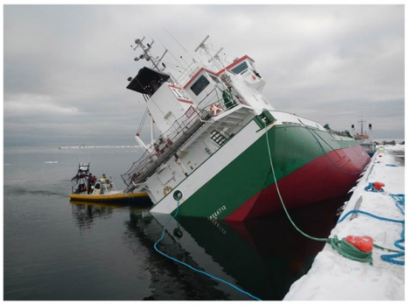
Statens haverikommission
Swedish Accident Investigation Authority



# *Final report RL 2018:05e*

**Accident at Siljansnäs Airport, Dalarna County, on 30/06/2017 involving the aircraft OH-PHE of the model Piper PA-28-161, operated by Blue Skies Aviation Oy.**

File no. L-71/17

9 March 2018

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 30 June 2017 that an accident involving one aircraft with the registration OH-PHE had occurred at Siljansnäs Airport, Dalarna County, on the same day at 19:25 hrs.

The accident has been investigated by SHK represented by Mr Jonas Bäckstrand, Chairperson, Mr Johan Nikolaou, Investigator in Charge and Mr Ola Olsson, Technical Investigator (aviation).

The investigation team of SHK was assisted by Mr Christer Magnusson, Magnic AB, as an expert specializing in sound.

Ms Tii-Maria Siitonen has participated as accredited representative on behalf of the Finnish Safety Investigation Authority.

The investigation was followed by Mr Magnus Axelsson of the Swedish Transport Agency.

The investigation was followed by Mr Alessandro Cometa of the European Aviation Safety Agency (EASA).

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

*Investigation material*
Interviews have been conducted with the instructor, the student, the passenger and three witnesses on the ground. A video recording of the event has been reviewed and analysed. SHK has visited the airport, examined the aircraft wreckage and documented the site of impact.

A factual meeting with the interested parties was held on 17 October 2017. At the meeting SHK presented the facts discovered during the investigation, available at the time.

Statens haverikommission
Swedish Accident Investigation Authority

## Final report RL 2018:05e

| | |
|---|---|
| Aircraft: | |
| Registration, type | OH-PHE, Piper PA-28 |
| Model | PA-28-161 |
| Class, Airworthiness | Normal, Certificate of Airworthiness and Valid Airworthiness Review Certificate (ARC)[1] |
| Serial number | 28-7716103 |
| Owner | Constella Aviation |
| Time of occurrence | 30 June 2017, 19:25 in daylight hrs<br>Note: All times are given in Swedish daylight saving time (UTC[2] + 2 hours) |
| Place | Siljansnäs, Dalarna County, (position 60°47N 014°49E, 186 metres above mean sea level) |
| Type of flight | Schooling |
| Weather | According to SMHI's analysis: wind northeast 10–15 knots, gusts 20 knots, visibility >10 km, no clouds below 5 000 feet, temperature/dewpoint +19/+6°C, QNH[3] 1007 hPa |
| Persons on board: | 3 |
| Crew members | 2 |
| Passengers | 1 |
| Injuries to persons | 1 with minor injuries |
| Damage to aircraft | Substantially damaged |
| Other damage | Some damage to crops and vegetation |
| Instructor: | |
| Age, licence | 58 years, PPL(A)[4]/FI(A)[5] |
| Total flying hours | 6 838 hours, of which 1 000 hours on type |
| Flying hours previous 90 days | 138 hours, of which 83 hours on type |
| Number of landings previous 90 days | 250, of which 220 on type |
| Student: | |
| Age | 28 years |
| Total flying hours | 28 hours, all on type |
| Flying hours previous 90 days | 28 hours |
| Number of landings previous 90 days | 105 |

[1] ARC – Airworthiness Review Certificate.
[2] UTC – Coordinated Universal Time.
[3] QNH – Barometric pressure at mean sea level.
[4] PPL(A) – Private Pilot License Aeroplane.
[5] FI(A) – Flight Instructor Aeroplane.

**SUMMARY**

The accident occurred on 30 June 2017 during take-off from Siljansnäs Airport. The aircraft was of the model Piper PA-28-161 (Cherokee Warrior II) and had the registration OH-PHE. The flight was performed as a cross-country flight and was a part of the training for two students. The aircraft was based in Jyväskylä in central Finland. The training was carried out by Blue Skies Aviation Oy, which is a training organisation whose registered office is in Vesivehmaa north of Helsinki.

During the flight from Jyväskylä via Helsinki, Turku and Mariehamn to Siljansnäs, the students had taken turns flying a sector each, while the instructor supervised the flights from the right seat. Blue Skies' duty limitations had already been exceeded before the flight commenced from Siljansnäs.

In Siljansnäs, the aircraft was refuelled in order to achieve maximum take-off mass to fly on to Åre. However, the take-off mass exceeded the maximum permitted.

A video film was recorded from a rear seat with a camera of the type Go-Pro directed towards the right wing. SHK has used the film and its soundtrack as well as ground reference points to the right of the runway in order to calculate engine RPM, airspeeds and pitch angles.

For training purposes, the intention was to execute the take-off using the procedure for take-off from a short runway. The rotation speed was set at 43 knots, which is nine knots below the recommended speed for maximum take-off mass. The recorded film shows that the aircraft, after lift-off, was flying with a high attitude with the aural stall warning continuously activated while the aircraft stalled twice before it came down in a cornfield.

The instructor was injured in the chest by impacting the GPS screen that was mounted on the steering wheel. He was transported to a hospital for treatment.

The accident was caused by prescribed operational take-off procedures not being applied with regard to the indicated airspeed, which resulted in a flight condition where the drag exceeded the available thrust.

SHK has found several contributing factors such as:

- The mass and balance where outside of permitted limitations, which may have had some effect on the course of events.
- The assessment of the wind conditions might have been adversely affected by the fact that the airport's windsock stood on the lee side of a forest.
- There were no detailed instructions in the operator's manual regarding rejected take-off.
- During the latter part of the event, a wind shear might have contributed to the airspeed dropping.

- The manoeuvring towards obstacle clearance area resulted in a banked turn, which at the low speed worsened the situation further.

**Safety recommendations**

None.

# 1. FACTUAL INFORMATION

## 1.1 History of the flight

### *1.1.1 Preconditions*

The intention of the flight was, as part of a training programme, to perform a cross-country flight with two students under dual control, i.e. with the instructor also at the controls.

The planning of the flight was performed in Jyväskylä in central Finland. The training was carried out by Blue Skies Aviation Oy (Blue Skies), which is a Finnish approved training organisation (ATO) whose home base is in Vesivehmaa. The students flew a sector each, while the flight instructor supervised the flight from the right seat.

The first flight was performed between Jyväskylä and Helsinki. Thereafter, the sectors Helsinki-Turku, Turku-Mariehamn and Mariehamn-Siljansnäs were flown. In Mariehamn, they performed a ground stop of two hours and twenty minutes. After the landing in Siljansnäs, the intention was to refuel the aircraft up to the maximum take-off mass, and then continue the flight to Åre.

The weather conditions were good. The windsock indicated a light wind from northeast. The decision was made to use the paved runway 32 with a crosswind from the right. The flight instructor preferred runway 32 instead of the opposite runway 14. This was due to his perception that the obstacle clearance in the north-westerly direction was better than in the south-easterly direction.

The runway was 850 metres long, which was sufficient for a normal take-off at maximum take-off mass. However the actual take-off mass exceeded the maximum permissible. For training purposes, the flight instructor chose to perform a take-off in accordance with the procedure for short runways as described in the pilot operating handbook (POH). The procedure was briefed before take-off with the students.

Piper's POH describes the procedure in the following manner: *A short field take-off with an obstacle clearance is accomplished by first lowering the flaps to 25°. Apply full power before brake release and accelerate to 52 KIAS and rotate. Maintain 52 KIAS until obstacle clearance is attained. After the obstacle has been cleared, accelerate to 79 KIAS and then slowly retract the flaps.*

In interviews with those on board, different details of the speeds that were decided for rotation and climb-out have been mentioned. The student who was pilot flying has stated 43 knots as rotation speed, and then to accelerate to 50 knots. The others have stated that the predetermined rotation speed was 50 knots.

Piper's POH also states: *Premature raising of the nose or raising it to an excessive angle will result in a delayed take-off.*

### 1.1.2 Sequence of events

A normal engine run-up was performed by the student under the instructor's supervision. All engine parameters showed normal parameters. The elevator trim was set to just aft of the neutral position.

During the take-off sequence, the brakes were applied until the engine reached 2 400 RPM. Thereafter the student released the brakes to accelerate. During the take-off roll he rotated the aircraft at 43 knots.

The aircraft became airborne a few meters in ground effect and then dropped back onto the runway with a high pitch angle, it then became airborne again for a few seconds and then once again touched the runway. The instructor then assumed control of the aircraft and made a new attempt to lift-off.

When the aircraft had come up to a height of five to ten metres, the instructor noticed that the stall warning[6] was active. The instructor has stated that the indicated airspeed was forty knots and that wind shear[7] might have been the cause of the low speed.

The instructor turned slightly to the right to avoid terrain and attempted to accelerate the aircraft in ground effect without succeeding. The right wing then dropped, which the instructor interpreted as the aircraft being about to stall. He attempted to counteract this by applying left rudder, but the aircraft stalled and impacted the ground in a cornfield.

During impact, all landing gears were torn away, and the aircraft yawed ninety degrees to the left. The instructor was pressed against the control wheel where a GPS screen was mounted, which caused a fracture of the sternum.

The aircraft was evacuated immediately after electrical master, magnetos and fuel selector had been turned off.

The accident occurred at position 60°47N°014°49E, 186 metres above mean sea level.

### 1.1.3 Additional information

The event was filmed by a camera that was mounted in the rear seat. From the film, SHK has measured that the engine sound showed a constant engine speed of 2 400 RPM from take-off to impact. The aural stall warning was active during the entire sequence from rotation to impact. All those on board were using active noise reduction headsets (ANR).

[6] Stall refers to the state at which the airflow over the wing changes so that the wing's lift begins to diminish because the critical angle of attack has been exceeded.
[7] Wind shear – A sudden change in movement of air in terms of direction, speed or both.

It is seen on the film that the instructor assumed control of the aircraft, that the aircraft became airborne and that it subsequently stalled, which was followed by a decrease in pitch attitude. The attitude then increased significantly, followed by a secondary stall when the runway threshold was passed.

## 1.2 Injuries to persons

| | Crew members | Passengers | Total on board | Others |
|---|---|---|---|---|
| Fatal | - | - | 0 | - |
| Serious | - | - | 0 | - |
| Minor | 1 | - | 1 | Not applicable |
| None | 1 | 1 | 2 | Not applicable |
| Total | 2 | 1 | 3 | - |

## 1.3 Damage to aircraft

Substantially damaged.

Figure 1. Recovery of the aircraft. Photo: Alexander Sülberg.

## 1.4 Other damage

Minor damage to crops and vegetation.

### *1.4.1 Environmental impact*

None. The fuel tanks were intact after impact and no fuel leaked out.

## 1.5 Personnel information

### *1.5.1 Qualifications and duty time of the pilots*

*The instructor*

The instructor was 58 years old, had PPL(A) and FI(A) with flight operational and medical eligibility.

The instructor completed his instructor training on 22 March 2014 at Blue Skies Aviation.

| Flying hours | | | | |
|---|---|---|---|---|
| Latest | 24 hours | 7 days | 90 days | Total |
| All types | 5 | 14 | 138 | 6,838 |
| Actual type | 5 | 10 | 83 | 1,000 |

Number of landings actual type previous 90 days: 220.
Latest PC[8] conducted on 06 February 2017 on the aircraft type.
The instructor had 232 hours as instructor at the time of the accident.

*The student*

The student was 28 years old, was under training for PPL with medical eligibility.

| Flying hours | | | | |
|---|---|---|---|---|
| Latest | 24 hours | 7 days | 90 days | Total |
| All types | 1 | 5 | 28 | 28 |
| Actual type | 1 | 5 | 28 | 28 |

Number of landings actual type previous 90 days: 105.

According to Blue Skies' training manual, the maximum daily duty time for one-pilot operations is 10 hours for a duty of 4 or 5 sectors. This includes 60 minutes check-in time before the first scheduled take-off.

At the time of take-off from Siljansnäs, the duty time of 10 hours had been exceeded by 2 hours and 11 minutes.

[8] PC – Proficiency Check.

## 1.6 Aircraft information

The aircraft is a four-seat, low-wing, single-engine aircraft equipped with a four-cylinder piston engine with fixed propeller and fixed landing gear. The aircraft is about seven metres long and its wingspan is about ten metres (see Figure 2).

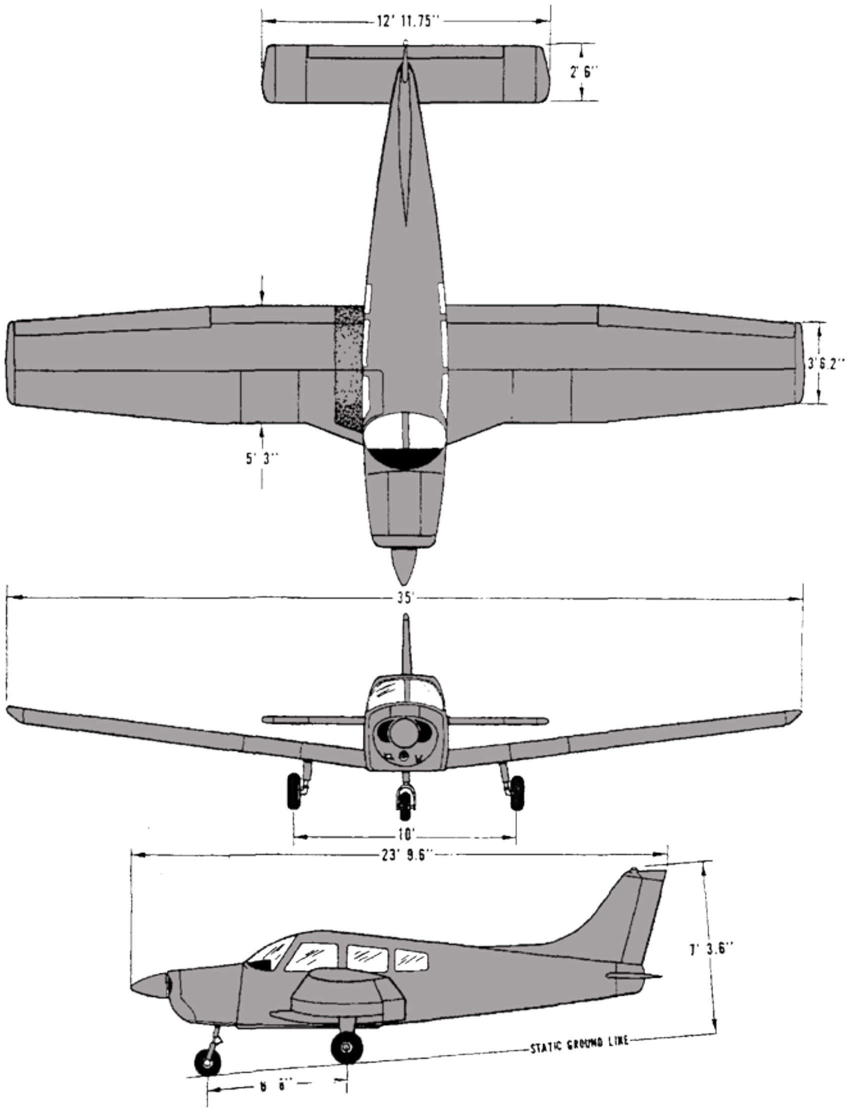


Figure 2. Three-view drawing of the aircraft type. Image: Piper Warrior Information Manual.

### 1.6.1 *Aircraft*

| | |
|---|---|
| TC-holder | Piper Aircraft, Inc. |
| Model | PA-28-161 |
| Serial number | 28-7716103 |
| Year of manufacture | 1977 |
| Gross mass, kg | Max authorised 1 055, actual 1 125. |
| Centre of gravity | Outside of limits. |
| Total flying time, hours | 8 374 |
| Flying time since latest inspection, hours | 9 |
| Type of fuel uplifted before the occurrence | 100LL |
| Engine | |
| TC-holder | Lycoming Engines |
| Type | O-320-D3G |
| Number of engines | 1 |
| Serial number | L-16090-39A |
| Total operating time, hours | 4 318 |
| Operating time since over-haul, hours | 9 |
| Operating time since last oversight, hours | 2 020 |
| Propeller | |
| TC-holder | Sensenich Propeller Manufacturing Company, Inc. |
| Type | 74DM6-0-60 |
| Serial number | A60028 |
| Total operating time, hours | 1 601 |
| Deferred remarks | None relevant for the accident. |

The aircraft had a Certificate of Airworthiness and a valid ARC.

### 1.6.2 *The stall warning system*

The stall warning system consists of a movable metal vane (see Figure 3) that is mounted on the leading edge of the left wing. The metal tongue activates a micro switch when the angle of attack is so high that the air begins to flow from the underside of the wing towards the upper side of the wing. The system is calibrated so that a constant aural warning is activated in the cockpit five to ten knots above the stall speed. The aural warning is sent out from a loud-speaker mounted under the instrument panel and is not linked to the internal communication system (intercom). The stall warning's fundamental frequency is 3 000 Hz.

Figure 3. Stall warning vane.

### *1.6.3 Extension of maximum permitted take-off mass*

According to the instructor, the aircraft had, via an STC[9], been approved for an extended maximum permitted take-off mass of 1 107 kg.

However, according to Trafi, the Finnish Transport Safety Agency, the aircraft's maximum permitted take-off mass is stated as 1 055 kg in the Finish aircraft register.

SHK has reviewed the aircraft's technical records and not found any evidence of the extended maximum gross mass.

The stated STC modification was thus not applicable on this aircraft individual.

## 1.7 Meteorological information

According to SMHI's analysis: Wind northeast 10–15 knots with gusts up to 20 knots, visibility >10 km, no clouds below 5 000 feet, temperature/dewpoint +19/+6°C, QNH 1007 hPa. Wind at 2 000 feet 060°/25 knots. Risk of moderate turbulence between the ground and 3 000 feet.

On the recording that was made from the rear seat, the airport's windsock can be clearly seen. It indicates a crosswind from the right of around 5–10 knots.

The windsock's location, on the right side in the take-off direction according to Figure 4, shows that it was located on the leeward side of a building and terrain that were higher than the windsock.

The accident occurred during daylight.

## 1.8 Aids to navigation

Not applicable.

[9] STC (Supplemental Type Certificate) – Approval of a modification that is not part of the aircraft's type documentation.

## 1.9 Communications

Not applicable.

## 1.10 Aerodrome information

Siljansnäs Airport is an airport that does not require approval from the Swedish Transport Agency. The airport will still meet certain requirements under the regulations. The airport owner and user is Siljan AirPark Samfällighetsförening. Siljansnäs Airport is described in KSAB[10] manual.

The airport has a paved runway and a parallel grass runway designated 14/32 (direction 140 and 320 degrees, respectively). The paved runway used for take-off was 850 metres long and 16 metres wide (see Figure 2). The airport has been measured by SHK. The measurements corresponded well with the measurements that are presented in the manual. There were also rollout areas in both ends of the runway. At the time of take-off the runway was dry. In addition to the runway length that was described, there was a paved section of 50 metres before the threshold of runway 32 that was available for take-off.

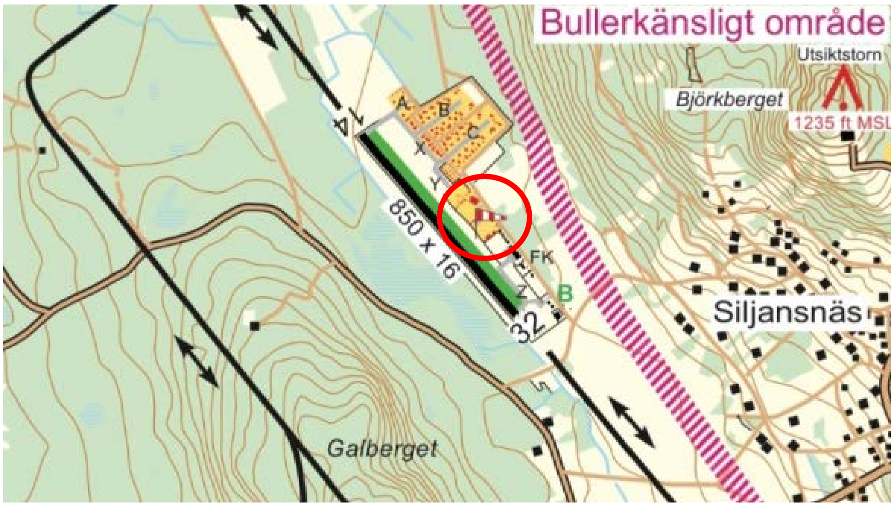


Figure 4. The airport with the windsock marked. Source: KSAB Svenska Flygfält.

## 1.11 Flight recorders

There were no requirements for flight recorders on the aircraft in question.

A camera of the model GO-PRO was temporarily installed in a rear seat. The camera was directed towards the right wing and recorded the entire take-off sequence from start to impact with high image and sound quality. The recording was 52 seconds long, was secured and has been analysed by SHK.

[10] KSAB (Company owned by KSAK, Royal Swedish Aeroclub) – Markets aircraft-related products.

## 1.12 Accident site and aircraft wreckage

### *1.12.1 Accident site*

The aircraft stopped in a cornfield about 50 metres after the runway end and veered 90 degrees to the left in relation to the take-off direction (see Figures 5–6).

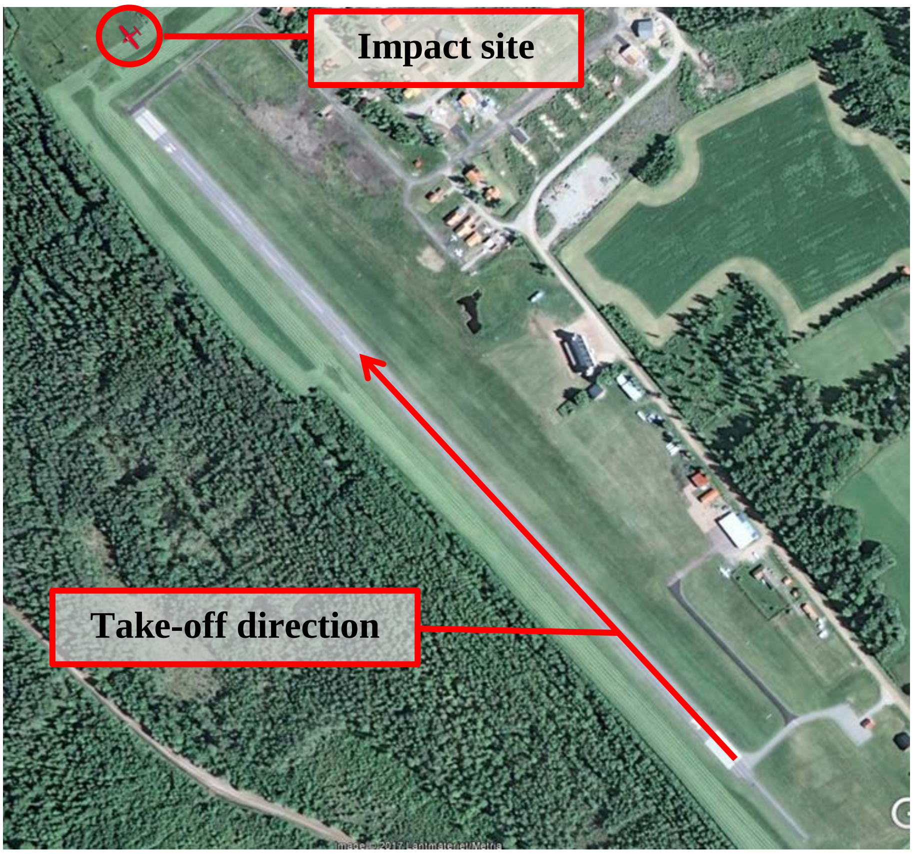

Figure 5. Overview image of the airport with the impact site marked. Photo: Google Earth.

Figure 6. The aircraft's final position in the field marked with a red circle.

Figure 7 shows the surrounding terrain in the take-off direction.

Figure 7. Overview image of the runway end with surrounding terrain.

### *1.12.2 Aircraft wreckage*

The aircraft had structural damage to the fuselage and wings with flaps and to the horizontal stabiliser. The engine and propeller where also damaged. The landing gear had extensive damage as these were torn from their attachments.

The aircraft was recovered and transported to a nearby hangar where a technical examination was later performed by SHK.

During the technical examination no faults where identified that could have been able to affect the sequence of events.

Figure 8. The aircraft at the accident site. Photo: Swedish Police.

## 1.13 Medical and pathological information

Long duty time may cause fatigue. Nothing otherwise indicates that the mental and physical condition of the pilots was impaired before or during the flight.

## 1.14 Fire

There was no fire.

## 1.15 Survival aspects

### *1.15.1 Rescue operation*

SOS Alarm was alerted at 19:51 hrs that an accident had occurred involving a light aircraft in Siljansnäs and 16 minutes after this, two ambulances arrived at the site. Immediately thereafter, rescue units from Leksand fire department also arrived. The three persons who had been on board the aircraft had evacuated unassisted. One of them had minor injuries and was taken to hospital.

The ELT[11] of the type PLB McMurdo FastFind Max was activated during the event.

[11] ELT – Emergency Locator Transmitter.

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

All on board were fastened with waist belts. The shoulder harnesses that were only mounted in the aircraft's two front seats were also used.

The instructor in the right front seat was injured in the chest by a GPS screen that was mounted on the right steering wheel (see Figure 9). The instructor was taken to hospital and was released from the hospital two days later.

There are no specific rules for the installation of equipment that can be mounted and removed without the use of tools.

Figure 9. The image shows the installed screen mounted on the right steering wheel. Photo: Peter Tähtinen.

## 1.16 Tests and research

### *1.16.1 Video films and sound analysis*

The video has been analysed and the times for the aircraft's passing of cones at the airport have been measured in order to calculate the speed. The calculations show an estimated groundspeed of just over 40 knots at rotation. The times are associated with some uncertainty since the aircraft's roll angle and height might affect these calculations.

The sound from the video film has been analysed using a sound analysis program. The quality of the sound was significantly better than that which usually occurs in recordings from CVR[12].

[12] CVR – Cockpit Voice recorder.

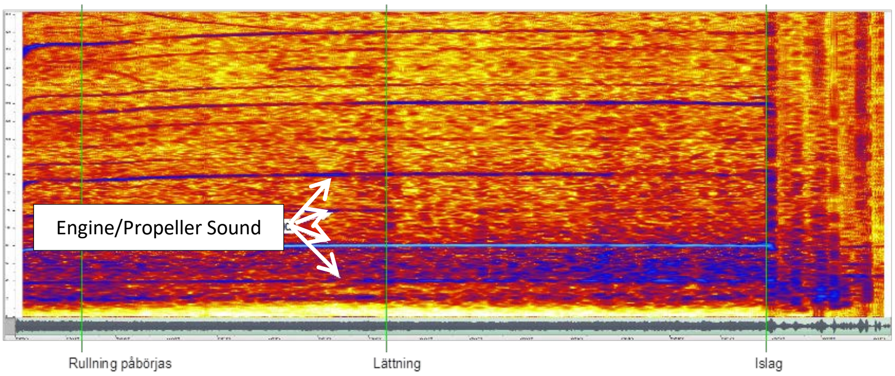


Figure 10. Spectrogram of the sound from the entire video film. The vertical scale goes from 0 to approximately 340 Hz and the horizontal scale from 0 to 52 seconds.

Based on the sound from the video film, a spectrogram has been extracted at commenced ground roll (four seconds into the film) and at rotation (22 seconds into the film).

The strongest tones were at 77 and 80 Hz, respectively. In addition, tones could be identified at half these frequencies and a number of overtones at the double and triple frequencies. The aircraft had a two-blade propeller, which gave rise to two sound pulses for every engine revolution, which explains why the tone around 80 Hz was strongest.

The sound information shows that the engine speed was first approximately 2 310 RPM, which then quickly increased to approximately 2 400 RPM (60 x frequency/2), after which it was constant until impact. SHK has calculated that the engine RPM corresponds to full power with the prevailing meteorological conditions.

### *1.16.2 Available engine power at different airspeeds*

The diagram in Figure 11 shows the principle of available engine power in level flight at different airspeeds. The green horizontal line symbolizes the maximum available engine power which at high speed provides a constraint corresponding to the maximum cruise speed in flight. The only way to further accelerate is to descend towards lower altitude.

Similarly, there is a minimum speed to maintain the altitude with the maximum available engine power. If the airspeed drops further it becomes impossible to keep the altitude, which is due to the increased air resistance.

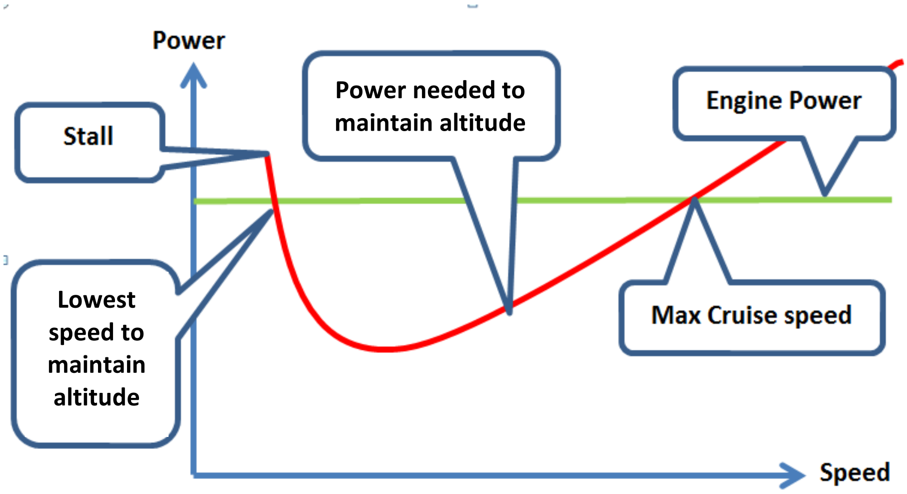


Figure 11. The relationship engine power – speed.

### *1.16.3 Stall*

Stall is defined within aerodynamics as the state at which the lifting force of the wing begins to decrease due to that the critical angle of attack (α) has been exceeded. Figures 12 and 13 show how the angle of attack (α) changes with and without extended flaps.

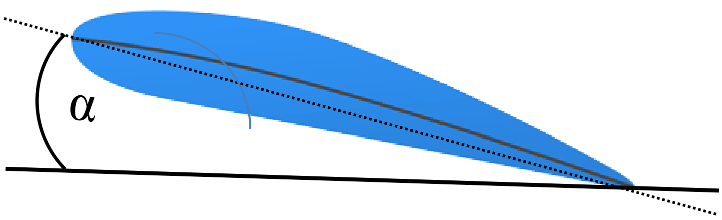


Figure 12. Angle of attack (α) without flap.

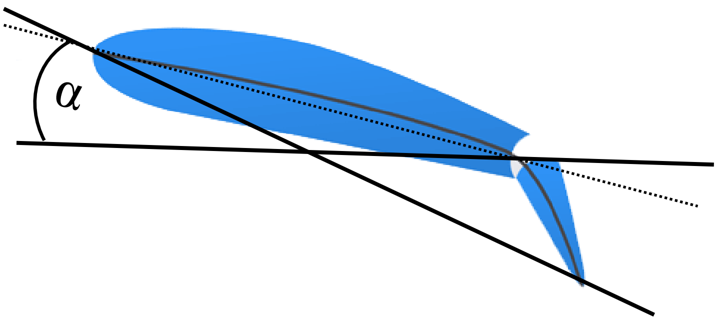


Figure 13. Angle of attack (α) with extended flap.

Figure 14 below shows a wing in profile and how the airflow separates from the upper side of the wing as the angle of attack increases.

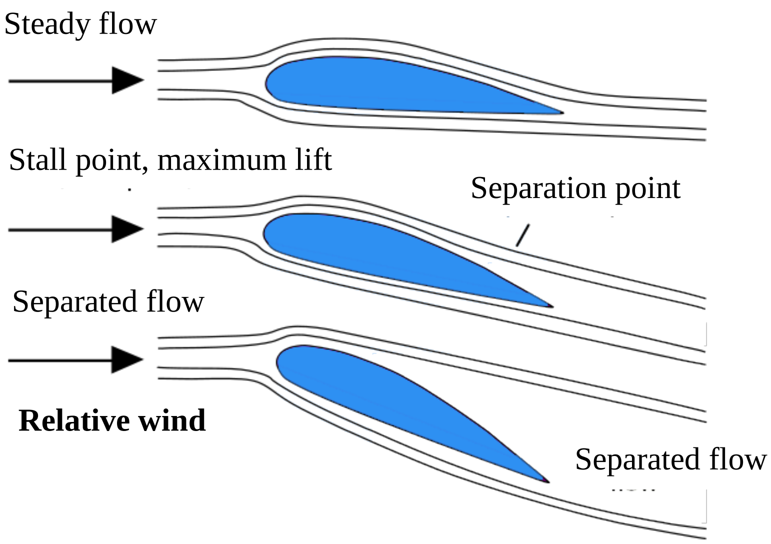


Figure 14. Angle of attack and airflow.

*The pilot operating handbook (POH)*

The POH describes stall as follows:

*"The stall characteristics are conventional. An approaching stall is indicated by a stall warning horn which is activated between five and ten knots above stall speed. Mild airframe buffeting and gentle pitching may also precede the stall. The gross weight stalling speed with power off and full flaps is 44 knots indicated. With the flaps up this speed is increased. Loss of altitude during stalls varies from 100 to 275 feet, depending on configuration and power."*

According to the POH the best angle of climb speed ($V_x$) is 63 knots and the best rate of climb speed ($V_y$) is 79 knots.

SHK could not find any instruction handling of stalls after take-off in the operator´s training material.

### *1.16.4 Angle of attack*

Figure 15 shows a screen dump from the GoPro video recording over the right wing when passing the threshold markings on the parallel grass runway. The wing has stalled at this point, whereafter the pitch angle has decreased and the aircraft descended and impacted in the field after the end of the runway.

Figure 15. Screen dump from GoPro film over the right wing of the aircraft during the event.

Based on the video film from the camera on board the aircraft, SHK has made a calculation of relative pitch angle. The measured angle is not exact but is dependent on roll angle, ground slope, asymmetry in the object and altitude, which means that the results should only be used to see how the pitch angle changes and not be seen as an exact value of the aircraft's attitude in the pitching plane. The angle increased by up to 15 degrees after lift-off and it was over 10 degrees all the way until the passing of the runway end.

### *1.16.5 Examination of fuel*

SHK has commissioned Exova AB to perform an analysis of the fuel from the aircraft's wing tanks. The result of the analysis shows that the fuel had a low to very low degree of contamination. The measured values for the distillation characteristics were within the limit values for ASTM D 910, which is the standard specification for aviation fuel 100LL.

### *1.16.6 Sound test with ANR headset*

SHK has performed reference flights with an aircraft of the same model and headphones of the same type as the crew were using during the accident in order to investigate the extent to which the stall warning sound is filtered out by the ANR system.

The tests were performed with ANR activated and deactivated in order to compare the difference. A microphone was inserted under the right ear cup.

The tests were performed at an altitude of 2 000 feet with an indicated airspeed between 40 and 55 knots at the same time as the engine's speed was 2 400 RPM. During the test, the stall warning system was activated and a constant sound warning was heard.

The tests show that the stall warning is clearly heard even with the ANR function activated.

## 1.17 Organisational and management information

### *1.17.1 The ATO*

The training was carried out by Blue Skies Aviation Oy, a Finnish approved training organisation (ATO) with permit number FI.ATO.2014 with authorisation to provide training for, inter alia, PPL(A), which was registered in Vesivehmaa, Finland.

*Short field take-off*

According to the training manual, the syllabus includes training short field take-off. However, no specific procedure for how this is to be done is described.

However, the POH describes the procedure for short field take-off. According to the manual, rotation is to be commenced at an indicated airspeed of 52 knots and with 25 degrees of flap extended.

*Procedure for stall*

The POH describes, among other things, how the stall warning system is activated and the consequences of a stall as regards altitude loss.

Blue Skies' training manual specifies different types of stall that are to be reviewed in the theoretical part of the training and that these are to be trained with an instructor.

However, neither the POH nor Blue Skies' training manual contains any procedure for how to handle a stall in situations other than in connection with landing, e.g. as in this case after take-off.

Blue Skies ATO has an implemented SMS[13] in which risks in its operations have been identified. Among the risks that have been identified is stall. Stall has been graded at risk category 6, which means that the degree of severity has been assessed as high but that it also has been assessed as unlikely to occur. Following risk reduction measures, including training of personnel, the risk category has been lowered to 3 and the probability has decreased to extremely unlikely.

*Rejected take-off*

Blue Skies' syllabus includes training rejected take-off. However, it is not stated when it might be relevant to reject a take-off.

### *1.17.2 Actions taken*

None.

[13] SMS – Safety Management System.

## 1.18 Additional information

### *1.18.1 Calculation of required take-off distance*

The instructor has reported that the aircraft mass at the time of take-off was 1 125 kg, which corresponds to 70 kg over the maximum permitted take-off mass. There is no basis for calculating take-off distance for the gross weight in question.

However, SHK has calculated the required take-off distance by means of the performance data for the aircraft according to the POH for maximum permitted take-off mass and based on the following conditions:

- Mass – 1 055 kg (max take-off mass)
- Flap – 25°
- Outside air temperature – 19°C
- Pressure altitude – 611 feet, which corrected for QNH 1 007 hPa corresponds to 791 feet.

SHK's calculations (see Table 1) show that the required take-off distance was well within the available runway length of 850 metres. However, the aircraft rotated too early compared with the required roll distance.

| Wind | Roll distance | Height of 50 feet |
|---|---|---|
| Zero | 350 metres | 530 metres |
| 5 knots tailwind | 426 metres | 640 metres |

Table 1. Calculated required roll distance and take-off distance to height of 50 feet.

# 2. ANALYSIS

## 2.1 Sequence of events

### *2.1.1 Circumstances*

The instructor made a decision on runway for take-off based partly on the details about ground wind that were reported by the AFIS[14] Officer at the airport in Mora in connection with the earlier approach to Siljansnäs and partly by analysing the windsock that had overshadowing terrain in the wind direction. According to SMHI's analysis, the wind in the area was north-easterly ten to fifteen knots with gusts up to twenty knots and with the risk of turbulence. SHK notes that because of the gusty wind it is possible that some wind shear may have occurred with an increasing tailwind at altitude.

According to the interviews that have been conducted, the aircraft was refuelled in order to achieve a maximum take-off mass. The details that SHK has obtained show that the aircraft's take-off mass was 70 kg over the maximum permitted or 18 kg over the increased take-off mass that the aircraft would have had if the previously described modification had been carried out. However, SHK considers this to have been a minor factor for the outcome. Exceeding the aircraft's limitations does, however, lead to increased risks. Furthermore, there are no performance calculations for the aircraft type outside the limitations.

Already upon landing in Siljansnäs, the crew had exceeded Blue Skies' maximum duty time for the day by one hour and thirteen minutes. At the time of take-off, the duty time had been exceeded by two hours and eleven minutes. SHK's opinion is that the exceeded duty time has probably not had any influence on the event.

The POH describes a procedure for short field take-off. After acceleration to the specified airspeed, rotation shall be executed and a certain airspeed maintained until obstacle clearance is attained. In the interviews that SHK has conducted, there have been different details about which rotation speed was used. Both 43 knots and 50 knots have been mentioned. The recommended rotation airspeed according to the manual is 50 knots at maximum take-off mass and 52 knots at the maximum take-off mass that would have applied if the aircraft had been modified. An overload causes a further increase of the stall speed. However, the manufacturer has not reported any such calculations since the aircraft is then outside its permitted limitations, i.e. its flight envelope.

[14] AFIS (Aerodrome Flight Information Service) – Airport service at smaller airports for weather conditions and air traffic information.

SHK's analysis of the ground speed at rotation shows that the aircraft rotated earlier than at the POH recommended airspeed. This indicates that a tailwind condition did not exist in the initial stage and that they had made use of the lower of the stated airspeeds at rotation.

### *2.1.2 Sequence of events*

Before take-off, the crew had decided on a rotation speed that was lower than the one that was prescribed for maximum take-off mass. The aircraft was airborne for a few seconds and then sank back onto the runway on two occasions while the stall warning was sounding uninterruptedly. The instructor assumed control of the aircraft in order to attempt to get the aircraft back in the air.

The sound from the stall warning came from a loudspeaker under the instrument panel. The crew has stated that they did not initially hear the stall warning and that this could be because they were using headphones with an ANR function that filters out external sounds. However, SHK's tests show that sounds with the frequencies corresponding to the stall warning are heard clearly even if ANR headphones are used. A slight right turn was executed in order to avoid terrain ahead. A turn at that low speed probably worsened the situation further during the time the aircraft was in the stall condition.

The instructor assumed control of the aircraft after the student had not succeeded in getting safely airborne. The remaining runway that they had in front of them was sufficient to reject the take-off while the aircraft was still on the runway. That this was not done even though there were still enough runway margins, might have been because there was no instruction in the operator's training plan for when a take-off sequence is to be rejected, e.g. when the aircraft had not become airborne by a predetermined point on the runway.

The POH describes when stall occurs with the flap retracted and fully extended, respectively, but not when the aircraft stalls at twenty-five degrees of flap. The manual describes that the aircraft stalls conventionally.

Obstacle clearance distance in the direction of climb out was just over 200 metres after the runway threshold. Slightly to the right, obstacle clearance increased up to 560 metres, which was the reason why a right turn was commenced. The terrain ahead might also have taken the instructor's attention during the stall stage. The instructor steering the aircraft to the right in order to avoid terrain ahead explains why the impact did not occur in the extension of the paved runway.

On the instructor's side a GPS screen was mounted on the steering wheel, which caused bodily injuries upon impact. SHK opinion is that operators should perform a risk assessment for the installation of non-certified installations in aircraft.

# 3. CONCLUSIONS

## 3.1 Findings

a) The pilots were qualified to perform the flight.

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

c) The aircraft's mass and balance were outside of permitted limitations.

d) The windsock's placement meant that the wind was disrupted by the terrain in the wind direction in question.

e) There was a risk for some wind shear.

f) According to the POH, a too low airspeed was used at rotation.

g) The student rotated the aircraft at too low airspeed with subsequent stall, which led to the aircraft sinking and touching the runway again.

h) The aircraft became airborne again with a high pitch attitude and stalled with a subsequent secondary stall. The instructor then perceived that the speed had dropped to 40 knots.

i) The aircraft's aural stall warning was active from the rotation until impact. The aural warning did not go out in the internal communication system.

j) The crew were using ANR headphones that reduce external noise.

k) The engine produced maximum available power during the entire sequence.

l) Upon impact, the aircraft yawed 90 degrees to the left. The instructor was injured by a mounted GPS screen.

m) Evacuation was performed in accordance with the checklist.

## 3.2 Causes and contributing factors

The accident was caused by prescribed operational take-off procedures not being applied with regard to the indicated airspeed, which resulted in a flight condition where the drag exceeded the available thrust.

SHK has found several contributing factors such as:

- The mass and balance where outside of permitted limitations, which may have had some effect on the course of events.

- The assessment of the wind conditions might have been adversely affected by the fact that the airport’s windsock stood on the lee side of a forest.
- There were no detailed instructions in the operator’s manual regarding rejected take-off.
- During the latter part of the event, a wind shear might have contributed to the airspeed dropping.
- The manoeuvring towards obstacle clearance resulted in a banked turn, which at the low speed worsened the situation further.

## 4. SAFETY RECOMMENDATIONS

None.

On behalf of the Swedish Accident Investigation Authority,

Jonas Bäckstrand Johan Nikolaou