's training for a LAPL. The goal of the flight was to approve the student for solo flight. The student would also practice flying the aircraft at its maximum mass.

The instructor had a limitation in his flight instructor license and could therefore not approve the student for his first solo flight. Thus, the Head of Training sat in the back seat of the aircraft as a supervisor for the instructor.

The weather conditions were good with light southerly winds that were in the direction of runway 19.

1.1.2 Course of events

The flight started with a take-off from runway 19 at Skövde Airport at 10:28. During the take-off, the instructor experienced that the aircraft accelerated slower than normal. Airwork were conducted at an altitude of 4 000 feet northwest of the airport. The student flew the plane back to the airport for landing. He joined the traffic pattern via the right downwind to runway 19. Abeam the touchdown point landing preparations where performed, which among other things included that a 10-degree of flap was selected and that the engine carburettor heating was switched on. At the base-leg, 20-degrees of flap was selected and on final approach full flap (30 degrees) was selected, after which the engine carburettor heat was switched off. The instructor reacted on that the student trimmed a lot with the elevator trim on the base-leg, but did not comment it. The student experienced that just before landing, the aircraft felt unstable and stopped trimming. After touchdown, the instructor asked the student to perform a "touch and go". The instructor retracted the flaps and the student gave full power.

The plane accelerated, but when the student pulled the steering wheel backwards to lift off, the plane did not take off from the runway. The student, who thought the speed was too low, released the back pressure of the steering wheel and let the aircraft accelerate further. At the next attempt to rotate, the student sensed that it was heavy when he pulled the steering wheel backwards. He therefore used more force, but the plane still did not lift off. The plane felt unstable, slided a little sideways and bounced on the runway. The student called out that something was wrong.

The instructor experienced that the aircraft's acceleration was slower than usual at the take-off. However, he did not interact with the student during the take-off process. When the student pointed out that something was wrong, the instructor took control of the aircraft. In the direction of departure, the instructor had the perception that there were obstacles in the flight path. He therefore closed the throttle, aborted the take-off and applied the brakes.

At the runway end, the aircraft continued out onto the roll-out area and further out into the runway extension. The landing gear sank into the soft ground. The aircraft tipped forward and ended up on its back 175 metres after the runway end. All three onboard were able to get out of the plane by themselves.

Up to the aborted take-off the Head of Training did not interact with the student or with the instructor. When the instructor pulled the power off, the Head of Training asked what was going on. The instructor then replied that they had no engine power.

During the take-off phase, none onboard noted the speed on the airspeed indicators. Instead, the speed was judged by external visual impressions.

The accident occurred at position 58°27N 013°58E, 99 metres above sea level.

1.1.3 Other

A pilot who was at the aeroclub observed that the aircraft passed abeam the aeroclub at high speed with a remaining runway length of about 500 metres. He then saw the aircraft pass the runway end and turn over on its back. The pilot went to the accident site by car to help.

1.2 Injuries to persons

	Crew members	Passengers	Total on-board	Others
Fatal	-	-	0	-
Serious	-	-	0	-
Minor	-	-	0	Not applicable
None	3	-	3	Not applicable
Total	3	0	3	-

The student and the Head of Training experienced stomach and back pain and was taken by ambulance to hospital for examination.

1.3 Damage to aircraft

Substantially damaged.

1.4 Other damage

1.4.1 Environmental impact

A limited amount of aviation fuel leaked. The airport staff sanitized it with Absol.

1.5 Personnel information

1.5.1 Qualifications and duty time of the pilots

The Instructor

The instructor, was 65 years old and had a PPL license with a valid SEP(land) class rating, FI(A)R and a medical certificate.

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types	1	1	23	802
Actual type	1	1	23	400
Instructor (FI)	1	1	20	68

Number of landings actual type previous 90 days: 87.
Skill test for PPL was conducted on the type on 21 April 2011.
Skill test for FI was conducted on the type on the 19 December 2019.
Latest PC[8] (proficiency check) conducted on 19 April 2019 on type.

The Student

The student, was 31 years old and was under training to LAPL with a valid medical certificate.

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types	1	1	6	11
Actual type	1	1	6	11

Number of landings actual type previous 90 days: 17.

1.5.2 Other personnel

The Head of Training

The Head of Training, was 59 years old and had a ATPL. He was also chairman of Skövde Aeroclub.

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types	1	1	10	12 300
Actual type	1	1	10	>1 500

Number of landings actual type previous 90 days: 26.
Class rating on type was conducted 11 December 1986.
Latest PC (proficiency check) conducted on 25 May 2020 on type.

[8] PC (Proficiency Check).

1.6 Aircraft information

The Cessna 172N aircraft is a four-seater, high-wing single-engine piston aircraft. It is just over 8 metres long and has a wing span of 11 metres.

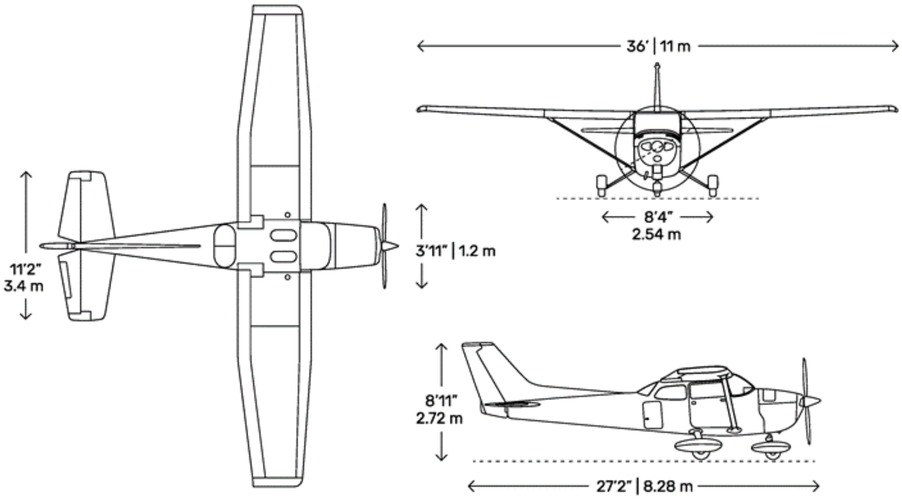

Figure 1. Three-dimensional image of the aircraft model.

1.6.1 Airplane

TC-holder	Textron Aviation Inc
Model	172N
Serial number	17273913
Year of manufacture	1980
Gross mass, kg	Max take-off 1 157 current 1 065
Centre of gravity	Within limits. (see Figure 2)
Total flying time, hours	7010
Flying time since latest inspection	0
Type of fuel uplifted before the occurrence	100LL
Engine	
TC-holder	Lycoming Engines
Type	O-360-A4M
Serial number	L-26617-36A
Total operating time, hours	1 051
Operating time since last oversight, hours	0
Propeller	
TC-holder	Sensenich Propeller Manufacturing Company, Inc.
Type	76EM8S14-0-60
Serial number	103493K
Total operating time, hours	1 051
Operating time since inspection, hours	0
Deferred remarks	None

The aircraft had a Certificate of Airworthiness, a valid ARC and had undergone a periodic inspection before the accident.

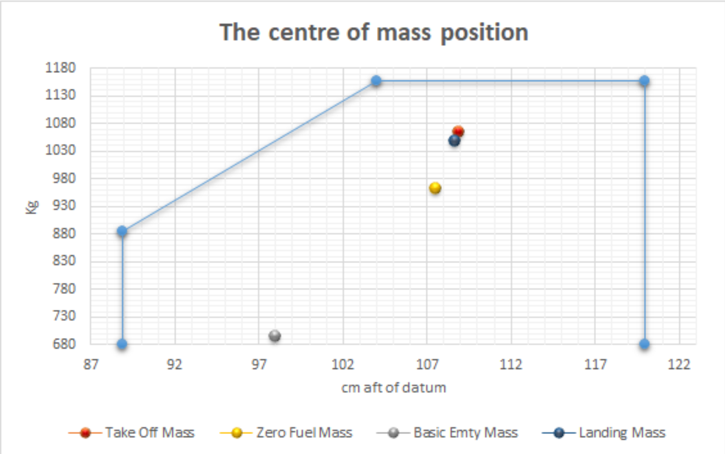

Figure 2. The centre of mass position for the flight.

1.6.2 Description of parts or systems related to the occurrence

Modifications

The aircraft was modified (STC[9]:s) with a stronger engine of 180 horse-power and an increased take-off mass of 1 157 kg. As a result of the modification the flaps were limited to max 30 degrees.

In addition to the conventional flight instruments, an electronic primary flight display of the model Aspen Avionics Evolution 1 000 was installed. This instrument displays speed information both digitally and through a vertical presentation through a so-called “Speed Tape”.

Figure 3. Instrumentation in SE-MDN with Aspen Avionics EFD 1000 as a complement to the primary flight instruments.

Elevator system

The airplane’s flight control system consists of conventional elevator control surfaces. The control surfaces are manually operated through mechanical linkage using a control wheels for the elevator.

Elevator trim system

The system consists of a trim rudder mounted at the trailering edge of the right stabilator. Elevator trimming is accomplished through the elevator trim tab by utilizing the trim control wheel. A mechanical indicator next to the trim wheel shows the position of the trim rudder.

The purpose of the rudder trim system is to eliminate the force on the steering wheel in different flight conditions.

[9] STC (Supplement Type Certificate).

In order for the aircraft to maintain a certain pitch attitude, a certain elevator angle is required. The angle depends on configuration and airspeed. The aerodynamic force on the rudder will cause a torque that is transmitted through the system as a force to the pilot's steering wheel. To reduce or eliminate this force, there is a trim rudder at the rear of the rudder that provides a counteracting moment on the rudder. The much smaller rudder can counteract the aerodynamic force on the rudder due to the fact that the rudder trim has a longer lever to the rudder hinge shaft.

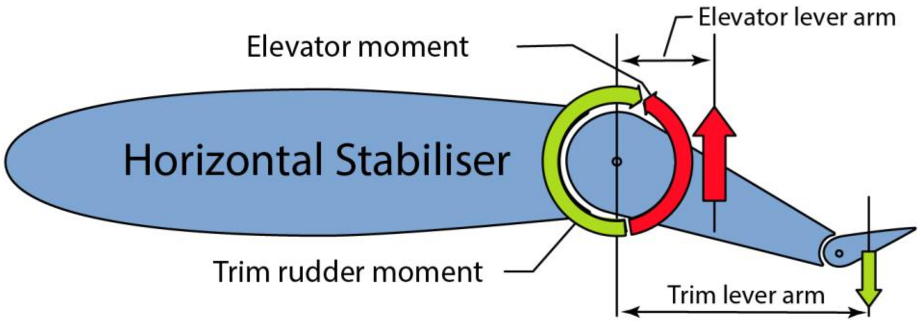

Figure 4. The trim moment arm gives authority over the rudder until equilibrium is reached.

The aerodynamic force increases with the square of the velocity of the air flow. This means that at a given angle on the trim rudder, the force of the trim rudder will increase significantly with increased airspeed.

Wing Flap System

The wing flaps are of the single-slot type, and are mounted on the wings inner trailering edge. In addition to a normally fully retracted position, the flaps have three fixed extended positions, 10, 20 and 30 degrees. For landing, 30 degrees is normally used.

The function of the wing flaps is mainly to increase the lift coefficient of the wings in the extended position, which leads to a decrease in stall speed.

The wing flaps are electrically operated with a lever in a slotted panel on the instrument panel.

On the Cessna 172, the combined aerodynamic forces provide a pitch up moment when the wing flaps are extended, and a nose-down moment when the wing flaps are retracted.

Braking system

The aircraft model is equipped with hydraulic disc brakes on the main wheels which are operated by brake pedals. The system has no function that prevents the wheels from locking.

Certification specification for the construction of normal aircraft

The aircraft was certified according to Civil Aviation Regulations (CAR) del 3 (valid 1 November 1949). The later models of the Cessna 172 with the same control system as the accident aircraft are certified according to CS-23[10]. According to CS-23, an aircraft must be controllable in all phases of flight. The pitch forces to control the airplane shall not temporarily exceed 222 newtons with one hand on the steering wheel and 334 newtons with two hands on the steering wheel.

1.6.3 Periodic supervision

The flight was the first after the most recent periodic inspection. During the inspection, a compression test of the cylinders was performed (leakage test) and a check of the static engine rpm.

The leak test, with an inlet pressure of 80 psi, showed that cylinders one to three had a reference pressure of 76 psi and cylinder four had 78 psi. According to the engine manufacturer's data, the reference pressure for all cylinders should be above 70 psi and should be equivalent within a tolerance of five psi. The leak test was within tolerances.

The maximum static rpm showed an engine speed of 2,290 rpm. Approved range is 2,250 to 2,450 rpm.

1.7 Meteorological information

According to SMHI's analysis: Wind south 5 to 8 knots, visibility >10 kilometres, no significant clouds, temperature/dewpoint +06/+04°C, QNH 1014 hPa. The analysis corresponds with the stated AUTO METAR[11] for the airport at the time of the accident.

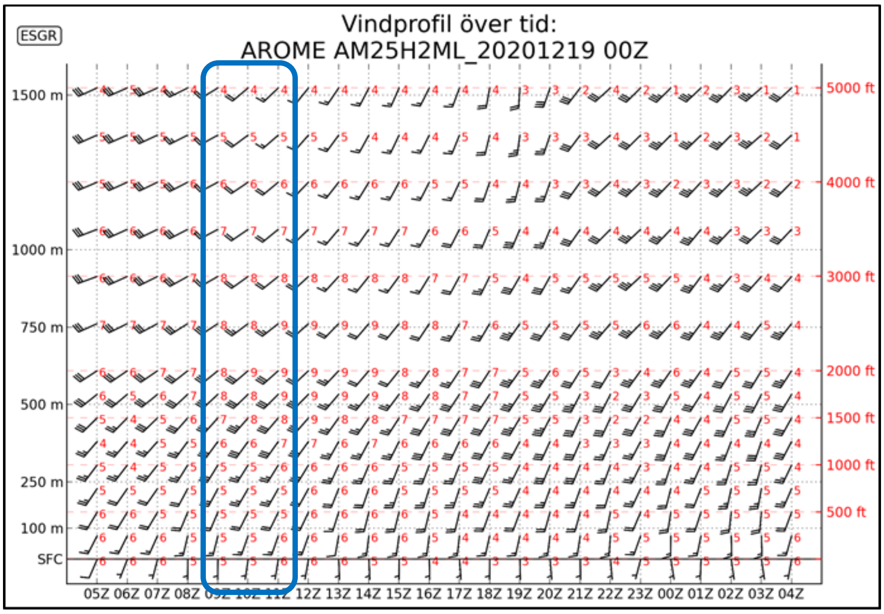

Figure 5. Forecasted wind profile ESGR with marking for current time interval. Source: SMHI.

[10] CS-23 (EASA Certification Specification for Normal Category Aeroplanes).
[11] METAR (Meteorological Terminal Air Report).

The headwind component for runway 19 was between 5 and 8 knots at the time of the accident.

The accident happened in daylight.

1.8 Aids to navigation

None.

1.9 Communications

The Flight Information Service (AFIS) was not on duty. Radio broadcasts from the aircraft have been obtained from ATS Skövde and analysed. No emergency message has been registered.

1.10 Aerodrome information

Skövde Airport is an approved instrument airport according to AIP[12] Sweden. The airport has two runways with runway designations 01/19. At the time, runway 19 was used. The runway is pawed, 1 736 metres long, 30 metres wide and has an average upslope of 0.5 %.

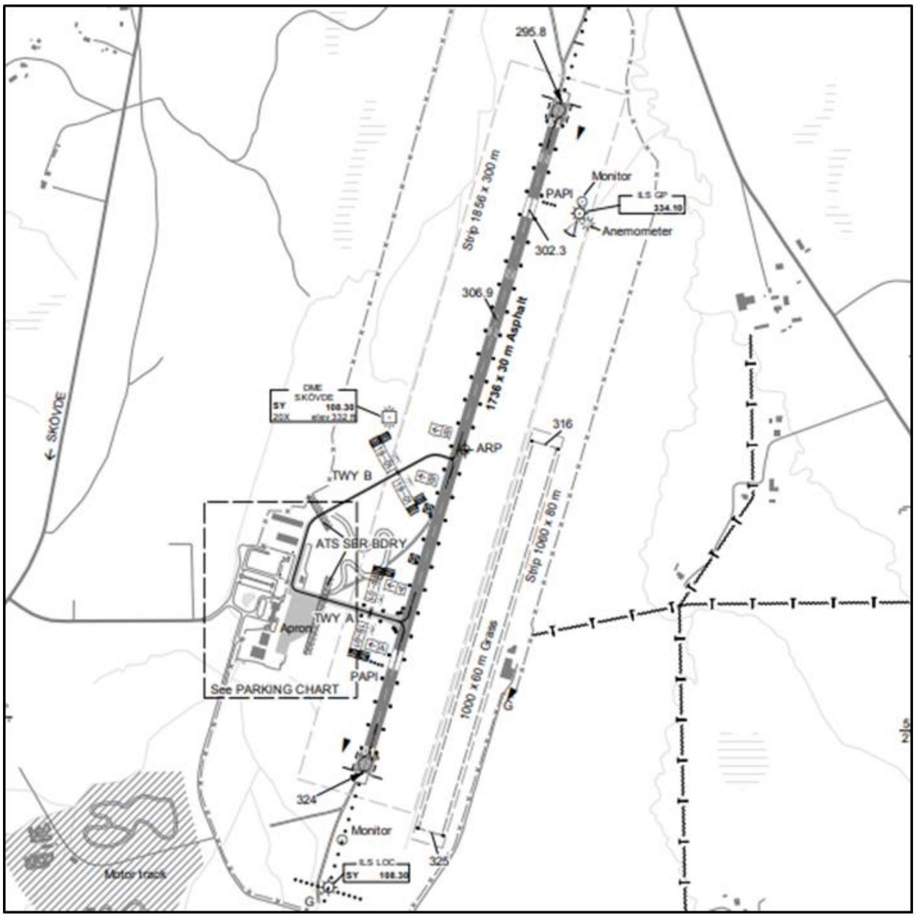

Figure 6. Skövde Airport with blue marking for runway in use. Photo: AIP Sweden.

[12] AIP (Aeronautical Information Publication).

1.11 Flight recorders

No flight or voice recorders were installed in the aircraft. Such equipment is not required for this type of aircraft.

Other registrations have been obtained and are presented in the following sections.

1.11.1 Registrations from Flightradar24

The flight was registered using MLAT (Multilateration) data that Flightradar24 collected, calculated and presented on its website. SHK has obtained data from Flightradar24 and illustrates the landing and the aborted take-off in Figure 7.

Figure 7. The aborted take-off. Each point represents the average speed (ground speed) calculated from the previous point. Image: Google Earth with markings inserted by SHK.

MLAT

MLAT means that four or more ground stations receive a signal from the aircraft's mode S-transponder. Flightradar24 calculates the aircraft's position and speed by comparing the difference in time it takes the signal to travel between the aircraft and the ground stations. The time stamp of the data comes from Flightradar24's server where the calculation is performed.

According to Flightradar24, tests have shown the general accuracy of the position within 10 to 100 metres.

Both individuals and professional organizations can have a ground station. Today there are many ground stations in Sweden. This means that the aircraft's position can be registered even where radar is not available or the aircraft lacks ADS-B[13] functionality.

1.11.2 GPS-data

The Head of Training had a smartphone with built-in GPS that registered and recorded the flight with the Garmin Pilot application. The recordings were recorded at a frequency of half a hertz (once every two seconds). The recording started when the aircraft took off for the first time from runway 19 at 10.28.23 and stopped automatically at 11.55.18. When the recording ended, the aircraft had 587 metres left of runway 19.

[13] ADS-B (Automatic Dependent Surveillance-Broadcast).

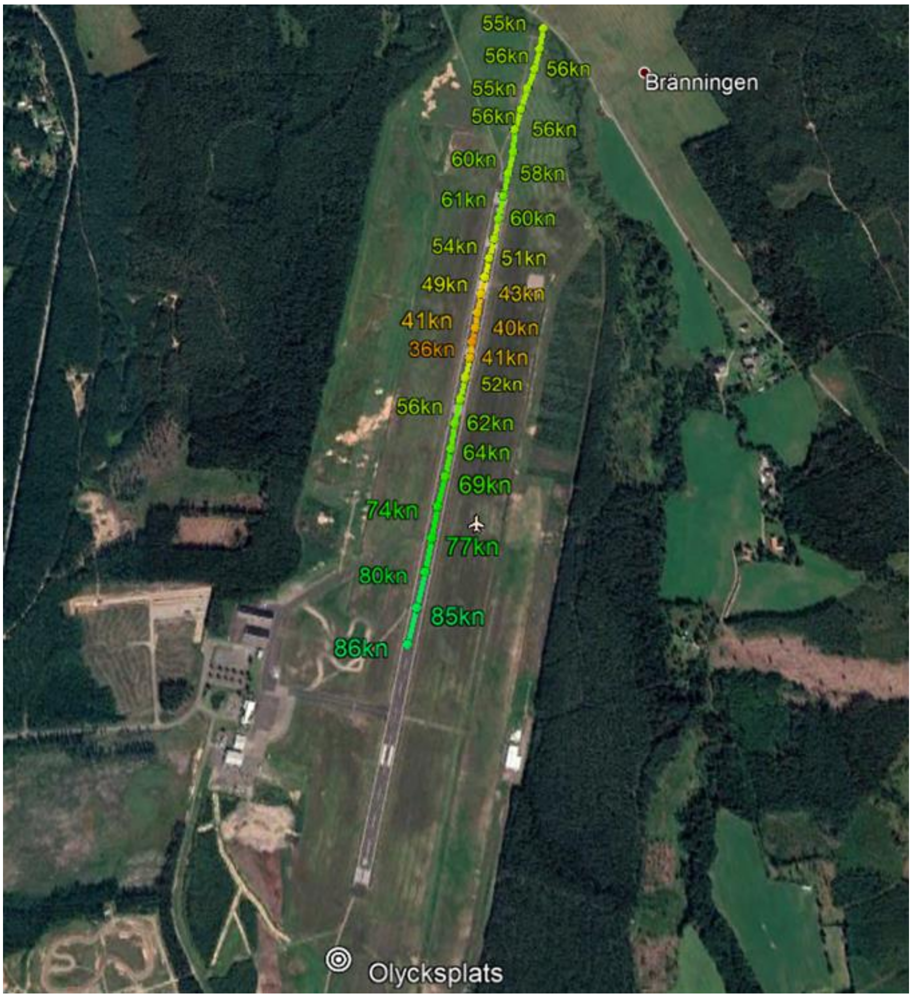

Figure 8. The landing followed by the aborted take-off. Each point represents the ground speed at each reading. Markings inserted by SHK. Image: Google Earth.

Figure 9 illustrates the change in speed over time for the take-off at 10.28 and the aborted take-off at 11.55. The curves are adjusted to achieve common speed at the point where power was applied for respective take-off. The travel speed represents the speed above the ground at each reading.

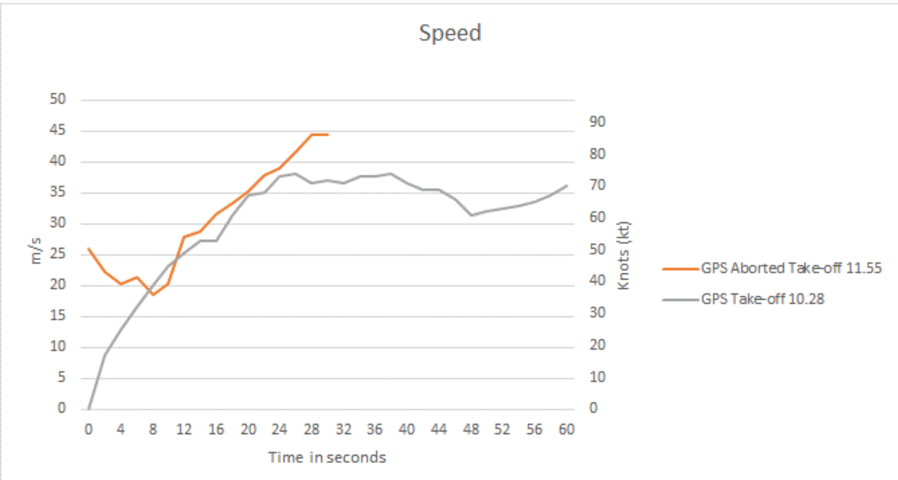

Figure 9. GPS data. The speed represents the speed above the ground at each reading. The gray line shows the first take-off. The orange line shows the aborted take-off.

1.12 Accident site and aircraft wreckage

1.12.1 Accident site

The aircraft's final position was 175 metres from the runway end. At the time of the accident, the runway was damp.

Figure 10. The aircraft at the accident site in relation to the runway. Photo: Swedish Police.

Tracks could be seen after the runway (see Figure 11).

Figure 11. The image from the runway end with clear tracks. Accident area circled. Text has been inserted by SHK. Photo: Swedish Police.

Just before the aircraft's final resting position, deep tracks could be seen in the ground from the left main landing gear. Figure 12 is taken the day after the accident directly over the accident site in the direction of the runway.

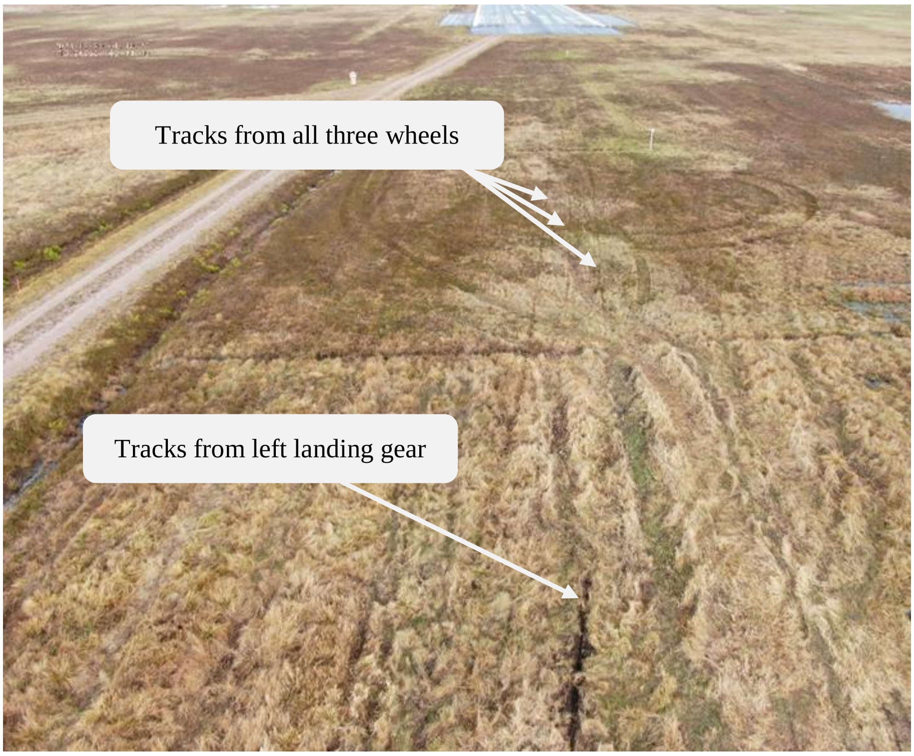

Figure 12. Tracks in the grass after the plane.

1.12.2 Aircraft wreckage

The aircraft had significant structural damage, mainly to the wings, where the left wing strut was broken. Damage was also found to the fuselage, fin, nose landing gear and propeller.

The position of the elevator trim and the indicator for trim position in the cockpit show that the aircraft's elevator trim was trimmed for nose down at the time of the accident (see Figures 13 and 14). The wing flaps were in the retracted position.

Figure 13. The position of the rudder trim at the accident site. The elevator trim marked by SHK. Photo: Swedish Police.

Figure 14. The position of the trim indicator after the accident. Photo: Tord Södergård.

The aircraft was salvaged and the SHK later carried out a technical investigation. See further in section 1.16.1.

Figure 15. The aircraft at the accident site. Picture Marcus Larsson.

1.13 Medical and pathological information

Nothing has emerged that indicates that the pilots' mental or physical condition was impaired before or during the flight.

1.14 Fire

Fire did not occur.

1.15 Survival aspects

1.15.1 Rescue operation

The AFIS official was not present in the tower. He received information about the accident from the Head of Training. The AFIS official reported the accident to the JRCC, who informed the rescue service. The rescue service ended at 12.50.

All onboard got out of the plane through the right door.

The ELT[14] manufactured by Kannad 406 AF Compact. was not activated during the accident.

[14] ELT (Emergency Locator Transmitter).

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

The student sat in the left pilot seat and the instructor in the right. Both used three-point belts. The Head of Training who was sitting in the left back seat was wearing a waist belt.

None of those on board sustained any serious injuries.

1.16 Tests and research

1.16.1 Technical inspection of the airplane

A visual inspection was carried out of the engine, engine controls, propeller, carburettor, intake system, ignition system and exhaust system. The inspection showed no deficiencies or remarks.

The propeller had minor damage. This indicates that the engine delivered low power when the aircraft tipped over on its back.

Brake discs and pads were without remarks. The left brake did not have any braking function. There were traces of leakage of fluid in the cockpit area of the brake fluid reservoir.

The left main wheel showed damage from aquaplaning of the type “Reverted Rubber Hydroplaning” (see Figure 16).

Figure 16. Damage to the left tire of a so-called “Reverted Rubber Hydroplaning”.

This type of aquaplaning can occur when a wheel is locked during hard braking and a thin film of water is present on the runway. The friction heat causes the water in the contact surface between the tire and the ground to evaporate. The water vapor prevents direct contact between the tire and the ground and the braking effect becomes insignificant.

The increase in temperature has damaged the rubber in the tire (see Figure 16).

Inspection and functional control of the aircraft's control system did not show any significant deficiencies.

Measurement of the rudder's movement showed a deflection of 30 degrees upwards and 24 degrees downwards, respectively. According to the manufacturer, the rudder's movement should be in the range of 28 to 29 degrees upwards and 23 to 24 degrees downwards.

Measurement of the movement of the trim rudder showed a deflection of 30 degrees upwards and 15 degrees downwards, respectively. According to the manufacturer, the movement of the trim rudder should be in the range 28 to 29 degrees upwards and 13 to 14 degrees downwards.

During interviews with the pilots, information has emerged that the trim indication is normally set to the letter "E" at the "Take-Off" marking. Measurement of this position shows a deflection of nine degrees upwards. Measurement of the position of the trim rudder similar to indication after the accident shows a deflection of 20 degrees upwards (see Figure 17).

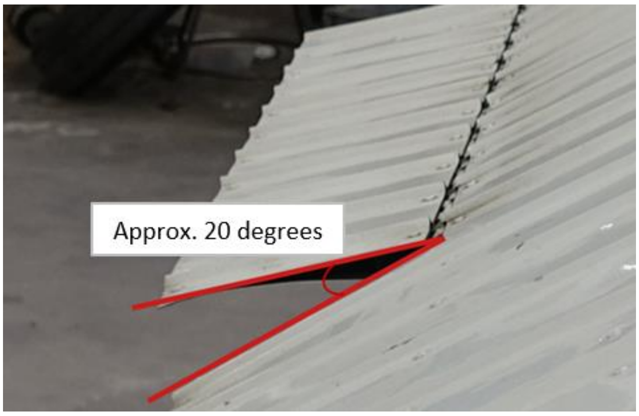

Figure 17. Trim rudder position after the accident.

To move the trim rudder from full position down to full position up, the trim wheel had to be rotated five revolutions. This implies a change of nine degrees per revolution. To rotate an entire revolution on the trim wheel, six turns (rotations) are required.

An airspeed indicator test was performed without remarks. It could be noted that the speed indication on the Aspen instrument had some lag compared to the analogue indicator. The same lag was observed during the reference flight.

1.16.2 Engine inspection

After the accident, a maintenance organization carried out a complete overhaul of the engine. No deficiencies of significance to the investigation were discovered.

1.16.3 Examination of the fuel

The aircraft was refuelled with 100LL. The fuel from the aircraft has been analysed. The results of the analysis showed good purity, low water content and that measured values were within the required limits according to the specification for the current aviation fuel.

1.16.4 Reference flight

SHK has carried out two reference flights with aircraft of the same type as in the accident.

The purpose of the reference flights was to understand the flight characteristics of the type, to understand the situation in which the crew were in and to produce relevant flight data for the investigation under as similar conditions as possible with the accident.

During the reference flights, the following manoeuvres were performed.

Repeated take-offs and landings (touch and go:s) were performed both with and without passengers in the rear seat. Prior to landing with fully extended flaps, the stick forces were manageable when the aircraft was trimmed to the same position as the accident flight. When landing, the touch down was sometimes harder than normal because you had to withstand the stick forces. Before take-off, flaps were retracted without changing the trim position. Significant stick forces were required to rotate at 55 knots which is the recommended rotational speed according to the flight manual.

During cruise, the aircraft was trimmed to the same position as SHK found the aircraft after the accident. The stick forces were measured at speeds from 50 to 90 knots at ten knots intervals. At an indicated airspeed of 90 knots, the force in the steering wheel corresponded to 170 newtons with a decreased force at lower speeds to maintain altitude.

An aborted take-off was performed. After reducing engine power, the aircraft was unstable. Full focus on course management was necessary. Care was required to ensure that the brakes were not locked. A considerable distance was required.

1.16.5 Merged data

SHK has compiled information from Flightradar24, GPS data and the reference flight in a common image.

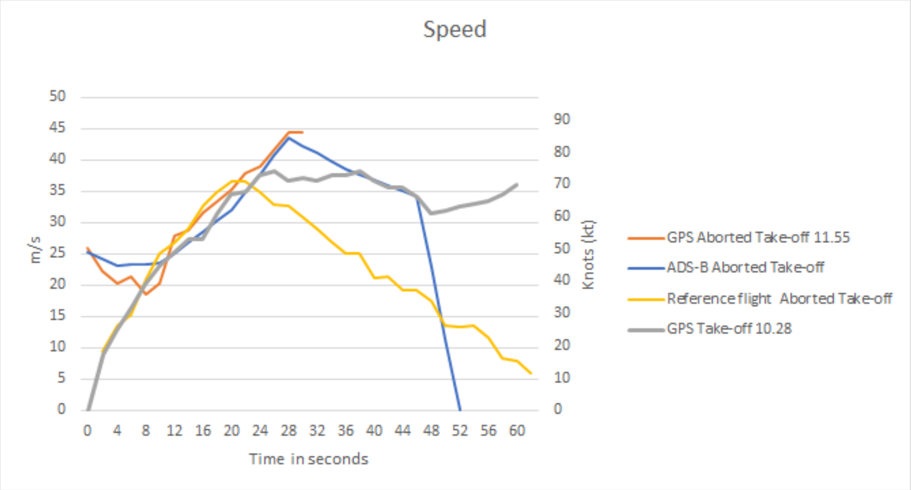

Figure 18. Merged data from Flightradar24, GPS data and the reference flight (GPS). Each point represents the average speed (ground speed) calculated from the previous point for data from Flightradar24. For GPS data and reference flight data, each point represents the ground speed at each reading.

1.17 Organisational and management information

1.17.1 Generally

The flight school was a DTO[15] with number SE-DTO-0028. The flight school was established in Skövde in 2019. Skövde was the flight school's principal place of business. Training was also conducted at Falköping Airport (Falbygdens Aeroclub) and at Lidköping Airport (Lidköping Aeroclub).

The flight school had declared training and qualifications for LAPL(A), PPL(A), night qualification, SEP(land), TMG, towing of gliders, aerobatics and theory for LAPL(A) and PPL(A).

[15] DTO (Declared Training Organisation).

1.17.2 The flight school's organisation

The flight school's school handbook (SHB) described the school's organization and management.

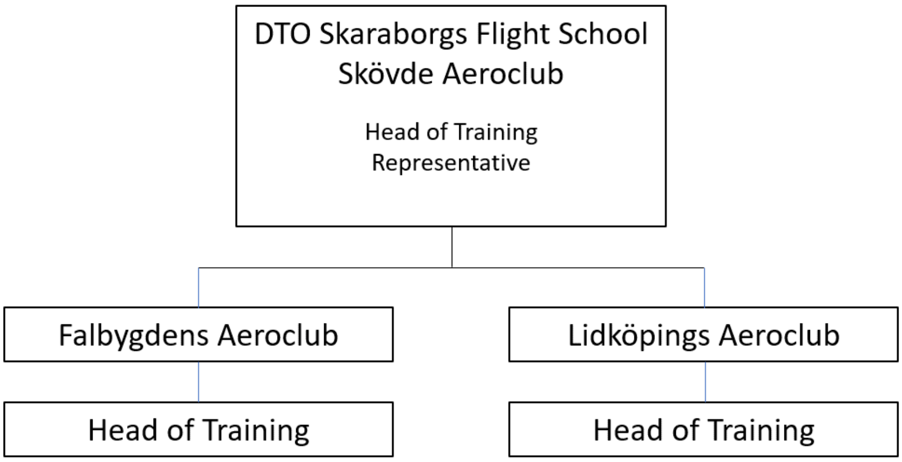

Figure 19. Organization chart Skaraborgs Flight School.

The flight school had a current flight safety policy. The policy addressed, among other things, the importance of reporting incidents, that the reporter should not be punished and that the Commander was responsible for safety and compliance to rules.

The flight school documented its risks in an incident report system and in a risk register. To define the risks, a risk matrix was used where probability and severity were assessed.

The experiences gained in applying the incident report system were presented at a meeting with the person responsible for training and the flight instructors concerned.

1.17.3 Flight school declaration and training program

A DTO conducts its training by declaring its activities to the Swedish Transport Agency. In support, the Royal Swedish Aero Club (KSAK) has developed a service for how to create the DTO declaration. The service was created in consultation with the Swedish Transport Agency to minimize the work of aeroclubs.

The flight school's declaration and training program for LAPL were obtained from KSAK. The training program from KSAK described the content and goals of the exercises.

1.17.4 Flight School Standard Operations (SOP)

Flight school theoretical training

The theoretical part of the training was carried out web-based by a sub-contractor to the flight school *(Flygcert.com).*

The part of the education relating to aborted take-offs is described as follows:

"There are many things that can happen even before the plane takes off and there is nothing that is as unnecessary as trying to fly an airplane that does not want to. There may be problems with the engine which means that you do not get full power or that the brakes are inadvertently applied and prevent acceleration. Before take-off, you should appoint a decision-point where you make the decision whether to continue or abort the take-off. If the decision is to stop, pull the throttle to idle and brake. When the aircraft is stationary, you must evaluate the situation and decide."

Flight School Handbook (SHB)

The flight school's school handbook described the following:

"The goal of SHB is that flight training is carried out in the same way regardless of where the flight training is performed and to be able to gather and take part of the experiences that everyone involved gets in this school activity that will ultimately generate the best possible flight safety for everyone involved."

Lesson 12 described the take-off and climb to downwind in the traffic pattern. As part of the exercise, an aborted take-off was included. There was no guidance on how to train an aborted take-off. Also, there was no instruction on how a "touch and go" should be performed.

In the theoretical training, the concept of a decision point was introduced. The purpose was to understand the importance of using a decision point to be able to abort the take-off in a safe way. The following was stated in SHB under the section performance, single-engine aircraft.

"*Be sure to have a specific decision point to abort the take-off if the aircraft would not have taken off at a specific point"*

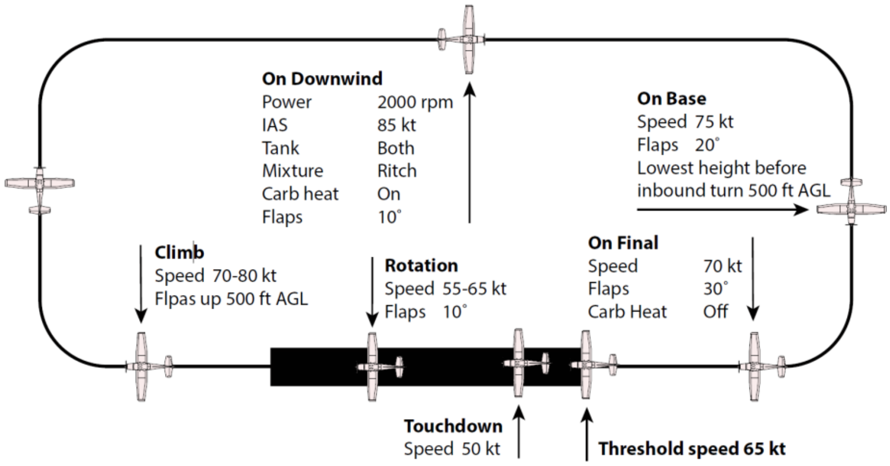

Figure 20. Take-off and landing, normal procedure for Cessna 172N.

In interviews, the following procedure has been described for how a take-off procedure is handled in the flight school. First, a decision point was designated. The brakes were released and the throttle was initiated smoothly. The aircraft accelerates and lifts off when ready. After lift-off, the flight continues at 75 knots.

According to the Head of Training and the Instructor the flight school did not teach that any special focus on the airspeed indicators where required to follow the aircraft's acceleration on take-off.

1.17.5 Pilot Operating Handbook (POH)

The POH describes the following regarding the standard procedure for take-off:

"NORMAL TAKE OFF

1. Wing Flaps - UP.

2. Carburetor Heat - COLD.

3. Throttle - FULL OPEN.

4. Elevator Control - LIFT NOSE WHEEL (at 55 KIAS).

5. Climb Speed - 70-80 KIAS."

For take-off on short fields 10 degrees flap should be used.

The POH does not contain any procedure for how a touch and go should be performed and consequently no performance calculations were available for this manoeuvre.

1.17.6 The Flight Instructor Course

The instructor was trained at the flight school Volflight in Jönköping. The flight school has ceased its operations.

The instruction for take-off and aborted take-off were described in the school's flight instructor manual (FIM).

The school's FIM stated the following regarding the take-off:

"Align the aircraft in the take-off direction and complete before take-off items. Repeat decision point - Landing light - Transponder. We take out an eye mark and gently apply full throttle. Hold your hand on the throttle and check that the speed increase is normal. We keep the run-way-track with the rudder and relieve the nose wheel by taking the steering-wheel slightly back. The aircraft now lifts off by itself. Check airspeed."

Aborted take-off was stated in the school's FIM during the flight exercise 12/13, emergency procedures in the traffic pattern. The school stated that measures in the event of an aborted take-off would be carried out, but not how the exercise would be carried out.

SHK has not succeeded in obtaining any documentation for the instructor's training.

1.17.7 Regulations for training organisations

Aviation activities conducted within the EU are subject to the common aviation rules set out in Regulation (EU) 2018/1139 of the European Parliament and of the Council laying down common rules in the field of civil aviation, etc. and regulations falling under it. Compliance with the regulations is monitored at EU level by EASA, which also supervises Member States' national aviation organizations and regulators.

Training for LAPL, PPL, seaplane, aerobatic, night qualification and similar simpler qualifications, can be completed at a DTO. More advanced qualifications such as training to a commercial pilot and instructor require a so-called ATO[16] for the training.

School activities of the type conducted at the flight school are regulated by Commission Regulation (EU) 1178/2011, Annex VIII, Part DTO. The regulation sets out the requirements that a flight training organization, the DTO, must fulfil in order to conduct flight training.

[16] ATO (Approved Training Organisation).

Safety management system for a DTO

Regulation 1178/2011 states that there must be a safety policy that handles the identification of risks, risk assessment and risk reduction measures. A DTO is covered by Commission Regulation (EU) No 376/2014 on the reporting, analysis and follow-up of civil aviation incidents.

1.17.8 Verification and Supervision during operation (DTO)

The Swedish Transport Agency is the competent authority for training organisations. Before an educational activity is to begin its activity, it must be declared to the competent authority.

When the competent authority receives a declaration from a DTO, the authority must verify that the declaration is complete. The authority should confirm receipt in writing within ten working days.

The Authority shall, within six months of confirmation, verify that the training program complies with the requirements of Annex I (Part-FCL).

The purpose of the Swedish Transport Agency's supervision is to verify that the DTOs comply with their governing documents and meet the requirements of relevant regulations.

The Swedish Transport Agency will carry out a notified inspection within 12 to 72 months from the time a confirmation is sent to the DTO. When the inspection is to be carried out depends on if the school has a previous permit or not to perform training.

1.18 Additional information

1.18.1 Touch and Go

The procedure can be considered as a landing directly followed by a take-off with sufficient time on the ground to reconfigure the aircraft. The purpose of a touch and go is to perform more take-offs and landings in a short time during training.

Regulations and guidance documents

There are no requirements or guidance documents in the regulations.

KSAK

KSAK has a flight safety program which is an updated version of the H50P[17]. The flight safety program was previously updated by the Swedish Transport Agency and KSAK based on regulations and statis-

[17] H50P (An aviation safety collaboration in project form. The abbreviation stands for "Accidents 50 % in General Aviation").

tics. The flight safety program describes the handling of aborted take-off as follows:

”The pilot aborts a landing in accordance with his plan of flight or take-off, as planned after landing, to make a renewed landing (touch and go).”

1.18.2 Aborted take-off

Decision point at aborted take-off

For take-off, it is a general practice that a decision point is appointed to be able to decide whether to continue or abort the take-off.

Decision point at the event

According to interviews with the instructor and the student, no decision point was selected before they started the take-off after the landing. The decision point from the initial take-off was indirectly used as a reference. Prior to the landing, the focus was more on the touch down point for landing.

Regulations and guidance documents

<u>EASA</u>

The requirements for aborted take-offs are set out in Commission Regulation (EU) No 1178/2011. There is no guidance material in the regulations.

Aborted take-offs must be performed during training, skill tests and proficiency checks. The training can be performed in a flight simulation training aid (FSTD) or in an aircraft. The aborted take-off must be performed *“at sufficient speed”*.

<u>KSAK</u>

The Aviation Safety Program describes the handling of an aborted take-off as follows:

“When should you abort the take-off? Early during the take-off, you decide that everything works as it should. Do you think it is slow, abort immediately and analyse the situation! Do not take-off if there is any remaining uncertainty! Determine a decision point where you should have been airborne or reached a certain speed. If the reality does not match what you planned, abort. Think about how the aborted take-off should be performed (idling, braking, steering wheel position)! Then test in reality but with a good margin. At the first attempt, you should abort well before the intended decision point. Note how good a margin you have. Now you have been helped to determine a better decision point. Here is a warning: Do not push your training so far that what you are trying to avoid becomes a reality.”

The same compendium presents a number of conclusions. One of the conclusions is that:

“Schools and flight instructors themselves must have imagination and realize what situations pilots can end up in and how students should be trained to be prepared. Instructors must therefore be well informed about accidents and incidents that have occurred.”

Federal Aviation Administration (FAA)

A general recommendation from the FAA Safety Team (FAAST) is available to decide whether to continue or abort a take-off. The recommendation is that at 50 % of the runway length you must have reached 70 % of the rotational speed to continue the take-off (also called the 50/70 rule). Otherwise, take-off must be aborted.

1.18.3 Braking distance

The distance to stop an aircraft on the ground is affected by the reaction distance and braking distance.

The braking distance is primarily affected by the kinetic energy created by speed and mass (Ek=(mv2)/2). In addition to speed and mass, there are several factors that affect braking distance, including; the aircraft’s equipment (anti-skid brakes, the design of the brakes), aerodynamic impact, the contact of the wheels to the ground, the surface condition of the runway and operational procedures. At a doubled speed, the braking distance can thus be at least four times as long at a constant deceleration.

The figure below illustrates how the length of the braking distance was affected by the speed at the aborted take-off. The blue mark shows the braking distance at rotational speed 55 knots and the red mark shows the braking distance at 94 knots which the indicated speed has been estimated at when the take-off was aborted during the accident flight. The speeds are estimated on the basis of GPS data from the time of the accident, where the points represent the groundspeed. The speeds have then been adjusted with the reported headwind to represent the indicated airspeed.

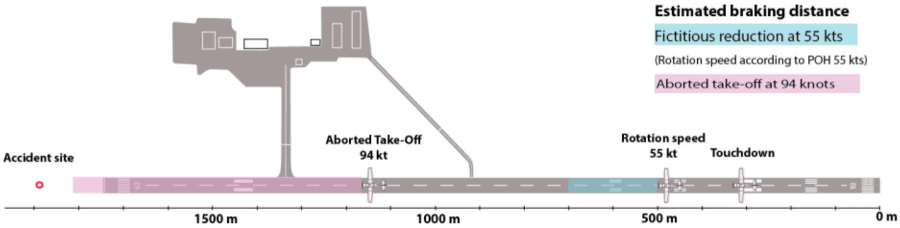

Figure 21. The effect of braking distance at power reduction at different speeds. Aircraft symbols not to scale.

1.18.4 Visual impressions of speed

In order to form a perception of speed, the human visual cortex needs to receive visual cues from the surroundings. It is mainly how the visual impression of different objects or objects changes over time that gives an impression of speed. An object that is initially very small but that quickly becomes larger will contribute to an experience that it is approaching at a high speed.

In environments where the number of objects is limited and where there are large distances to or between visual objects, it often becomes difficult to form a representative perception of speed. An example of such an environment is a runway at an airport. A runway is straight and there are often long distances to surrounding buildings. The difficulty of estimating speed based on only visual impressions from the environment outside the cockpit increases when an individual focus forward in the field of view, which is also the case at take-off or landing.

One way to support the visual processes is to make greater use of the peripheral field of view at angles from the direction of travel. This means that you use the field of view to the right or left in relation to the direction of travel.

The speed of an aircraft over the ground is directly dependent on the movement of the air, which means that the speed over the ground can be significantly lower than the indicated speed through the air at e.g. head-wind. This in turn affects the experience of speed. A take-off in strong headwind would therefore contribute to an experience of the aircraft traveling more slowly than the indicated airspeed shows. By taking part in information from e.g. instrumentation, a coherence between perceived speed and indicated airspeed can be achieved.

1.18.5 Mental models

"Mental models" are a way of describing how people create representations of knowledge. The term formulates a way of describing how people think, reason and analyse their surroundings. A mental model is an individual's perception of a specific set of circumstances. It can be about how we perceive the world to work, what it looks like and what processes we can predict based on how our mental models are structured. When we make decisions, we rely on the information available in the mental models we have formulated. The information in our mental models is constantly being built on with new experiences, which means that the models are dynamic and always changing. At the same time, mental models are very powerful, and conflicting experiences can be difficult to accept and immediately incorporate into the available mental models.

To describe a mental model that is shared by several individuals, one can use the term shared mental model. To achieve a shared mental model, communication is of utmost importance. By communicating, the shared model is created. Communication also makes it possible for everyone to identify where the individual models are diverging and, if necessary, make corrections so that it better supports the shared model.

1.18.6 Shared responsibility and impact on performance

Situations where there are several strong individuals, either through an organizational structure or for that matter through social roles, and where it is perceived that there is a shared responsibility, can lead to uncertainty about who it is that is in charge and can in turn influence individuals who shall act within the framework of such a structure.

Uncertainties can normally be handled by discussing the assignment of roles and clarifying the division of responsibilities in advance. In an arisen situation, where the assignment of roles is unclear, this can lead to questions about who is expected to act and corrective measures can be delayed.

1.18.7 Actions taken

In the flight school's risk register, a restriction has been introduced for touch and go for runways shorter than 1,000 metres during check flights where there are more than two onboard in the aircraft.

1.18.8 Similar events

SHK has obtained information from the EU computerised register ECCAIRS (European Co-ordination Centre for Accident and Incident Reporting Systems). Figure 22 illustrates the number of accidents and serious incidents during the period 2002–2021 in regards to touch and go or aborted take-off.

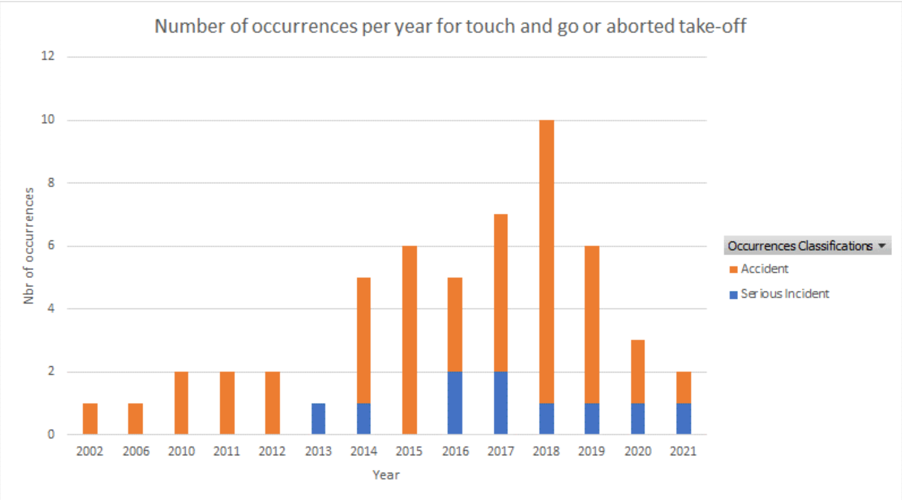

Figure 22. Occurrences sorted by airplane with a maximum take-off mass of 2 250 kg, flight phase equal to take-off or landing and non-commercial operations.

1.18.9 Special investigative methods

None.

2. ANALYSIS

2.1.1 Initial starting points

Based on the established course of events, SHK has analysed a number of questions. How did the abnormal trim position occur? Why did the aircraft not get airborne during the take-off phase? What is the role of the instructor and how should the instructor follow up a flight?

SHK has also found reasons to analyse in more detail the decision point and braking distance, the flight school's training, the structure and function of the regulatory system in combination with the safety management system's routines for identifying hazards and how experiences are handled within the system.

No technical circumstances have been identified that affected the accident.

2.2 The abnormal trim position

SHK has established that the trim position after the accident was in a position that deviated from the normal position for take-off. This resulted in significantly greater stick forces than normal to lift the aircraft of the ground.

During the approach, the flaps were extended and the landing was conducted with full flaps. The aerodynamic forces when extending the flaps provides a nose-up pitching moment. This needs to be compensated by trimming nose down.

According to the instructor, the student was manoeuvring the trim wheel more than normal before landing. The student experienced that the aircraft felt abnormal during the final approach and stopped trimming. It is therefore probable that the student overcompensated the trim towards nose down to compensate for the stick forces that the flap extension caused. This may explain the position of the trim.

2.3 Why did the aircraft not get airborne?

The reference flights showed that it was possible to fly and land the aircraft with the trim in the position it was in for the accident. However, this trim position required considerably more force on the steering wheel to lift off the aircraft from the ground.

With the technique taught by the flight school, to let the aircraft lift off by itself, it is understandable that the student thought that the speed was too low for lift off. He therefore relieved the backpressure of the steering wheel to accelerate the aircraft.

There is a risk that the actual speed is underestimated in environments with few objects with large distances between the objects. The time required to accelerate to lift off speed is significantly shorter during a touch and go than during a normal take-off. At a higher speed, the air resistance is higher, which gives a lower acceleration. All in all, this may explain why neither the student nor the instructor thought rotational speed was actually achieved even though the speed exceeded the rotational speed by a good margin.

The effect of the trim rudder increases with speed. This means that greater stick forces are required to affect the rudder when the aircraft is nor correctly trimmed. As the speed increased during the take-off, this correlation is strengthened. When the student made a new attempt to lift off, a greater force was required compared to the first attempt. He has stated that he used greater stick force on this occasion, but he had probably never experienced the amount of force that was required to lift off during his previous training.

The student had only eleven hours of flight time and he was facing a situation he had not experienced before. During the event, the student had many impressions to process. The student has subsequently stated that he probably would have aborted the take-off earlier if he had been alone in the aircraft. It is also likely that the student expected some response from the instructor or Head of Training if the situation was not safe as they had extensive experience. The fact that the student did not choose to abort the take-off can partly be explained by the fact that the instructor did not communicate with him, which meant that the student continued the take-off, despite his feeling that the situation was abnormal.

When the aircraft approached the decision point, the student felt that he could no longer handle the situation. He therefore told the instructor that something was wrong. The instructor then aborted the take-off.

2.4 The role of the instructor the and follow-up of the flight

An instructor shall continuously monitor and guide a student to ensure that all behaviours and manoeuvres are performed in an appropriate and correct manner. The instructor shall as far as possible, be able to anticipate the situations that may arise and be prepared to handle them. If the situation so requires, the instructor must be prepared to take control of the aircraft.

The instructor has stated that he had a good confidence in the student and his ability. The instructor has also stated that he wants his students to learn from their mistakes as long as it’s safe to do. He therefore lets the students manage the situations that may occur and he only intervenes if it becomes necessary. This is a learning method that has good prerequisites for a good knowledge building. The method in combination with a positive learning style, i.e. reinforcement of good behaviour, provides independent students with a good system understanding who can take responsibility for their own development. However, communication gaps can arise in vulnerable situations if a student becomes insecure and does not have the tools to express his insecurity. An instructor who does not understand the student's insecurity can let a situation go too far, which in turn means that the room for manoeuvring is quickly reduced.

A few seconds after initiating the take-off, the aircraft reached rotation speed and at this point, the experiences between the instructor and the student seem to have begun to diverge. Their experience of the course of events appear to differ from the actual development of events. The student and the instructor have stated that they both had the impression that the speed was not sufficient for the aircraft to lift off, but for different reasons. The student assessed that the speed was not sufficient because the aircraft did not lift off, while the instructor felt that the engine did not give full power. However, their perception that the speed was not sufficient did not correspond to the actual conditions. According to flight data, the aircraft accelerated constantly after take-off. There is no evidence that the aircraft's acceleration was abnormal.

The instructor did not fly the aircraft and was not following along in the controls, which is normal with a student who is close to the solo flight stage. This meant that the instructor's contact points with the aircraft were limited, which limited the possibility of knowing what the student was doing. There are other methods for creating a good picture of the flight progress, such as closely monitoring the aircraft's flight instrumentation. The fact that the indicated speed was not monitored can to some extent be explained by the flight school's routine and the instructor's training. The student has stated that he perceived the situation as abnormal. He communicated his experience of the situation to the instructor when he felt that he didn't have any control over the situation. The instructor thus had an incorrect picture of how the take-off process developed, which may explain why the instructor did not take over the controls until the student alerted him.

No decision point had been discussed prior to the landing and subsequent take-off. Prior to the first take-off, a decision point was defined. It is therefore likely that the instructor saw this point as where he at the latest had to act to abort the take-off. The training material and guidance information for aborted take-off presume that the speed is not sufficient at take-off and that the take-off must be aborted for that reason. This can result in the pilot expecting the braking distance to be equivalent to a normal landing.

The high speed that the aircraft achieved just before the decision point resulted in a significantly longer braking distance compared to the braking distance at rotational speed. The fact that speed is not a factor in the flight school's routine for take-off results in that a decision point is designated without all factors being considered. The braking distance is therefore difficult to predict, especially since the training material and guidance material only deals with low speed. It is important to consider how the speed affects the required braking distance when determining a decision point and this will be discussed further in section 2.5.

It cannot be ruled out that the Head of Training may have had a certain influence on the student's and the instructor's actions. The Head of Training may have been perceived as a strong individual partly through his position within the organization, partly due to his flying experience. The instructor was in command and had the immediate responsibility of supervising the student. At the same time, the Head of Training was in the back seat and was the one who would formally approve the student for his first solo flight. The presence of the Head of Training in the back seat may have contributed to further delaying corrective measures from the instructor.

2.5 The decision point and the braking distance

Commission Regulation (Part-FCL) state that aborted take-offs must be included in training, Skill Test and Proficiency Check. Furthermore, it is stated that an aborted take-off must be carried out at a sufficient speed, but not that there must be a specific point or speed that indicates when the manoeuvre is possible or not.

As shown in sections 1.17.3, 1.17.5 and 1.18.2, there is also other guidance material that deals with the fact that a decision point should be designated to provide the pilot with a for when it is safe to abort the take-off. The material does not state which factors should be considered in order to be able to predict the braking distance required after an aborted take-off. As an example, the FAA has a general recommendation for assessing when a start should be aborted, which is called the 50/70 rule. This means that at half the runway length, 70 percent of the rotational speed must have been achieved. By this event, 70 percent of the rotational speed had already been achieved at the start of the take-off. This is due to the effect of performing a touch and go where you still have speed from the landing. Therefore, one can question whether this rule would have been helpful during the start if it had been used. An advantage of this method, is that it gives the pilot a focus on the speed of the aircraft.

The only information for estimating the braking distance that a pilot can indirectly use is the flight manual's calculations for landing distance. This presupposes that the aborted take-off has similar conditions on which the landing distance has been calculated. As previously stated, there is a general aim in the documentation that a start is aborted due to low acceleration. It is likely that the assumption for that reasoning is based on take-offs on short runways that are performance limited. Furthermore, it is probable that a decision point is appointed to a greater extent on a short runway compared with a longer runway as a longer runway can be perceived as less restrictive. The instructor has, for example, stated that it is difficult to appoint a decision point at take-off runway 19 in Skövde.

At the time of the accident, the aircraft was traveling at high speed. None of those on board looked at the air speed indicators. The instructor's decision to abort the take-off therefore lacked a primary parameter (speed) to be able to predict the braking distance. Other factors that affect the braking distance also became more prominent due to the high speed. Examples of this are the aerodynamic impact on the aircraft and the wheels contact against the ground.

Figure 23 illustrates the braking distance required for an aborted take-off at different speeds at the approximate point where the instructor aborted the take-off. The blue marking is the calculated braking distance based on the flight manual's landing distance at landing speed. The red marking is the SHK:s calculation of the braking distance at the speed that the aircraft had when the take-off was aborted. If the instructor had an opinion similar to the blue marking, there was no reason for him to believe that the braking distance would not be sufficient in case of an aborted take-off.

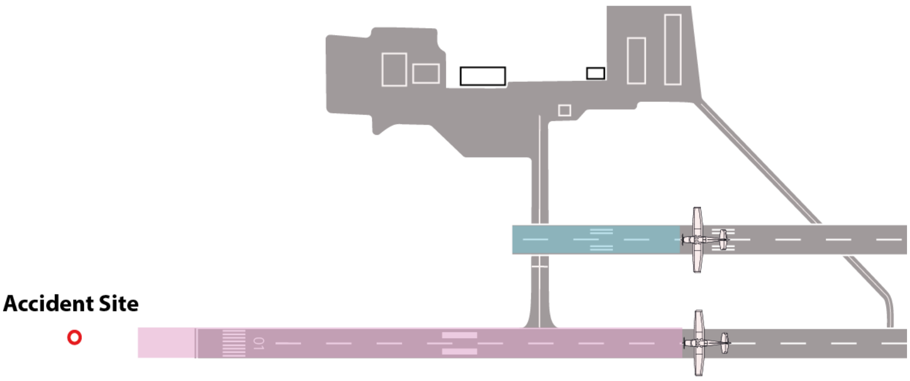

Figure 23. Aborted take-off at the approximate point on the runway where the instructor aborted the take-off. Illustration of braking distance depending on the speed of the aircraft according to the paragraph above.

It can be concluded that the flight school's education and the collected guidance material did not involve risks at high speed on ground.

2.6 The Flight School Safety Management System and Standard Operating Procedures

The safety management system in the flight school followed the guidelines specified by the regulations. The training program had been obtained from KSAK, which meant that the design of the training program was defined in advance. The training program from KSAK was included in its entirety in the flight school's school handbook (SHB) and described the content and goals of the exercises.

The training program was not risk-analysed in safety management systems prior to the flight school started its operations. This is not a requirement and this means that the content of the exercises had not been defined in the flight school from a risk perspective. Thereafter, the risk identification was conducted in the flight school's incident reporting system where events that could lead to an incident or accident were to be reported. The flight school had a risk log where risks from the incident report system were documented. In the risk log, three risks were documented, none of which was related to concerned the current accident.

The experiences gained from the incident report system were presented at meetings with the person responsible for training and the flight instructors concerned. It was the only occasion where training exercises could be discussed and standardized. This was not documented in SHB. The SHK assesses that it can be difficult to determine how standard operations can be handled and uniformed in a DTO if there is no collective documentation that can guide an instructor in how exercises should be trained. There is therefore an obvious risk that the instructors in the flight school trained the students based on their previous experiences and how they themselves were taught as instructors.

In the previous section of the analysis, deficiencies have been identified primarily in view that the indicated speed was not a part of the standard operations procedure prior to take-off, even though the flight manual stated a rotational speed. Speed was also missing as a parameter when the decision point was selected in relation to the braking distance. Therefore, the SHK has found that the flight school’s standard operations procedures were not appropriate. All in all, this meant that the aircraft, after landing and the following take-off (touch and go), reached and exceeded the rotate speed without anyone identifying it.

A question that arises is whether a flight school (DTO) can identify and design the exercises in the organisational structure specified by the regulations. Another question that arises is whether EASA’s overall view of regulations and Safety Management Systems provides sufficient guidance to flight schools according to the DTO for how the training is to be carried out.

2.7 The Regulations for Safety Management Systems in a DTO

Commission Regulation (EU) No 1178/2011 Annex I (Part-FCL) specifies the training to be performed within the training organization (DTO). EASA has stated that there are three safety nets that will ensure that the training in a training organization is appropriate. The first safety net is that the national supervisory authority examines the declaration and the training program at the flight school’s initial application. The second safety net is the flight school’s safety management system and the third safety net are the national supervisory authority’s recurring operational inspections.

The regulations state that upon receipt of a declaration, the national supervisory authority must verify the content of the declaration. After that, the authority has six months to carry out a verification that the training program follows Part-FCL. This means that the first and last safety net only verifies the accuracy of the content and does not examine how the training is carried out. Neither EASA nor the type certificate holder provides guidance on how to carry out the training, as long as you follow the regulations and the type certificate holder's directive. The remaining safety net is the flight school's safety management system. In this case, the training program was obtained from KSAK and contained the content and goals of the exercises.

In order to be able to proactively identify and manage complex risks, a Safety Management System that is well developed is required. A DTO's safety management system lacks that structure. The management of risks within the framework of a DTO is therefore reactive, i.e. that the risks are identified after an event has occurred. The Safety Management System in this DTO has also not been able to identify the shortcomings identified by this report.

The SHK assesses that there is a risk of only relying on the training organizations' Safety Management System and their ability to identify and manage risks. In the investigations RL 2017: 04 and RL 2021: 03, the SHK has identified similar deficiencies regarding guiding material for other training organizations.

To ensure that the training provided in a DTO is equivalent in the training organisations, the design of the training should be described in guiding material to the EASA regulations. A uniform design of the education contributes to an appropriate and safe operation.

2.8 Rescue operation

The investigation has not revealed any indications of deficiencies with regard to the implementation of the rescue operation.

2.9 Survival aspects

The emergency transmitter was not activated in the accident. The rescue service was informed by the JRCC about the accident by the school Head of Training who called and reported the incident. No ATS flight plan had been submitted for the flight, which meant that there was no follow-up for rescue service. In this case, the crew was not seriously injured and they had the opportunity to report the incident.

3. CONCLUSIONS

3.1 Findings

a) The pilots were authorised to perform the flight.

b) The aircraft had a Certificate of Airworthiness with a valid ARC.

c) The flight school had a declared training organization (DTO).

d) No technical circumstances that have affected the accident have been identified.

e) The Head of Training sat in the back seat to supervise the instructor and evaluate the student's before solo flight.

f) The weather conditions were good.

g) The runway was damp.

h) The landing took place at the Touch Down Zone.

i) The trim position was in a nose down position that deviated from the normal take-off position.

j) It was possible to lift off when the normal rotational speed was passed. Greater forces were required as the speed increased.

k) There is no evidence that the acceleration was abnormal.

l) The flight school's Standard Operations Procedures did not follow the aircraft's manual. The indicated speed was not used as a reference during the take-off.

m) The training organization that trained the instructor did not use the indicated speed as a reference during the take-off.

n) None of the occupants observed the indicated speed during the course of events.

o) The regulations state that an aborted take-off start must be carried out at a sufficient speed, but not that there must be a specific point or speed that indicates when the manoeuvre is possible or not.

p) Guidance material that enables uniform education is lacking in indicative material for the regulations.

q) The safety management system in a DTO lacks the structure to proactively identify risks.

3.2 Causes/Contributing Factors

The cause of the accident was that the flight school's procedures for take-off were not appropriate. This resulted in that the speed became considerably higher than the rotational speed without being noticed. When the instructor aborted the take-off, the speed was so high that it was not possible to stop the aircraft on the remaining runway length.

Contributing causes of the accident was that the instructor had an incorrect picture of the course of events and took over the controls in a late stage of the take-off. The long runway and the aircraft's flight characteristics gave the pilots a false assurance that the margins were large. Furthermore, the flight school's training material did not describe the impact of the speed and required braking distance in relation to the decision point designated at take-off.

EASA does not describe in guidance material how training should be performed for a DTO. This has been identified as a deficiency at a system level.

4. SAFETY RECOMMENDATIONS

The EASA is recommended to:

- Evaluate the benefit of a review of the exercises contained in the training programmes that may pose a safety risk and to decide on the best course of action to make the training organisations aware of these risks, either through dedicated safety promotion, development of best practises or developing guidance material to the existing requirements. *(RL 2021:10 R1)*

The Swedish Accident Investigation Authority respectfully requests to receive, **by 15 March 2022 at the latest,** information regarding measures taken in response to the safety recommendations included in this report.

On behalf of the Swedish Accident Investigation Authority,

Kristina Börjevik Kovaniemi Mats Trense