aibn Accident Investigation Board Norway

Issued April 2020

REPORT SL 2020/07

REPORT ON THE AIR ACCIDENT NEAR ØIAN AIRFIELD IN MERÅKER IN THE COUNTY OF TRØNDELAG, NORWAY ON 7 NOVEMBER 2018 WITH VAN'S AIRCRAFT INC (EX) RV-6, LN-AAL

The Accident Investigation Board has compiled this report for the sole purpose of improving flight safety. The object of any investigation is to identify faults or discrepancies which may endanger flight safety, whether or not these are causal factors in the accident, and to make safety recommendations. It is not the Board's task to apportion blame or liability. Use of this report for any other purpose than for flight safety shall be avoided.

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AIR ACCIDENT REPORT

Type of aircraft:	Van’s Aircraft Inc. (Experimental) RV-6
Nationality and registration:	Norwegian, LN-AAL
Owner:	Private
Operator:	Private
Commander:	1, fatally injured
Passengers:	1, fatally injured
Accident site:	784 meters north of the end of runway 34 at Øian Airfield in Meråker, Trøndelag, Norway, 63° 22' 48.3" N 11° 48' 9.9" E
Accident time:	Wednesday 7 November 2018 at 1509 hours.

All times given in this report are local time (UTC + 1 hour) unless otherwise stated.

ACCIDENT NOTIFICATION

On 7 November 2018, at 1750 hours, the police operations center in Trøndelag notified the Accident Investigation Board Norway’s (AIBN) on-call accident inspector of an air accident at Meråker Airfield Øian in Trøndelag county. Shortly after, it was confirmed that an RV-6 aircraft with registration LN-AAL had crashed and that the two people on board had been found dead. The following morning, three AIBN accident inspectors arrived on the site to start the investigation.

In line with ICAO Annex 13, Aircraft Accident and Incident Investigation, the AIBN notified the US authority National Transportation Safety Board (NTSB), as the aircraft kit had been manufactured in the US. The European Aviation Safety Agency (EASA) and the Civil Aviation Authority of Norway were also notified.

SUMMARY

Earlier that afternoon, the commander and his brother had taken off from Trondheim Airport Værnes (ENVA) for a VFR flight in the local area. The flight went via Selbu and Tydal before heading north towards the Meråker Airfield Øian to do some landing circuits. After the second landing, they came to a complete stop before taxiing back for a new take-off from runway 34. The aircraft lost control shortly after take-off and crashed into dense forest approx. 800 meters north of the end of the runway. The two onboard were fatally injured.

Following its investigation, the Accident Investigation Board has established that the weather conditions at Øian were highly unusual and challenging on the day of the accident. At the time, an extreme temperature inversion occurred in Central Norway. In North-Western Norway, record-high temperatures of 19°C were recorded, while at the same time temperatures near 0°C were registered in Meråker. Calculations have shown that there may have been strong downbursts and rotor winds at Øian Airfield on this particular day. The AIBN finds it likely that the commander unexpectedly entered this weather phenomenon shortly after take-off and lost control of the aircraft, so that it crashed just north of the airfield.

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 The commander left his house in Trondheim in the morning and travelled to Trondheim Airport (ENVA) to fly his private RV-6 type aircraft. The previous evening, it was agreed that his brother would accompany him on the flight. A relative had a cabin in Tydal and one purpose of the trip was to locate this cabin.

1.1.2 It has not been determined when and how preparations were made for the flight. However, an instructor at Værnes Flying Club met the two at the club's premises, at around 1310 – 1330 hours. Among other things, they talked about how the flight plan should be completed. The commander submitted a visual flight rules (VFR) plan for a local flight via Selbu, Tydalen and Meråker.

1.1.3 The RV-6 with registration LN-AAL was parked in the Værnes Flying Club hangar. The aircraft was started up outside the hangar and at 1405 hours the commander contacted air traffic control at Værnes on ground frequency 121.600 MHz. He requested clearance to taxi to the fueling facility to refuel. He received clearance and was also notified of another aircraft approaching the fuel pump. At 1420 hours, LN-AAL made another call on the ground frequency requesting clearance to taxi from the fueling facility to the runway. According to witness observations and the fueling facility log, the LN-AAL did not refuel.

1.1.4 At 1424 hours, LN-AAL called the Værnes control tower on frequency 119.400 MHz and reported that they were ready for line-up on runway 27. They received clearance immediately and were cleared for take-off a few minutes later. They departed from the runway in a westerly direction and made a left turn before heading south-east towards Selbu at an altitude of approx. 1,500 ft and at an airspeed of 120 kt.

1.1.5 At 1427 hours, LN-AAL left the tower frequency and contacted Værnes approach (APP) on frequency 118.600 MHz. They left the Værnes control zone heading towards Selbu. A few minutes later, they requested clearance to climb to 3,500 ft. They received clearance from APP and continued at 3,000 ft in the direction of Tydal, having passed east of Selbu.

1.1.6 During the flight, the commander used a tablet and the SkyDemon navigation program. The AIBN has downloaded data that were stored on the unit. It shows a somewhat incomplete flight plot for the Værnes-Øian flight, where the first part of the flight is not registered (see Figure 1).

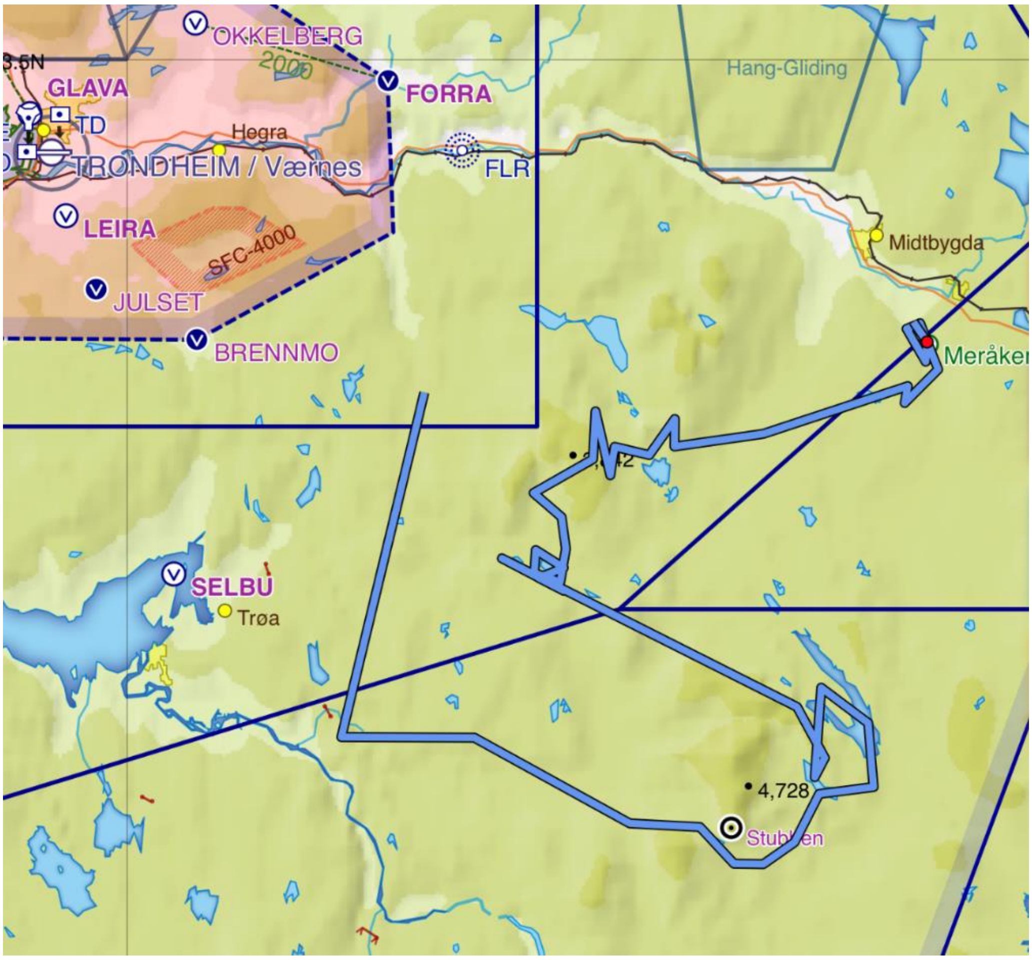

Figure 1: Map plot showing the final part of the flight from Værnes to Øian Airfield. Source: SkyDemon

1.1.7 At 1441 hours, LN-AAL passed a reporting point that had been entered in the navigation program as "Stubben", which is the name of the cabin they were going to fly over. They then headed north towards Esandsjøen and the mountainous area near Fongen.

1.1.8 At 1500 hours, the commander of LN-AAL contacted Værnes approach and reported that they were heading towards Meråker for touch-and-go landings at Øian. They were then 6 NM west-southwest of Øian Airfield flying above Revhaugvollen at 3,400 ft and maintaining an airspeed of 140 kt. Shortly after, LN-AAL disappeared from the radar screen at Værnes approach, as it was flying below the radar coverage altitude in the area.

1.1.9 The SkyDemon map plot (see Figure 2) indicates that they performed a touch-and-go landing, then a full stop followed by a back track on the runway.

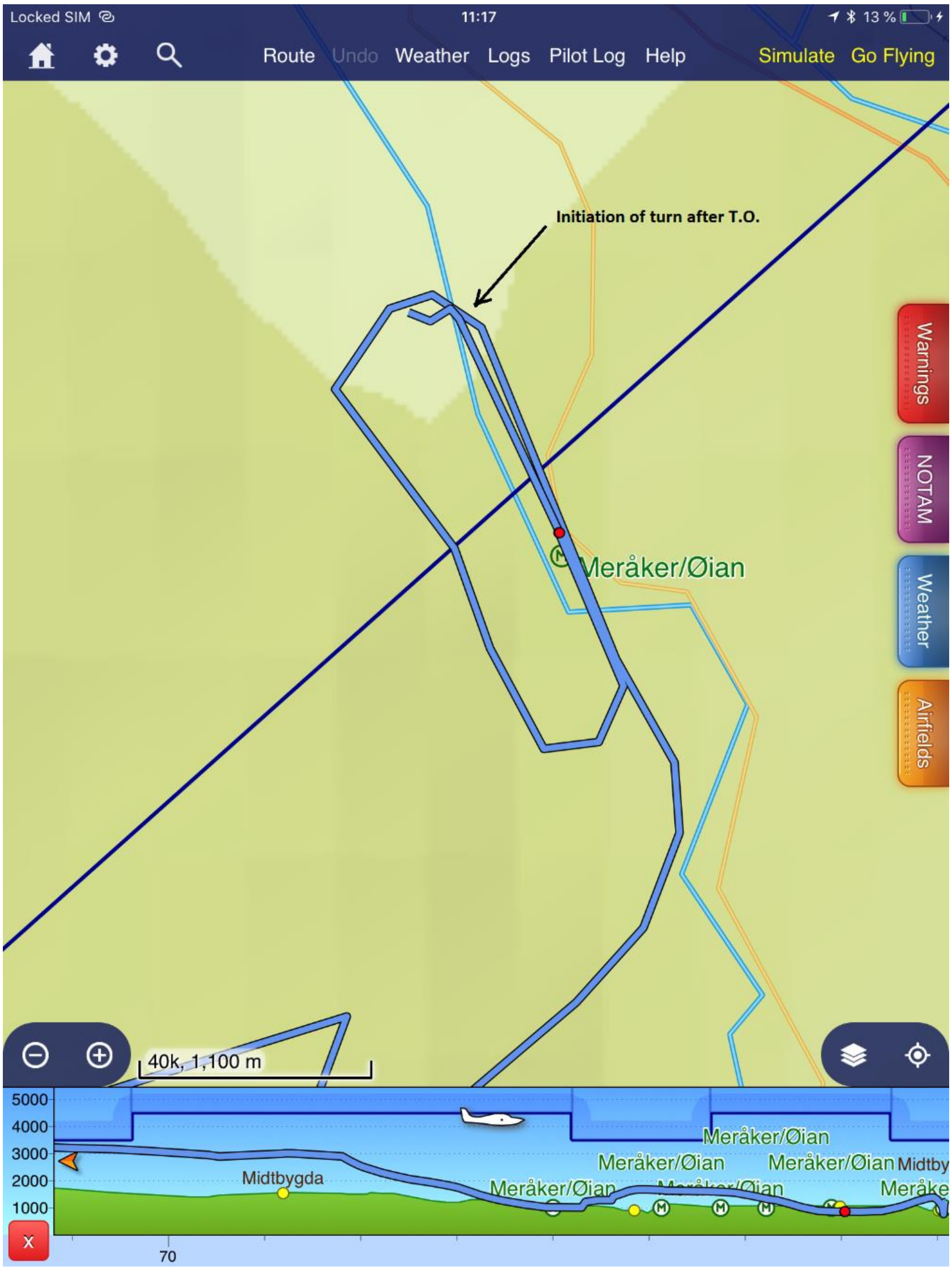

Figure 2: SkyDemon map showing the touch-and-go and the last take-off from Øian Airfield. The red dot indicates that the system briefly lost GPS coverage while the aircraft was on the ground. Source: SkyDemon

1.1.10 At 1507 hours, the commander of a Lancair 235, LN-XKY received a message on his mobile phone with a photo of Øian (see Figure 3) and the text *"ENØYAN intl. Where are you now?"* The commander of LN-XKY was on his way from Kristiansund Airport Kvernberget (ENKB) to Trondheim and had agreed to meet the LN-AAL commander in the air to fly in formation. When the commander of LN-XKY did not receive a reply, he decided to head towards Værnes for landing. The photo was probably taken during back-track before LN-AAL's last take-off from runway 34.

Figure 3: Photo sent from the LN-AAL commander's mobile phone just before take-off. The photo shows the windsock hanging motionless. Photo: LN-AAL commander

1.1.11 A witness who lives close to the airfield at Øian heard an aircraft at the airfield. She was used to aircraft operations in the area and did not notice any particular details about what happened. However, she did look out and saw that the aircraft was parked in the parking area between the runway and the road. She then heard the aircraft take off again. She was not sure how long the aircraft was in the area, but believes it touched down twice. She also believes that the final take-off was in a northerly direction.

1.1.12 A truck driver heading north on county road 6770, which runs parallel with Øian Airfield, has reported hearing an aircraft engine (see Figure 4). He looked left and spotted an aircraft passing his truck and taking off from the runway, approximately 50 meters ahead, to the left of the truck. The aircraft took off approximately 200 meters before the end of the runway and made an apparently normal climb towards the north. It passed 5 – 10 meters above the trees at the end of the runway. As the truck drove on, the aircraft disappeared from view behind some trees along the road. Approximately 310 meters ahead, the driver spotted the aircraft again as the truck passed a clearing in the woods, where there was a power line. The aircraft was then to the left of the truck, almost level with the road. He saw it going into a nosedive and disappearing behind some trees. One aircraft wing was much lower than the other. When asked by the AIBN, he could not verify whether the aircraft had been flying straight or upside down.

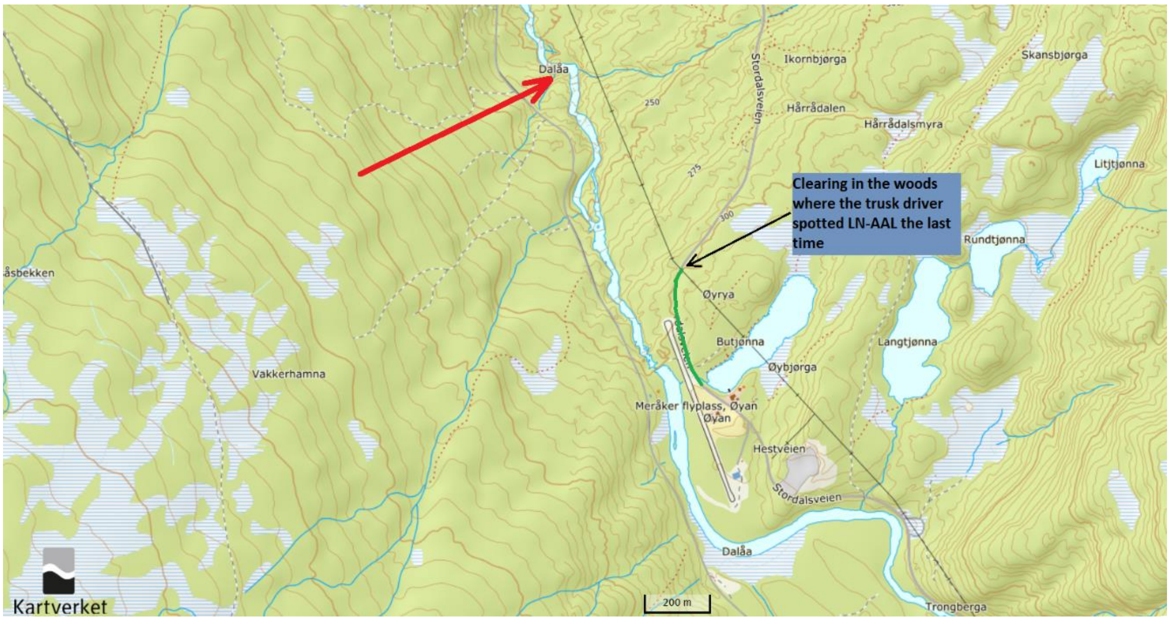

Figure 4: Map of the airfield and the crash site (indicated by a red arrow). The road section which the truck driver drove along while observing parts of the flight is indicated in green. Map: © The Norwegian Mapping Authority. Illustration: AIBN

1.1.13 The driver looked for the aircraft again, but did not spot it, nor did he see any smoke or signs of a crash. However, he was quite sure that he had witnessed an accident and subsequently called the police to report what he had seen.

1.1.14 Figure 2 shows the take-off from Øian Airfield. It shows that a turn had been initiated in roughly the same place as LN-AAL had initiated its cross-wind leg turn during the previous touch-and-go.

1.1.15 Information from SkyDemon shows that the last flight had a maximum altitude of 1,360 ft and a maximum airspeed of 79 kt.

1.1.16 Later, the truck driver and representatives from the AIBN, drove the same section of county road 6770 that the truck had taken previously. They used a stopwatch to estimate the time it took. Due to an icy road, they drove at a speed of 50 km/h during the reconstruction. It then took 22 seconds from the place where the aircraft was observed taking off from the runway to the place it was seen disappearing behind the trees. The truck driver believes he drove a little bit faster when he observed the aircraft on the day of the accident.

1.1.17 At 1532 hours, the Værnes control tower received information from the Joint Rescue Coordination Centre Southern Norway (JRCC-S) confirming that LN-AAL's Emergency Locator Transmitter (ELT) had been activated. They contacted Værnes approach and asked them to contact the aircraft. Værnes approach made several attempts but did not receive a reply. Attempts at contact were also made via a SAS and a Widerøe aircraft that both passed the accident site. They also failed to make contact but confirmed that they heard the ELT signals.

1.1.18 At 1548, LN-XKY landed at Værnes after its flight from Kvernberget. Værnes tower asked the commander if he had enough fuel to fly towards Meråker to look for LN-AAL. The commander accepted the request, and after two minutes, LN-XKY took off again heading east towards Øian Airfield.

1.1.19 LN-XKY was flying north of the usual course to Øian when it encountered heavy turbulence in the Kulåsen area, a couple of kilometers north of Flornes in Stjørdalen, approximately 20 km northwest of Øian. The commander experienced such severe turbulence that he decided to return to Værnes, having seen no signs of LN-AAL.

1.1.20 The JRCC initiated a search operation using a Sea King helicopter from Ørlandet and a Bell 412 helicopter stationed at Røros in connection with the Trident Juncture military exercise. At approx. 1700 hours, the accident site was located in woodlands about 800 meters northwest of the end of Øian runway, and the search was called off. The commander and his brother were found dead on board.

1.2 Injuries to persons

Table 1: Injuries to persons

Injuries	Crew	Passengers	Others
Fatalities	1	1	
Serious			
Minor/none			

1.3 Damage to aircraft

The aircraft was destroyed. See Chapter 1.12.2 and 1.16 for details.

1.4 Other damage

There was damage to four fir trees and run-off of about 6 liters of engine oil to a stream leading to the Dalåa river.

1.5 Personnel information

1.5.1 <u>Commander</u>

1.5.1.1 The commander was an experienced commercial pilot. He had been employed by Widerøe since 1997. He started as first officer of a Dash-8 (DHC8) and was upgraded as commander for the same aircraft type in 2004. He held an Air Transport Pilot License - ATPL(A) with type rating for Dash-8 in addition to instrument rights IR(A) ME. He also had a valid type rating for single engine piston (SEP) aircraft. His last OPC/PC[1] was performed in a flight simulator on 17 March 2018 and was valid until 31 March 2019.

1.5.1.2 The commander had also been checked out to fly several light aircraft like e.g. Cessna 172, Cessna 177RG, Piper PA-28 and Saab Safir. Furthermore, he had conducted several acro flights with the latter aircraft type, together with an instructor from Værnes flying club. He purchased LN-AAL in the spring of 2018 and had logged a total of 31:00 flight hours on the aircraft.

1.5.1.3 He held a class 1 medical certificate valid through 5 May 2019. However, in the months before the accident, he had been on sick leave and had not been at work since 2 August 2018 (see 1.13.4).

[1] OPC/PC Operator's Proficiency Check / Proficiency Check

Table 2: Flying hours commander

Flying hours	All types	Relevant type
Last 24 hours	0:40	0:40
Last 3 days	0:40	0:40
Last 30 days	0:40	0:40
Last 90 days	2:15	2:15
Total	8 388:52	31:00

1.5.2 The passenger

The passenger was the commander's brother. He was an aviation enthusiast and had accompanied the commander on several flights. This includes at least one known occasion where the commander let his brother fly the aircraft.

1.6 Aircraft information:

1.6.1 General information

Van's Aircraft RV-6 is a homebuild, low-wing aluminum construction aircraft, which is sold as a kit. It is a two-seat side-by-side aircraft with a fixed undercarriage and a tail-wheel. LN-AAL was amateur-built by a previous owner from a kit manufactured by Van’s Aircraft Inc. in the US. The Civil Aviation Authority granted LN-AAL a special certificate of airworthiness in 1996. The RV-6 aircraft type is popular with amateur aircraft builders and, including other similar models supplied by Van's Aircraft, a total of 10,400 aircraft have been built. The commander acquired the aircraft in April 2018.

1.6.2 General data

Serial number:	21149
Length:	6.15 meters
Wingspan:	7.01 meters
Height:	1.60 meters
Engine:	Lycoming O-360-A1AD
Engine output:	180 hp at 2,700 rpm
Total flight hours:	557:13 hours
Certificate of airworthiness	Valid until 8 June 2019

Figure 5: LN-AAL. Photo: Private

1.6.3 Performance

1.6.3.1 Test flights with LN-AAL have shown that the suitable take-off speed was 55 kt, and the best climb speed was 95 kt. The test flights also showed that the best climb angle was achieved at a speed of 80 kt and the optimal climb rate was achieved at 113 kt (2,000 ft/min).

1.6.3.2 According to the Pilot Operating Handbook (POH) the stall speed for RV-6 without flaps is 65 mph (56.5 kt).

1.6.4 Maintenance

1.6.4.1 Last maintenance on the aircraft, a 100 hours/annual inspection, was performed on 19 May 2018. At the time, the aircraft's total time was 534:25 hours. There were no remaining items in the aircraft flight log.

1.6.4.2 No daily inspection had been signed off prior to the flight on 7 November. Consequently, it has not been possible to ascertain whether daily inspections of LN-AAL were performed prior to take-off, nor can it be confirmed that the aircraft water separator was drained of water. According to previous AIBN investigations involving GA aircraft, daily inspections are frequently not logged in the aircraft flight log prior to take-off.

1.6.5 Fuel

1.6.5.1 LN-AAL had a fuel tank in each wing, with a total capacity of 140 liters. The left fuel tank was fitted with a flexible hose connected to the fuel intake (pendant hose). This made it possible to supply the engine with fuel even if e.g. the aircraft was flown inverted. The tank on the right had an ordinary fuel outlet at the bottom of the tank. A fuel selector in the cockpit could be set to position left, right or closed.

1.6.5.2 According to the fuel facility's log for AVGAS 100LL at Værnes, LN-AAL refueled 104.3 liters on 1 September 2018[2]. According to the flight log, the aircraft had 140 liters of fuel on board. LN-AAL subsequently made three flights. Only the first flight from Værnes to the private grass airfield Ler was logged, with 20 minutes' flight time. LN-AAL then flew to Ørland (ENOL) and back to Værnes. The last two flights were not logged, but in total the three flights are estimated at one hour.

1.6.5.3 The next refueling at Værnes took place on 28 October 2018. At the time, 67.9 liters were filled. Although it has not been logged in the aircraft flight log, the tanks were probably full, i.e. they contained 140 liters before take-off from Værnes on 28 October. Air traffic control has reported that the flight time was 40 minutes.

1.6.5.4 The commander did not refuel on 7 November. At the time of the accident, the aircraft had consequently been airborne for 83 minutes since the last refueling. The aircraft flight log indicates that the aircraft consumed 32 – 38 liters of fuel per hour. This is in line with the experience of other RV pilots, who have reported consumption of 32 – 36 liters per hour. Estimating an average consumption of 34 liters per hour, the aircraft would have consumed 47 liters of fuel at the time of the accident. This means another 93 liters remained in the fuel tanks.

1.6.6 Mass and balance

1.6.6.1 LN-AAL was last weighed on 10 August 2015. At the time it was established that the final mass was 1,094 lb and the center of gravity 69.87” behind datum.

Table 3: Estimated mass and balance at take-off from Værnes

	MASS (lb)	ARM (in) behind datum	MOMENT (in lb)
Final mass	1,094	69.87	76,437
People	379	87.40	33,125
Fuel	146	70.00	10,220
Total	1,619	74.00	119,782

1.6.6.2 The maximum allowed take-off mass is 1,600 lb. According to the AIBN's calculations, the total mass at the start of the flight was 1,619 lb, which is 19 lb above the maximum allowed take-off mass. 40 minutes into the flight with an estimated average fuel consumption of 34 liters per hour, the fuel level would have been reduced by 22.7 liters. This corresponds to a weight reduction of approx. 50 lb, meaning that the take-off mass was approx. 1,569 lb, and consequently within the maximum allowed take-off mass upon take-off from Øian Airfield. The center of gravity must be 68.7” – 76.8” behind datum, and the AIBN's calculations show that the aircraft was within the permitted values during the entire flight.

[2]The AIBN has looked into whether the aircraft may have refuelled at another location than Værnes during the period, but has not found anything to confirm that this was the case.

1.7 Meteorological information

1.7.1 METAR and TAF for Værnes

All times given in this chapter are Universal Time Coordinated (UTC).[3]

ENVA 071320Z VRB03KT CAVOK 04/02 Q1014 NOSIG RMK WIND 670FT VRB02KT=

ENVA 071350Z 00000KT CAVOK 04/02 Q1014 NOSIG RMK WIND 670FT VRB02KT=

ENVA 071420Z VRB03KT CAVOK 02/01 Q1014 NOSIG RMK WIND 670FT 10003KT=

ENVA 071100Z 0712/0812 10007KT CAVOK PROB30 TEMPO 0719/0809 16017G27KT=

1.7.2 Temperature recordings

1.7.2.1 Several exceptionally high temperatures for the time of year were recorded on the day in question. The following five weather stations registered the highest temperatures in the country:

Ytterøyane lighthouse (new county record for Sogn og Fjordane):	19.4 °C
Kråkenes:	19.2 °C
Etne (new county record for Hordaland):	18.3 °C
Svelgen:	18.2 °C
Gullfjellet (345 masl.):	18.1 °C

1.7.2.2 Observations in Meråker, 14 UTC and 15 UTC:

Vardetun (169 masl.): +4.1 °C, +2.8 °C

Norwegian Public Roads Administration station (465 masl.): +0.8 °C, +0.8 °C

1.7.3 Analysis from Norwegian Meteorological Institute (MET) researcher/senior meteorologist

1.7.3.1 *On 7 November 2018, the weather situation was characterized by a high pressure in the east and a low pressure in the west. The pressure gradient was not strong. However, extreme temperature differences at lower levels formed density gradients which contributed to a greater pressure difference. In addition, there was a low-level wind pushing air from Sweden towards the coast of Norway. The warm air at high altitudes created record-high temperatures in Western Norway that day, and the highest registered temperature was 19.4 °C, measured at Ytterøyane lighthouse in Sogn og Fjordane. At the same time, temperatures as low*

[3] For an explanation of meteorological abbreviations, see: https://www.ippc.no/ippc/index.jsp

as 0.8 °C were recorded near Meråker Airfield. Moreover, there was a south-easterly breeze of 15-20 kt at lower levels, but hardly any wind at higher altitudes. The wind picked up again at 30,000 ft, turning towards the south-west.

The strong low-level inversion with a certain wind field formed mountain waves, which most likely broke at higher altitudes as the wind decreased and then changed direction (critical level[4]) with increasing altitude. A 500 m resolution model indicates potential downslope winds and rotors in the Øian area (see Figure 6 and Figure 8). The 500 m model also indicates areas with moderate turbulence and moderate downdrafts on the leeward side of the mountains in this area. The exact location of the rotor does not need to be the same as predicted by the model, and such phenomena may fluctuate in time and space.

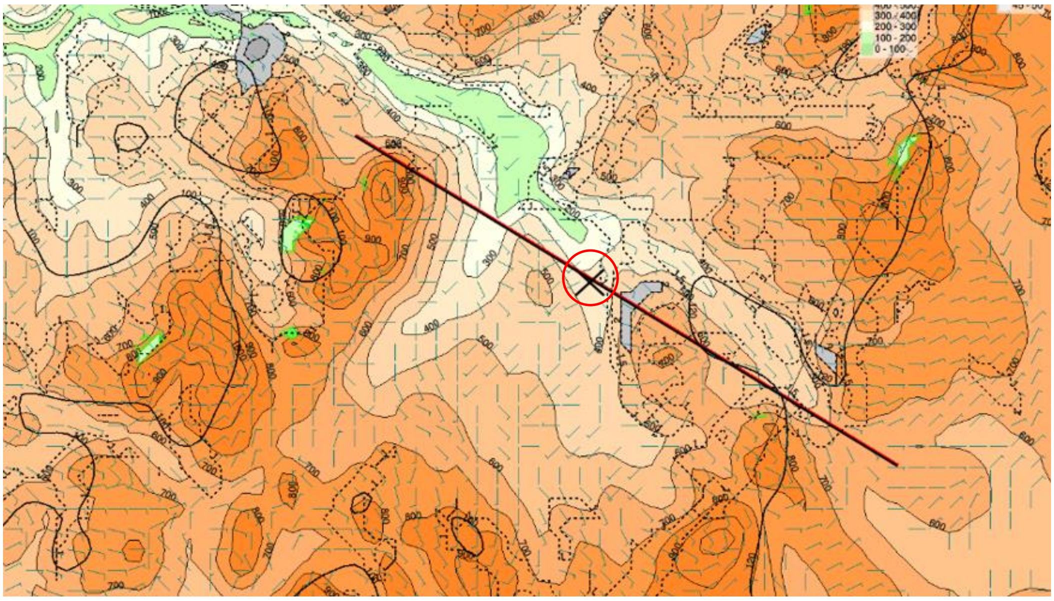

Figure 6: The figure shows wind and turbulence in the Meråker area at 1500 hours on 7 November 2018. The black line shows the cross-section used in Figure 8, and the grey fields indicate areas of turbulence. Øian Airfield is indicated by a black, circled X. Source: The Norwegian Meteorological Institute

1.7.3.2 Due to the special weather conditions, the AIBN requested an analysis from a researcher/senior meteorologist specializing in mountain waves. He ran a numeric weather prediction model with a much higher resolution (500 m between the grid points and 90 vertical layers) than the operational version of the model (2,500 m between the grid points and 65 vertical layers) covering a small area above Trøndelag (see Figure 7). The fine scale model indicates more detailed structures associated with the wind conditions around Øian. Among other factors, the model shows more turbulence and a pronounced rotor (see Figure 8 and Figure 9), of which there were no indications in the operational model. Such a high-resolution model was essential to be able to prepare a satisfactory meteorological assessment of the special weather situation.

[4]Theories describing currents over mountains and mountain waves define a critical level as a level in high-altitude strata up-current or above a mountain where the wind velocity (in the same direction as the current over the mountain) is significantly lower than the wind velocity at lower levels just above the mountain (U(z) -> 0, when z increases). This is due to the wave energy being absorbed and reflected to the lower-altitude levels, where it may cause strong winds and turbulence down-current of the mountain. Source: MET

1.7.3.3 The full analysis (in Norwegian only) is available in electronic format at:

https://docs.google.com/presentation/d/1up1q0fUBUNLINGdsdfG6p9JA_zr7FI92B_mr1R89-7w/edit#slide=id.p6

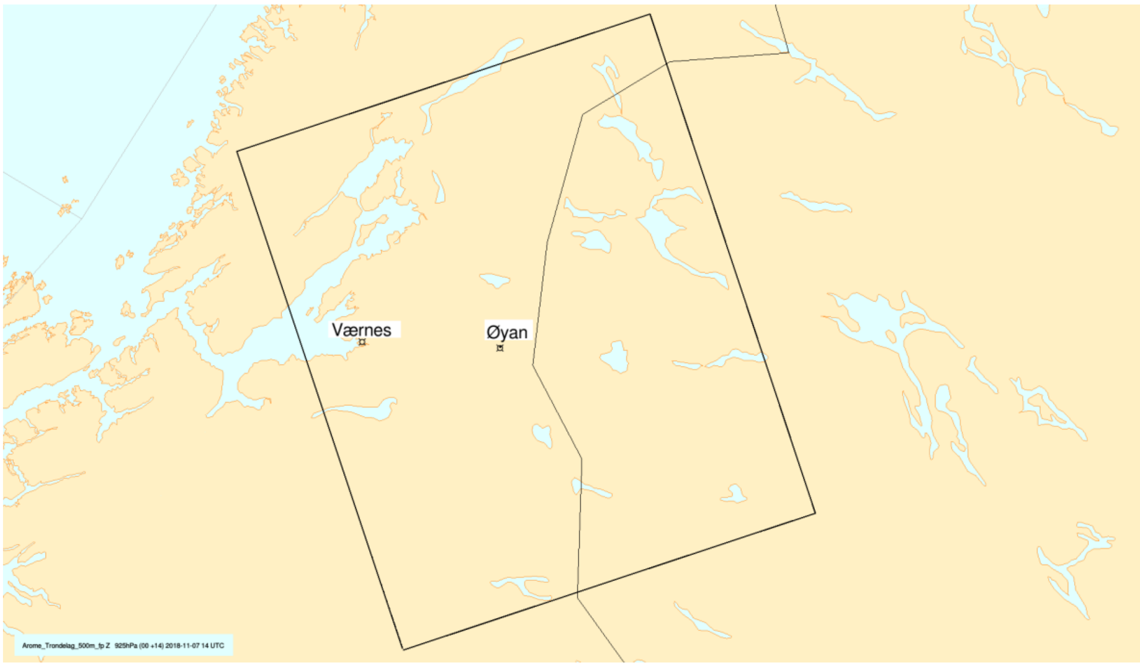

Figure 7: Overview picture of the area used in the model. Source: The Norwegian Meteorological Institute

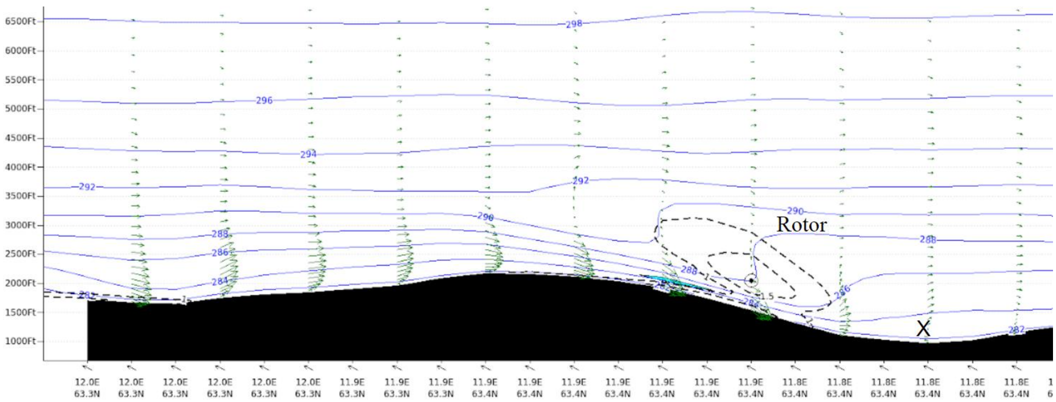

Figure 8: The figure shows tendencies of a hydraulic jump with a turbulent rotor in the area and wind shear downstream of the mountain south-east of Meråker at 1500 hours on 7 November 2018. The blue lines show the potential temperature in Kelvin. The green arrows show the wind along the section. The X indicates the approximate position of Øian Airfield. Source: The Norwegian Meteorological Institute

1.7.4 MEPS chart[5]

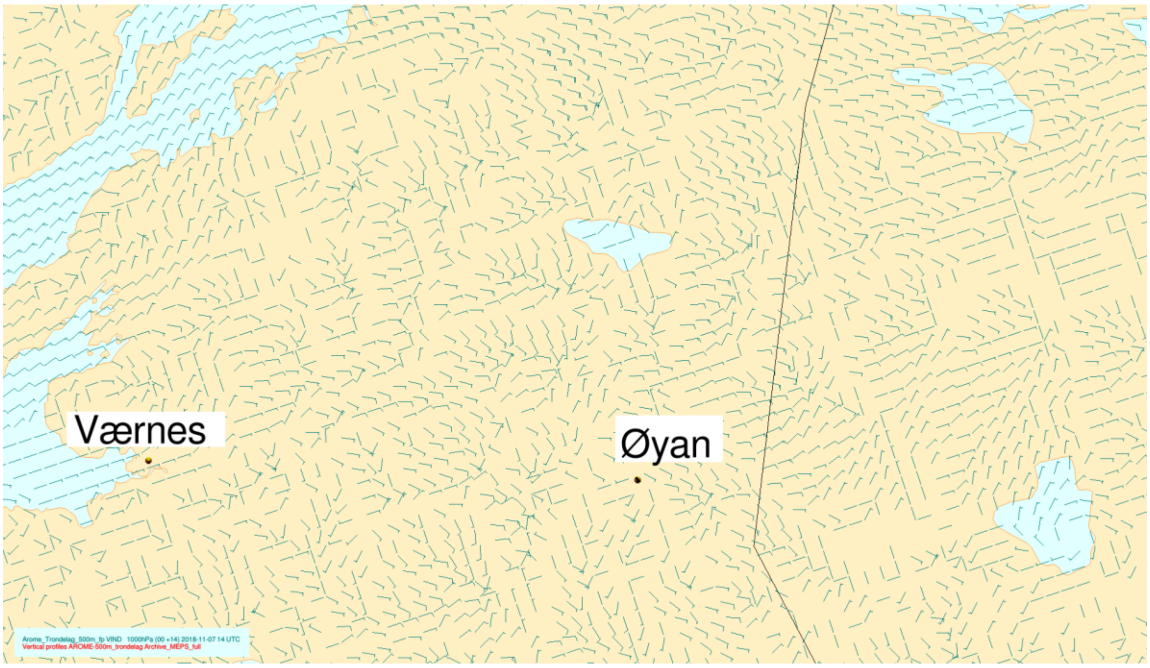

Figure 9: Wind chart - pressure height 1000 hPa (500 m model). Source: The Norwegian Meteorological Institute

1.7.5 Vertical profiles based on model prognoses ENVA

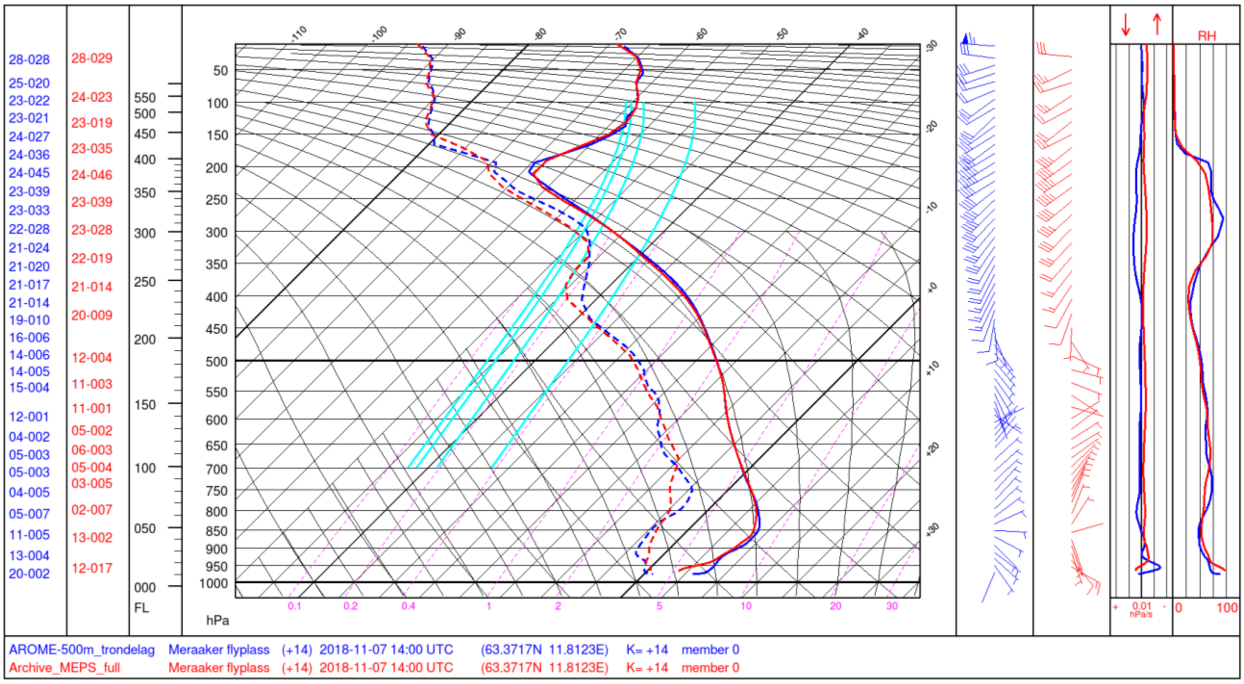

Figure 10: Vertical profile 7 November 2018 at 1500 hours local time (1400 hours UTC) above Meråker Airfield Øian, showing how the temperature (solid line), dew-point temperature (dotted line), horizontal wind (figures and wind arrows), vertical wind (negative values show upwind and positive values downwind) and relative humidity change with the altitude, according to high-resolution model calculations. Source: The Norwegian Meteorological Institute

[5]MEPS (MetCoOp Ensemble Prediction System) is an atmospheric ensemble model covering Scandinavia and the Nordic seas.

1.7.6 Witness observations

1.7.6.1 The information about the severe temperature inversion is supported by witness statements from the Meråker area. The owner of the farm near Øian Airfield had observed frost on the ground by the near the airfield the day of the accident, combined with significantly higher temperatures in areas higher up than the airfield.

1.7.6.2 On the same day, the pilot of LN-XKY (see section 1.1.10) made observations that support the Meteorological Institute analysis. On his way back from Kvernberget, he registered temperatures ranging from 16.5 ° – 17.7 °C at approx. 2,000 ft. The same pilot also flew towards Meråker to look for the LN-AAL but encountered such heavy turbulence that he chose to return to Værnes. This is described in more detail in section 1.1.19.

1.7.7 Turbulence in connection with a strong inversion

Turbulence in connection with a strong inversion is a well-known phenomenon and is referred to in the book *Aviation Weather – FAA advisory Circular* published by the US Federal Aviation Authorities, see extract below and Figure 11:

> *A temperature inversion forms near the surface on a clear night with calm or light surface wind. If the wind just above the inversion is relatively strong, a wind shear zone develops between the calm and the stronger winds above. Eddies in the shear zone cause airspeed fluctuations at a relative speed as an aircraft climbs through the inversion. An aircraft most likely is either climbing from takeoff or approaching to land when passing through the inversion; therefore, airspeed is relatively slow - only a few knots greater than stall speed. The fluctuation in airspeed can thus induce a stall precariously close to the ground.*
>
> *Since surface wind is calm or very light in such conditions, takeoff or landing can be in any direction. If the wind direction above the inversion is not taken into account, the aircraft may encounter a sudden tailwind and a corresponding loss of airspeed when climbing through the inversion, and a stall is possible. If approach is into the wind above the inversion, the headwind is suddenly lost when descending through the inversion. Again, a sudden loss in airspeed may induce a stall.*
>
> *When taking off or landing in calm wind under clear skies within a few hours before or after sunrise, be prepared for a temperature inversion near the ground. You can be relatively certain of a shear zone if the wind at 2,000 to 4,000 feet is 25 knots or more. Allow a margin of airspeed above normal climb or approach speed to alleviate danger of stall in event of a sudden change in wind velocity.*

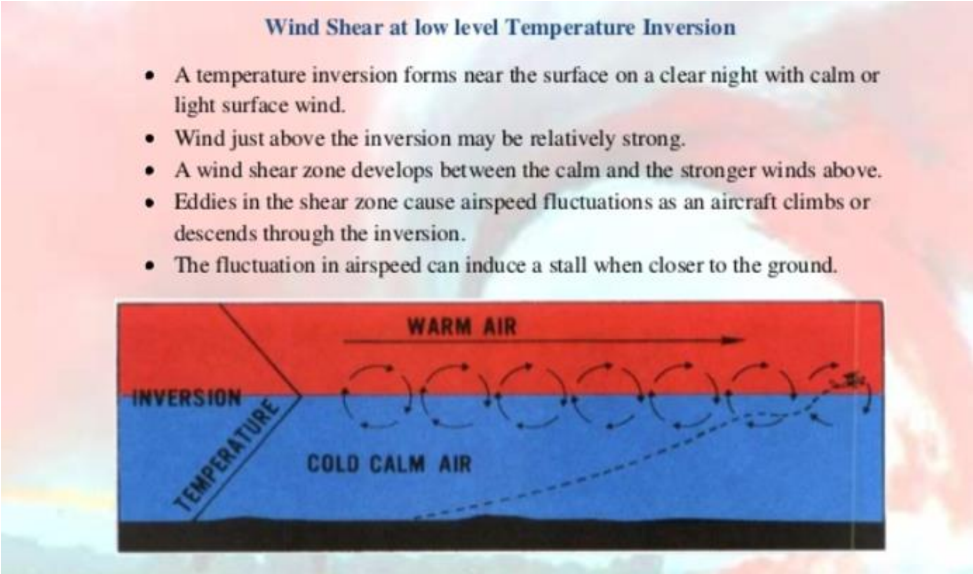

Figure 11: Illustration of wind shear in the event of a temperature inversion. Source: Aviation Weather - FAA Advisory Circular

1.8 Aids to navigation

1.8.1 Navigation took place using visual references and a tablet navigation program. After the accident, two smartphones and an iPad were discovered at the accident site. The AIBN managed to retrieve data from the iPad, showing that much of the flight had been recorded in the SkyDemon navigation program.

1.8.2 SkyDemon is a navigation program for tablets and smartphones and is widely used among GA pilots. It has several functions that make planning and execution of VFR flights easier. In the program, it is possible to enter waypoints which enable flight planning in terms of airspeed, time and fuel consumption. The map shows control zones, restriction areas, radio frequencies and other relevant information for pilots. During the flight, it functions as a moving map, which makes navigation a lot easier. SkyDemon also has a vertical profile at the bottom of the screen (see Figure 2).

1.9 Communications

Normal two-way radio communication had been established between the commander and air traffic control units.

1.10 Aerodrome information

Øian Airfield is privately owned. The 592-meter long and 14-meter wide grass runway has directions 16/34. The airfield is located 308 meters above sea level (1,010 ft) and is surrounded by forest. There is downward sloping terrain north of the end of runway 34. There is a windsock on a barn on the east side of the runway. North of the barn, an area has been prepared for aircraft parking. There is also a hangar near the southern end of the runway. There are no other facilities at the airfield.

1.11 Flight recorders

Not mandatory and not installed.

1.12 Wreckage and impact information

1.12.1 The accident site

1.12.1.1 LN-AAL came to a halt in a streambed, 784 meters straight north of the end of the Øian Airfield runway, see Figure 13). The accident site is situated in rugged terrain with a dense spruce forest, approximately 50 meters from Dalåa river. Several of the trees are about 15 meters tall. The accident site is about 210 meters above sea level and situated approximately 100 meters lower than the Øian Airfield.

1.12.1.2 Before crashing, the aircraft grazed two treetops, 13 and 11 meters from the accident site, respectively. To the right and left of the trees struck by the aircraft, there were two trees with a 4-meters distance between them. There was no damage to these two trees.

1.12.1.3 At the accident site itself, the aircraft had struck two spruce trees, located about 30 cm from each other. The thickest of the two trees was to the right and was 35 cm diameter at the base. This tree was struck 9 meters above the ground. In some places, the bark was stripped off. At the top of the tree, the damage was on the south side, but the furrows on the tree turned westward further down the trunk. There were no branches left below the point of impact on the south and west side of the tree. The force of the impact had uprooted the tree, causing it to tilt about 10° north. The tree had also been broken in two approximately 12 meters above the ground and the top of the tree had fallen to the ground. The other tree was thinner, approximately 15 cm in diameter at the base. It had been splintered and divided in two about a meter above the ground. There were no indications of propeller impact on either of the trees (see Figure 12 and Figure 13).

1.12.1.4 

Figure 12: Photo taken facing north. The top of the photo shows the point of impact 9 meters up on the tree, which was tilted by the impact. The aircraft's right wing is visible to the left of the tree. Photo: AIBN

1.12.1.5 The height of the first two trees' points of impact, seen in connection with the last two trees, indicates that the aircraft descended through the forest at an angle of 40°.

1.12.2 The wreckage

1.12.2.1 *General*

The aircraft was found upside down in a streambed, with its left wing curved around a tree. The fuselage was on the ground facing an approximate direction of 040°. The aircraft was more or less located at one place; only a few minor parts had broken off and were located in the immediate vicinity of the wreckage itself. The propeller, which was located in the middle of the stream, was the lowest part of the wreckage.

Figure 13: Photo taken facing south-west. The aircraft descended over the trees shown in the background in the top left section of the photograph. Photo: AIBN

1.12.2.2 *The fuselage*

The main damage to the wreckage was near the cockpit and the center section. The canopy was broken, and the canopy frame bent down. The top section of the fuselage was indented, and the vertical stabilizer and the rudder bent to the left.

1.12.2.3 *The landing gear*

The right-hand landing gear was bent backwards, at an angle of approximately 20 – 30°. Large sections of the wheel fairing were missing. The break disc was bent as a result of the impact and long wood fibers had become wedged between the wheel and the break disc. The right-hand landing gear was apparently undamaged. The tail wheel had come off but was lying next to the tail.

1.12.2.4 *The wings*

The left wing was severely bent and the section in front of the wing spar was completely destroyed. The left fuel tank was squashed and torn. Both the flaps and the aileron were attached to the wing. The wing tip had been knocked off. The points of impact after contact with the trees are shown in Figure 21.

The forward section of the outer half of the right wing was bent sharply upwards. Parts of the right flaps were also torn off. The right fuel tank was somewhat deformed and punctured in some places. There were no indications of fuel in the tank. Otherwise, the right wing was relatively intact. The wing tip had been knocked off.

1.12.2.5 *The cockpit*

Observations of the cockpit included the following:

- The throttle and mixture controls were pushed all the way forward.
- The engine's tachometer showed 1,000 rpm.

1.12.2.6 *The flight controls*

The flight controls were examined in detail in the AIBN hangar. All control surfaces, except the right-hand flaps, were still attached to their respective control hinges. Although there was some damage to the control hinges, all control surfaces could be moved. The stick grip on the left stick had come loose (pulled up) and was found on its own at the accident site. It was still possible to move the elevators using the left stick. It could also move the rod to the left aileron. However, the aileron mechanism of the left wing was so badly damaged that the aileron could not be moved by the flight controls.

The right stick grip was still attached, but the stick was damaged at the attachment, jammed and thus not able to move the control surfaces. The rod between the right-hand and left-hand sticks had broken at the attachment points by the right stick. The mechanism from the right-hand stick to the right aileron was intact.

The left set of rudder pedals was deformed and jammed. The right set of rudder pedals was intact but connected to the left set and could thus not be moved. The cables from the pedals to the rudder were intact.

The flaps motor was in the full up position. The transfer mechanisms between the fuselage and the flaps were broken.

All breakages and damage to the flight controls are consistent with damage that may have occurred due to overload during the crash.

1.12.2.7 *The engine and propeller*

The engine was attached to the fuselage and seemed to have only minor damage. Both propeller blades were bent backwards, and the propeller shaft flange was bent sharply to the left. The damage to the propeller might indicate that the engine did not produce power when the aircraft struck the streambed. The engine, propeller and the aircraft's fuel system were consequently examined in more detail. This is described in Chapter 1.16.

1.13 Medical and pathological information

1.13.1 The two fatalities were autopsied at the St. Olav Hospital in Trondheim. Both had sustained extensive injuries and it was concluded that they died instantly from the injuries that occurred on impact with the ground.

1.13.2 The two fatalities showed no signs of consumption of alcohol, narcotic substances or medication.

1.13.3 There was nothing to indicate that the commander suddenly fell ill or had a seizure prior to the accident.

1.13.4 The commander had for an extensive period been absent from his job as a pilot for Widerøe due to illness. The AIBN has no information indicating that this was of relevance for the accident.

1.14 Fire

No fire occurred in connection with the accident.

1.15 Survival aspects

1.15.1 The aircraft was equipped with an Artex ME 406 emergency locator, which transmits emergency signals to both the Cospas-Sarsat satellite system and over the 121.500 MHz emergency frequency. At 1530 hours, the JRCC received a notification informing them that the LN-AAL emergency locator transmitter had been detected by the satellite system. The emergency signals transmitted on the 121.500 MHz frequency were only picked up by aircraft in the vicinity of the accident site. This could be because the aircraft landed upside down with the antenna of the emergency locator transmitter under the aircraft.

1.15.2 The aircraft was equipped with a curved frame in the rear part of the canopy, which also functioned as a roll bar. This was knocked backwards and bent all the way down as the aircraft hit the ground upside down. (see Figure 14).

Figure 14: The frame in the canopy, which was bent all the way back and down (left). After the aircraft was turned over, the frame partially returned to its original position. Photo: AIBN

1.15.3 The commander wore a five-point seat belt. The passenger wore a four-point seat belt. Neither wore a flight helmet.

1.16 Tests and research

1.16.1 <u>Examination of the propeller and the front of the engine</u>

1.16.1.1 Both propeller blades were bent backwards. The right propeller blade was more sharply bent than the left one. Furthermore, the propeller shaft flange had in part come off and was bent about 30° to the left (see Figure 16). Neither blade was bent in the plane of rotation. All scratch marks on the front side of the right-hand blade were radial.[6] Most of the scratch marks on the left-hand blade were also radial, but there were also some marks across the blade. At one point on the blade's leading edge, however, the scratch marks were across the blade (see Figure 15 and Figure 16).

Figure 15: Front view of the propeller. The right propeller blade is to the left in the photo. Photo: AIBN

1.16.1.2 The disc that drives the generator belt and holds the starter ring gear in place was shattered and most of the parts were missing. The starter ring gear hung loose around the propeller shaft. There were pronounced marks on the starter and the starter casing was

[6] Radial means the marks spread out from the propeller's central point towards the tips of the blades.

cracked as a result of contact between the starter ring gear and the starter. The generator belt was virtually undamaged. The generator pulley was bent as a result of the impact. The marks from the impact were radial, indicating that the pulley was not rotating at the time of impact. The impact was so severe that parts of the generator casing including the attachment lugs were broken off (see Figure 17).

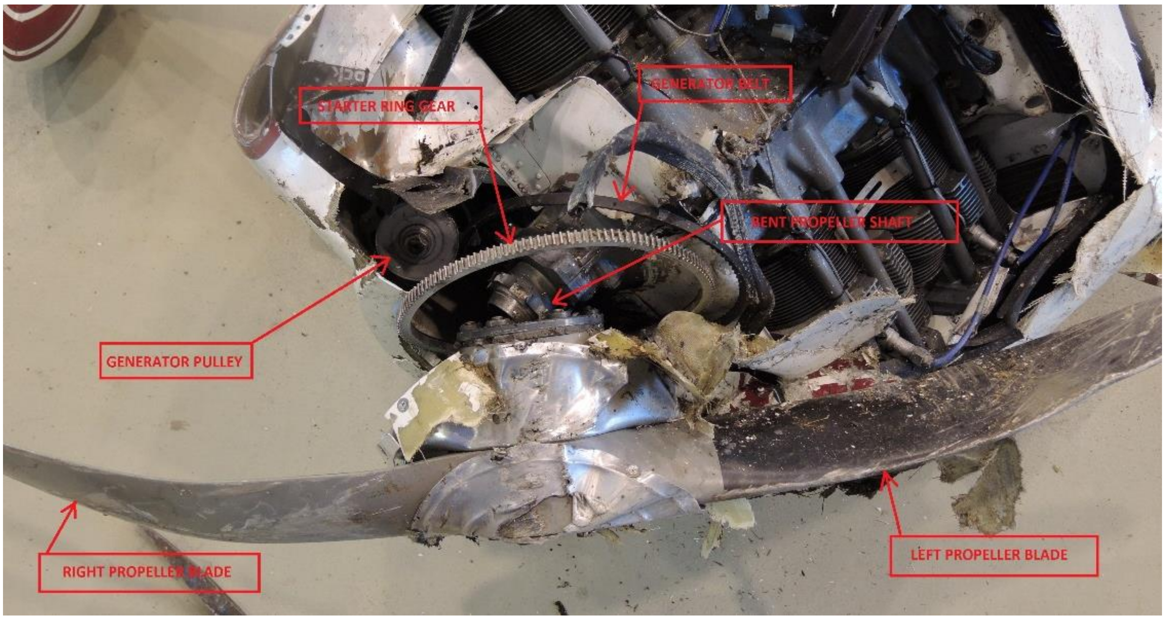

Figure 16: The propeller seen from above. The right propeller blade is to the left in the photo. Photo: AIBN

Figure 17: The generator pulley was bent as a result of the impact. The broken generator casing can be seen at the top of the photograph. Photo: AIBN

1.16.1.3 The AIBN wanted to examine the propeller flange fracture surfaces more closely, hoping to determine whether the propeller flange had been bent while transmitting power from the engine. The propeller was removed from the propeller flange and the Norwegian Armed Forces' chemistry and material technology laboratory service (FOLAT) at Kjeller performed a more detailed examination of the six fracture surfaces. The propeller's retainer bolts were numbered from 1 to 6, where bolts 1 and 2 were closest to the left propeller blade, and bolts 4 and 5 were closest to the right propeller blade. Figure 18 shows the fracture surfaces near propeller bolts 4 and 5.

Figure 18: Parts of the propeller flange and parts of the disc that drives the generator belt and keeps the starter ring gear in place. The arrow shows the opening that formed as propeller bolts 4 and 5 were bent upwards. Photo: AIBN

1.16.1.4 The fracture surfaces by propeller bolts 4 and 5 were examined more closely using a Scanning Electron Microscope (SEM). The purpose was to determine the direction of the fracture surface overload. The examination revealed typical dimples, which are associated with overload. There were few distinct lines on the fracture surfaces that could indicate the direction of the forces that had caused the fractures. However, it was possible to see the direction in some sections of the surface. Figure 19 shows an area where the dimples in some places run in a 20° direction to the right.

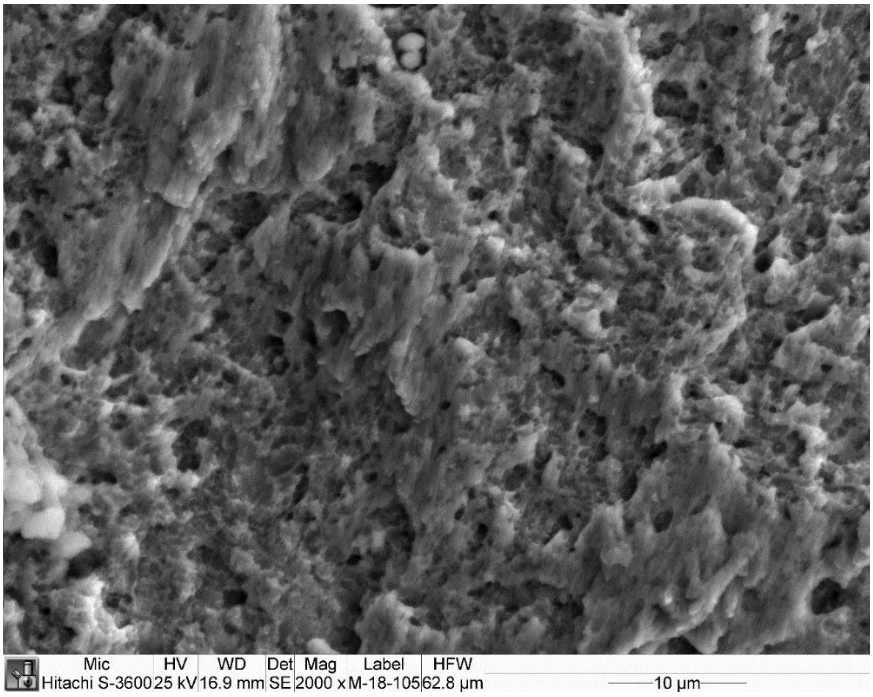

Figure 19: The fracture surface near propeller bolt no. 5. Some places the dimples run in a 20° right direction. Photo: The Norwegian Armed Forces' chemistry and material technology laboratory service (FOLAT)

1.16.2 The engine and the fuel system

1.16.2.1 The engine was dismantled at the AIBN's premises. There was little external damage to the engine. The following was observed:

- At some point, the propeller shaft/crankshaft was so severely bent that the left half of the crankcase fractured by the front bearing. As a result, the oil seal at the front of the engine was broken.
- The cylinder head of cylinder no. 1 was damaged. Several cooling fins were knocked off, the valve cap was dented, the valve mechanism damaged, and the top spark plug broken. The push rod and push rod tube for the exhaust valve were bent.
- The cylinder head of cylinder no. 2 was damaged after impact from the propeller. Several cooling fins were broken and the push rod case and push rod for the inlet valve were bent and flattened.
- The Ellison EFS-4-5 carburetor flange had fractured and the carburetor had partly come off. The choke was fully open.
- The Christen Inverted Oil System was nearly undamaged. The oil cooler and oil separator tank were dented.
- The engine air inlet was undamaged, and the carburetor heating valve functioned as intended. There was some dirt in the air filter, but this did not obstruct the airflow.
- The engine controls were intact and almost without damage.

1.16.2.2 Upon inspection and dismantling the engine, the following was observed:

- Four spark plugs were light brown. Two spark plugs were slightly dark. Two spark plugs were wet with oil, but otherwise looked normal. There was loss of spark within normal values for two of the spark plugs.
- An 80-psi compression test was conducted. To conduct the test, it was necessary to remove the exhaust valve push rods on cylinder no. 1, as well as the exhaust valve on cylinder no. 2. The test provided the following values: 73, 76, 73 and 60 psi.
- After the spark plugs and the broken push rods were removed, the engine rotated freely. The impulse coupling on the magneto tripped at the expected moment[7].
- The engine and the oil sump had almost no oil inside. There was no debris at the bottom of the oil sump.
- The engine oil filter was opened and inspected. There was no debris in the filter beyond what could be expected.
- All internal mechanical engine components were undamaged and well-oiled. The inside of the engine seemed to be in a generally good condition.

[7]The propeller flange was broken, making it difficult to establish the exact angle of the crankshaft.

1.16.2.3 The double ignition magneto, Bendix 10-382555-11, had serial number 15655. According to the component log, it was overhauled by WMT AG in Germany and installed on LN-AAL on 12 May 2015. At the time, the aircraft had a total time of 433 flight hours. At the time of the accident, it was therefore 114:13 hours since the last ignition magneto overhaul.

1.16.2.4 The ignition magneto was tested on bench at Norrønafly maintenance center at Rakkestad. It then supplied sparks to all spark plugs for about 15 seconds, before the sparks suddenly disappeared from the right-hand magneto. The ignition magneto was opened, which revealed that the right-hand breaker did not open and that the gap on the left-hand breaker was small. It was confirmed that the camshaft bearing and the distributor mechanisms were undamaged and that the breaker attachment screws had been sufficiently tightened. Consequently, it was decided to adjust the breaker gap for the left distributor to ensure that it opened as normal. The ignition magneto was then assembled and tested. Again, the ignition magneto supplied sparks to all spark plugs for about 15 seconds, before the sparks suddenly disappeared from the right-hand magneto. In order to troubleshoot, the ignition magneto was tested with a different set of condensers, without it making any noticeable difference. The magneto was then disassembled, yet no defects were discovered. Measurements of the electrical resistance in the primary and secondary coil showed correct values, in accordance with the given specifications. It was subsequently decided to discontinue the work, as it would have been very challenging to identify the exact fault.

1.16.2.5 Upon inspection and dismantling of the fuel system, the following was observed:

- The pendant hose in the left fuel tank was relatively stiff. There was a natural bend in the hose pointing towards the bottom of the tank. However, the hose was so stiff that it could not be bent correspondingly in the other direction. An experiment showed that it straightened but did not bend upwards (downwards if the plane is flown inverted) when affected by gravity (see Figure 20).

- The fuel valve was in the left fuel tank position.

- The electric fuel pump was undamaged and functioned as expected when supplied with 12 V. When turned off, it allowed fuel to bypass through it.

- The extra fuel filter that had been fitted at the front of the firewall was clean.

- The filter in the water separator was clean. Moreover, the water separator was undamaged and contained a small amount of fuel and water (see section 1.16.3.1).

- The engine's fuel pump was undamaged and functioned as expected when tested manually.

- Except for the damage to the flange, the carburetor was intact and undamaged. The carburetor fuel filter was clean.

- There was damage to some tubes and hoses between these components, but all this damage is consistent with damage that could have occurred due to overload during the crash and the subsequent dismantling.

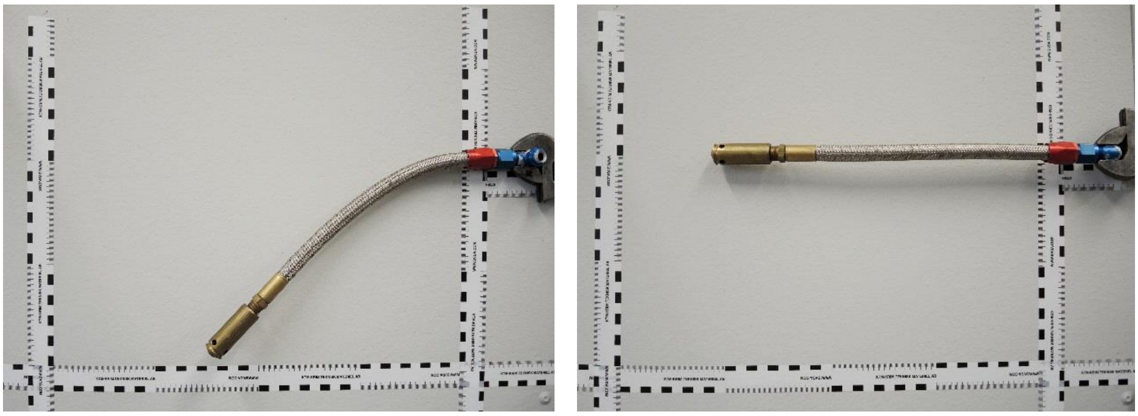

Figure 20: The pendant hose from the left tank. In the picture to the left the hose is in the normal position with the combined pendulum bob/inlet pointing down towards the bottom of the tank. To demonstrate how stiff the hose had become, the hose in the picture to the right was turned upside down. As is shown in the picture, the weight of the pendulum only manages to straighten the hose. It is too stiff to bend down to what would be the bottom of the tank if the aircraft is flown inverted. Photo: AIBN

1.16.3 The amount of fuel in the fuel system

1.16.3.1 When dismantling the aircraft's fuel system, approximately 5 ml of fuel and 1 ml of water were discovered in the water separator. In addition, some fuel was found in the engine driven fuel pump, the carburetor and the hoses between these components. In total, well below 100 ml of fuel was found in the system.

1.16.3.2 The AIBN has measured how much fuel normally fills up the fuel system from the left fuel tank to the engine. The following components were examined:

- The pendant hose in the left fuel tank
- The fuel selector tap
- The electrical fuel pump
- The extra fuel filter
- The water separator
- The motorized fuel pump
- The carburetor
- The 2.5-metre fuel tube/hose

The test showed that this contained a total of approx. 280 ml of fuel.

1.16.3.3 The AIBN assumes that the engine's fuel supply stopped when the engine driven fuel pump started to draw in air. A measurement of the volume in the components from the inlet at the pendulum of the left fuel tank to the engine driven fuel pump, showed that the components contained 220 ml[8].

[8]This excludes the volumes in the carburettor and parts of the fuel hose. Approx. 60 ml.

1.16.3.4 According to the Lycoming Operator's Manual, an O-360-B consumes approx. 67 liters of fuel per hour at full power, corresponding to 180 hp. An O-360-AIAD is presumed to consume the same volume. This corresponds to 1.12 liters per minute. 220 ml would consequently be consumed in approx. 12 seconds.

1.17 Organizational and management information

The flight in question is defined as a private flight, which means that the commander is personally responsible for complying with relevant laws and regulations.

1.18 Additional information

None

1.19 Useful or effective investigation techniques

No methods warranting special mention have been used in this investigation.

2. ANALYSIS

2.1 Introduction

The accident investigation was mainly based on analyses of findings at the accident site and the wreckage, meteorological information, information from the SkyDemon navigation program and witness statements. The AIBN has not had access to information from flight data recorders or from witnesses who have observed the whole accident sequence. The analysis starts with a description of the accident sequence in Chapter 2.2. Chapter 2.3 discusses whether the engine supplied power. Then, in Chapter 2.4, the weather situation on the day in question is analyzed. Based on the available information, the AIBN has assessed several potential courses of events in Chapter 2.5. Finally, the AIBN has assessed aspects relating to survival in Chapter 2.6.

2.2 The accident sequence

2.2.1 Measurements at the accident site indicate that the aircraft passed between two trees located 4 meters apart. In order for a 7-metre wingspan aircraft to pass the two trees without hitting the trunks, it must have flown at an angle (roll) of minimum 55° relative to the longitudinal axis. The damage pattern after the impact, when the aircraft struck two other trees at 9 meters, shows that the left wing must have been lower than the right wing. Furthermore, the damage pattern indicates that the aircraft had rotated another 20° towards inverted, striking the two trees at an angle of about 35°. This corresponds to a roll movement of 145° to the left. The AIBN believes that the aircraft hit the two trees as described in Figure 21 before coming to a halt and plunging into the stream.

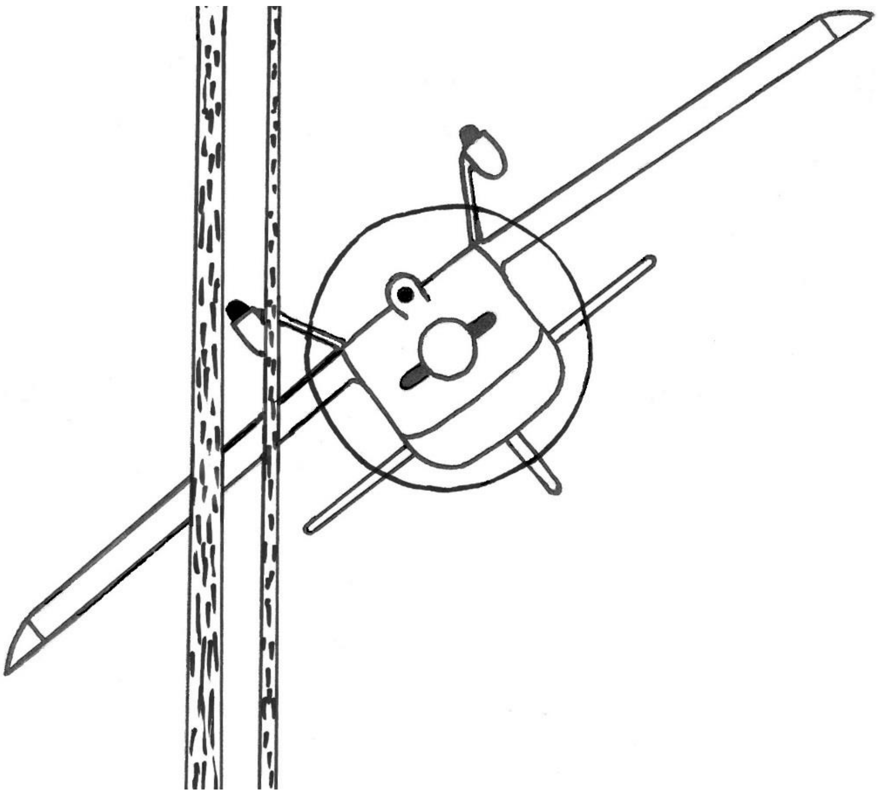

Figure 21: How the AIBN believes the LN-AAL hit the two trees. The aircraft seen from the front. Sketch: AIBN

2.2.2 Measurements at the accident site also indicate that the aircraft descended through the forest with the nose down at an angle of 40°. Overall, the damage to the trees indicate that the aircraft was totally out of control when it crashed into the forest.

2.2.3 Based on witness statements from the truck driver, the take-off from Øian appeared to be normal. Based on the reconstruction, the aircraft was occasionally observed in the air over a period of between 18 and 22 seconds, before disappearing from view (see section 1.1.16.). The truck driver reported that he lost sight of the aircraft as it disappeared behind some trees. Assuming that the aircraft fell for another 2-3 seconds before hitting the trees, the duration of the flight was maximum 25 seconds. This estimate is based on the truck travelling at a speed of 50 to 60 km/h.

2.2.4 The AIBN's calculations of the assumed bank angle and G forces in the turn after take-off from Øian are based on information from the SkyDemon navigation program. (see Figure 22). However, there is some uncertainty related to the accuracy of the SkyDemon information, due to, among other factors, unstable GPS reception in the Meråker area.

Figure 22: Calculation of the turning radius after take-off from Øian Airfield. The outer track is from the touch-and-go, whereas the track nearest the center shows the climb and turn after the last take-off. Source: SkyDemon

2.2.5 The following figures have been used as a basis for the calculation:

Airspeed in the turn: 79 kt corresponding to 91 mph. This is the maximum airspeed registered on the last flight.

Radius in the turn: 55 meters corresponding to 180 ft. This is the assumed radius based on a more detailed examination of the left turn after take-off and before the. The AIBN assumes that the turn started at level flight and this has been used as a basis for the following calculations.

The bank angle calculation formula is as follows:

$$R = \frac{V^2}{11{,}26 * \ tanx}$$

V equals airspeed in kt, R = radius in the turn in ft and x is the bank angle to maintain level flight.

Thus, the calculation is as follows:

$$tanx = \frac{79^2}{11{,}26 * 180}$$

$$tanx = \frac{6241}{2032}$$

$$tanx = 3{,}1$$

$$\underline{x = 72°}$$

According to the AIBN's calculations, the bank angle is consequently 72°.

Taking into account the G forces required to maintain a bank angle of 72° at a constant altitude, the following formula applies where *n* = the number of G:

$$n = \frac{1}{cos\emptyset}$$

$$n = \frac{1}{\cos 72}$$

$$n = \frac{1}{0{,}31}$$

$$n = 3{,}2$$

This means that the G forces in the turn were 3.2 G.

Another interesting calculation is the effect such a sharp turn has on the stall speed. The table below shows the increase in stall speed in percentage in relation to the bank angle:

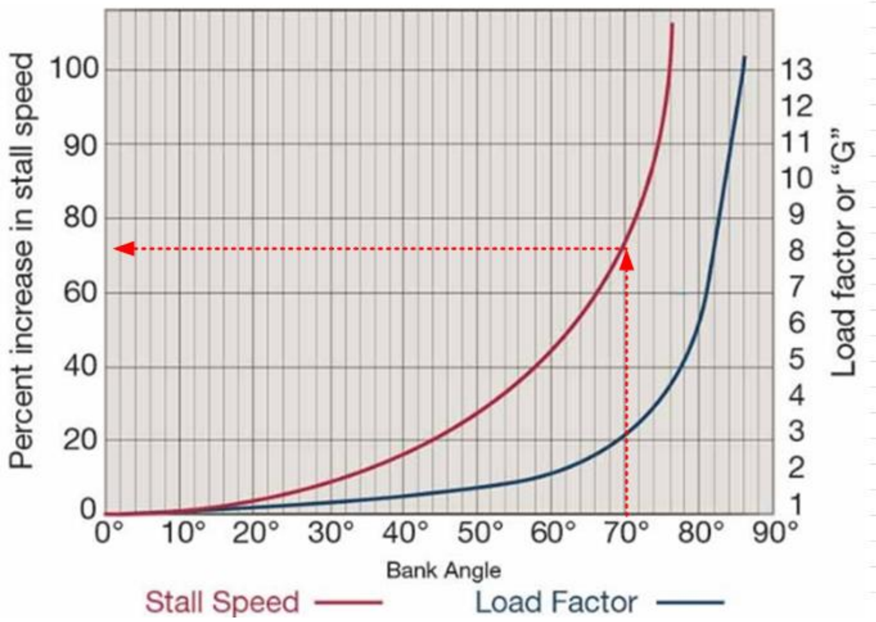

Figure 23: Bank angle vs increase in stall speed and load factor. Source: www.aviationsafetymagazine.com

2.2.6 According to the calculation table for increased stall speed in the event of variations in the bank angle, one finds that a 72° bank angle increases the stall speed by just over 70%. According to the Pilot Operating Handbook (POH) the stall speed for RV-6 without flaps is 65 mph (56.5 kt). A 70% increase gives the following calculation:

Stall speed during horizontal flying with 72° banking = 56.5 kt x 1.7 = 96 kt.

2.2.7 96 kt is 27 kt over the assumed maximum speed registered for LN-AAL after the last take-off from Øian Airfield. Assuming that the SkyDemon registration is correct, it means that the turn could not have been performed during horizontal flying as the aircraft would have stalled before it could reach a bank angle of above 70°. According to the AIBN's calculations, it is impossible to perform such a turn with an RV-6 during horizontal flying, regardless of the speed. This indicates that the LN-AAL must have lost altitude in the turn and that the commander no longer had control of the aircraft.

2.3 Engine power

2.3.1 <u>Indications of power loss</u>

2.3.1.1 There are a number of factors indicating that the engine did not provide power when the aircraft hit the two trees and came down into the stream. The most significant indication is that both propeller blades were bent backwards, without any indication that they had been bent in the direction of rotation. Furthermore, most of the scratches at the front of the propeller blades are radial, not running across the blades, as would be expected if the propeller rotates under power when hitting something solid (see Figure 15 and Figure 16).

2.3.1.2 The AIBN has rarely seen a propeller shaft bent as shown in Figure 16. The bent shaft was primarily due to the fact that the propeller shaft had lightening holes, and that the material between these holes was torn off. Moreover, the AIBN assumes that the visible lines in the metal structure of the fracture surfaces indicate the direction of the forces that were applied. A purely bent propeller shaft would have dimples without any indication of direction or vertical lines. Mere overload caused by torsional forces transmitted from the engine (torque) would have produced horizontal deformation and lines. A direction of 20° to the left, which appears in some places in Figure 19, indicates that torsional forces make up a small part of the total load. This might indicate that the engine rotated at low speed and power.

2.3.1.3 The generator rotates about 2.7 times the speed of the engine. If the engine provided full power when the propeller hit the ground, the stopping of the engine from 2,700 rpm would be almost instantaneous. The generator pulley showed no signs of rotation damage. This indicates that the generator rotated at low or no speed when the damage occurred. If the generator rotated at 7,290 rpm when the aircraft hit the ground, it is unlikely that the pulley would have had time to stop completely before impact. Moreover, it is likely that the transmission belt would have been damaged had the engine and the propeller come to a sudden halt while the generator rotated at a speed of approximately 7,290 rpm. The AIBN believes that this supports the theory that the engine did not provide sufficient power and was operating at a significantly lower rotational speed than 2,700 rpm when the propeller hit the ground.

2.3.1.4 After the accident, the engine's tachometer showed 1,000 rpm. Although the tachometer reading may be accidental, it may also be an indication that supports the theory that the engine failed to provide sufficient power.

2.3.1.5 The engine had almost no oil when it was found. However, there were no indications that the engine had been running without oil. The AIBN concluded that the oil had leaked through the damaged propeller shaft seal after the accident and that the engine had sufficient lubrication throughout the flight.

2.3.2 The fuel system

2.3.2.1 Findings at the accident site clearly show that the aircraft was in a partly inverted position as it hit the trees. This indicates that the commander had lost control of the aircraft. The truck driver observed an apparently normal take-off and a normal flight which lasted for about 5 seconds. Based on the assessments in Chapter 2.2, the entire flight lasted no more than 25 seconds. Consequently, the aircraft could have been out of control for a period of maximum 20 seconds.

2.3.2.2 According to our calculations in Chapter 1.16.3, it would have taken 12 seconds to empty the fuel system between the tank and the engine driven fuel pump.

2.3.2.3 The hose connected to the fuel intake must be flexible enough to bend with gravity. If so, the fuel intake at the end of the hose will point towards the fuel supply even if the aircraft is flown at an angle or inverted. As pointed out in section 1.16.2.5, the hose was so stiff that it would not have reached the fuel if the aircraft was in the inverted position and the fuel level in the tank was low.

2.3.2.4 It is impossible to ascertain how much fuel was left in the left fuel tank. Assuming that the aircraft’s total remaining fuel quantity was 93 liters and that the aircraft consumed all the fuel from the left tank, 23 liters would have remained at the time of the accident. If the aircraft was flying uncoordinated, pressing the fuel to the left in the wing tank, or was inverted, it is very likely that the engine would start to draw air. If consumption from the tanks was evenly distributed, approximately 47 liters would have remained in the left tank. This would have reduced the risk of fuel starvation. However, the stiff hose meant that the left tank would have had to be almost full to ensure sufficient fuel supply during all flying attitudes.

2.3.2.5 The AIBN finds it possible that the LN-AAL entered an attitude that prevented fuel supply, before plunging into the stream. If so, the engine would have stopped delivering power 12 seconds into the flight, (see section 1.16.3.4). Alternatively, there might have been some water in the water separator (see section 1.16.3.1), which was sucked into the engine when the aircraft entered the inverted position. This could also have resulted in loss of engine power. Even though the propeller could have rotated at a relatively high speed at the time, the torsional forces would not have been strong enough to bend the propeller blades in the direction of rotation, nor provide clear indications of overload of the propeller shaft due to torsion.

2.3.2.6 Another possible explanation for the low engine power output may be that the commander pulled the throttle out when he realized that the aircraft would hit the ground. In such a case, the engine power would have been reduced. However, the fact that the throttle control was found in the full forward position and the carburetor throttle was found in the fully open position, does not support such a theory. The AIBN is aware that the throttle may change position in accidents such as this and the observation is not given much emphasis.

2.3.2.7 In the AIBN's opinion, the stiffness of the flexible hose did represent a safety risk, regardless of any causal connections. Consequently, measures should be implemented among amateur builders to prevent old, stiff hoses from causing fuel supply problems in other similar aircraft.

2.3.3 Carburetor ice

The spread between temperature and dewpoint above Øian Airfield was approximately 5 °C according to Figure 10. The likelihood of getting carburetor icing was therefore limited. LN-AAL had an Ellison carburetor that has good resistance against carburetor icing. It is therefore unlikely that the loss of engine power was caused by carburetor icing.

2.4 The weather situation

2.4.1 Analyses from the Norwegian Meteorological Institute show that the weather situation was highly unusual on the day of the accident. There were record-high temperatures in Nordvestlandet, combined with frost on the ground and a strong inversion in the Meråker area. Wind in the lowest layers above the surface came from a south-easterly direction, whereas there was hardly any wind at ground level. The meteorological analysis for the day in question shows that rotors and wind shear were likely to occur near Øian Airfield as a result of unusual weather conditions combined with the mountain formations south-east of Meråker. Observations from the pilot of LN-XKY, who flew in the direction of Meråker shortly after LN-AAL had been reported missing, confirm that there was heavy turbulence in the area.

2.4.2 The LN-AAL commander took a photo of the windsock at Øian Airfield just a few minutes before take-off. It showed that there was almost no wind at all, and take-off was towards the north on runway 34. However, there was a south-easterly breeze at higher altitudes. It means LN-AAL took off with no or a low wind component, but that the aircraft most likely entered a stratum of air with a significant tailwind component during its climb from Øian Airfield. This, combined with a possible rotor or wind shear, may have caused the commander to lose control of the aircraft.

2.5 Alternative courses of events

2.5.1 Introduction

2.5.1.1 The AIBN has assessed the following alternative courses of events:

- For unknown reasons, the engine lost power shortly after take-off causing the commander to lose control of the aircraft.
- One of the two people on board was incapacitated, which caused the aircraft to lose control.
- Shortly after take-off, the commander initiated an acrobatic manoeuvre and lost control of the aircraft.
- The flight controls malfunctioned or jammed causing the commander to lose control of the aircraft.
- The aircraft entered an extreme weather phenomena causing the commander to lose control of the aircraft.

2.5.1.2 The commander and the passenger were brothers, and the commander had let his brother fly the aircraft on previous flights. The AIBN believes that it cannot be ruled out that the commander at some point let his brother take over the flight controls. However, it is unlikely that he would do so during take-off and departure from Øian Airfield immediately before the accident. That the brother was not flying the aircraft is supported by the fact that the stick grip on the commander's side was ripped off, which indicates that he held the stick as the aircraft hit the ground inverted.

2.5.2 For unknown reasons, the engine lost power shortly after take-off causing the commander to lose control of the aircraft.

2.5.2.1 A number of indicators signal that the engine was not providing power when the aircraft hit the ground (see Chapter 2.3.1). However, the AIBN believes that this was a result of the aircraft entering an unusual attitude, not the result of an engine failure. According to the truck driver, the take-off seemed normal, as did the first 5 seconds of the flight. A potential total loss of engine power for the period of up to 17 seconds when the aircraft was out of sight, would not normally cause loss of control of an aircraft. Even if total loss of engine power occurred shortly after take-off, the aircraft commander would most likely have reached farther than he did, without losing control. It is also unlikely that the commander tried to turn back to the airfield and then stalled and lost control of the aircraft. The best sites for a potential emergency landing were ahead, in the flight direction. As the AIBN sees it, it would have made sense to continue ahead in the event of loss of engine power. Furthermore, it is likely that the experienced commander would have handled a loss of engine power in a way that did not make him lose control of the aircraft and crash where he did.

2.5.2.2 The engine has been thoroughly examined. No malfunctions were discovered that would explain such a significant loss of engine power under normal conditions. If there was a defect in the right ignition magneto during the flight, it would only cause minor loss of engine power. Furthermore, it is unlikely that the problem with the magneto existed before the flight started. The AIBN assumes that the commander tested the ignition immediately prior to the flight. Such a potential serious defect in the right ignition magneto would have been discovered as the engine would have stopped during the test.

2.5.3 One of the two people on board was incapacitated, which caused the aircraft to lose control

There is nothing in the autopsy reports to indicate that either of the two was incapacitated immediately after take-off. If the commander had suffered a loss of consciousness, it is unlikely that control of the aircraft would have been lost immediately, nor is likely that control would have been lost had the passenger lost consciousness. Even though it cannot be completely excluded, the AIBN finds it unlikely that uncontrolled movements of the arms or legs of one of the two people on board would have resulted in loss of control shortly after take-off.

2.5.4 Shortly after take-off, the commander initiated an acrobatic manoeuvre and lost control of the aircraft.

In theory, the accident could have been caused by a failed roll at a low altitude. In general, it is not difficult to perform a roll manoeuvre, but in the situation in question, it would have been a reckless manoeuvre to perform at such a low altitude. Even though the commander was trained in acrobatic manoeuvres, it is highly unlikely that he would have initiated an acrobatic manoeuvre shortly after take-off.

2.5.5 The flight controls malfunctioned or jammed, causing the commander to lose control of the aircraft.

The aircraft has been thoroughly examined and there are no indications that the accident could have been caused by defect or jammed flight controls. All breakages and damage to the flight controls are consistent with damage that could have occurred due to overload during the crash. According to the truck driver who observed the take-off, it was a stable and normal take-off. In a stable situation, defective or jammed flight controls would generally not result in major or sudden changes in the flight path. One exception could be if the control surfaces came loose causing a sudden and unintentional turn. However, examinations of the wreckage indicate that all the control surfaces and flaps were undamaged prior to the crash. Consequently, the AIBN finds it highly unlikely that the accident was caused by malfunctioning or jammed flight controls.

2.5.6 The aircraft entered an extreme weather system, causing the commander to lose control of the aircraft.

2.5.6.1 The analyses from the Norwegian Meteorological Institute described in Chapter 2.4 substantiate the occurrence of downbursts and strong rotor winds in the area of Øian Airfield on this particular day. The AIBN believes this could have had a significant impact on the aircraft. Airspeed immediately after take-off is generally relatively low, and according to the information retrieved from SkyDemon, the speed did not exceed 79 kt. Although SkyDemon data are not always 100% accurate due to unstable GPS reception in the area, the AIBN is of the opinion that the airspeed was close to the recorded speed. This is close to the best climb angle speed and well above the stall speed without the use of flaps at 56.5 kt. Furthermore, the AIBN believes a turn was initiated as is apparent from the navigation plot in Figure 22.

2.5.6.2 The turn starts at almost the same point as where cross wind was initiated during the previous landing circuit, indicating that the plot is correct. The AIBN believes something happened during this turn which caused the aircraft to come out of control and lose altitude. Presumably, the altitude was too low for the aircraft to escape the situation, resulting in the aircraft entering an inverted 40° dive as described in Figure 21.

2.5.6.3 The AIBN believes the course of events described above is the most likely scenario explaining the accident involving LN-AAL.

2.5.6.4 Based on the weather information for Værnes (TAF and METAR), the AIBN believes that it was impossible to predict such a weather phenomenon. Nor was there any reason to believe that the commander found the flying conditions challenging immediately before the accident, so that he should have aborted the flight and returned to Værnes.

2.5.6.5 However, the AIBN is of the opinion that the information that has emerged concerning the special weather phenomena should be included in the flight clubs' training material.

2.6 Survival aspects

2.6.1 The damage shows that the aircraft hit the ground inverted and with great force. The two people on board died instantly and it is unlikely that the outcome would have been different had the two persons worn flight helmets. The bar at the rear of the cockpit did absorb some of the crash forces. However, according to the AIBN's assessment the bar would have had to be much taller and sturdier to be able to prevent the fatal outcome.

2.6.2 The two people on board died instantly. The timing of the search and rescue operation that was launched is therefore of little importance to this accident. However, it is worth noting that it took approximately 20 minutes from the time of the accident until the JRCC was notified of a potential accident involving LN-AAL. Moreover, it is worth noting that the antenna of the emergency locator transmitter ended up under the aircraft, so that the signals were blocked. There is reason to believe that distress signals would have been received sooner, both via the 121,500 MHz frequency and via satellite, had the antenna ended up in a better position.

3. CONCLUSIONS

3.1 Key findings

AIBN believes the special weather phenomena were contributing factors to the accident. There was a strong inversion in Central Norway combined with unusual wind conditions, where there was hardly any wind at ground level at Øian while at the same time a south-easterly breeze at higher altitudes. Calculations have shown that there may have been strong downbursts and rotor winds near Øian Airfield on this particular day. The AIBN finds it likely that the commander shortly after take-off initiated a left turn and unexpectedly entered this weather phenomenon, thus losing control of the aircraft. This happened at a low altitude, making it impossible for the commander to regain control.

3.2 Investigation results

a) The aircraft's mass and center of gravity were within permitted limits at the time of the accident.

b) The AIBN has not revealed faults or irregularities in the aircraft during the investigation that could have affected the course of events.

c) There was sufficient fuel on board.

d) The commander held a valid license as well as a valid medical certificate and was checked out to fly the RV-6.

e) The commander and his brother had flown together on previous occasions and the commander had, on one or several occasions, let his brother fly the aircraft. The AIBN has not found anything to indicate that the brother was in control of the aircraft at the time of the accident.

f) There was no wind at ground level prior to take-off.

g) In the air above Øian Airfield there was a 10-20 kt wind from the south-east.

h) There was a strong inversion in Central Norway with major temperature differences between the eastern and western parts of the region.

i) Analyses conducted by a meteorologist indicate a high likelihood of downbursts and rotor winds near Øian Airfield at the time of the accident.

j) According to the SkyDemon navigation program, LN-AAL initiated a left turn shortly after take-off.

k) LN-AAL most likely entered a downburst or rotor which caused the commander to lose control of the aircraft.

l) The aircraft was inverted and fell at an angle 40° when it hit the trees.

m) The fuel hose in the left tank was too stiff to bend towards the bottom of the tank when the aircraft was in the inverted position. This did not affect the outcome of the accident, but may explain why the engine did not provide full power when the aircraft hit the ground.

n) It was not possible to survive the impact with the ground.

o) The two people on board did not wear flight helmets. However, it is unlikely that the outcome would have been different had they done so.

p) The emergency locator transmitter was activated in connection with the crash, but because the antenna ended up under the aircraft, transmission was delayed. This delay was of no importance for the outcome of the accident.

4. SAFETY RECOMMENDATIONS

The Accident Investigation Board Norway makes no safety recommendations in connection with this investigation.

The Accident Investigation Board Norway

Lillestrøm, 17 April 2020

APPENDICES

Appendix A: Abbreviations

APPENDIX A: ABBREVIATIONS

AIBN	Accident Investigation Board Norway
EASA	European Aviation Safety Agency.
ELT	Emergency Locator Transmitter
GA	General Aviation
hPa	Hektopascal
in	Inch (2.54 cm)
JRCC-S	Joint Rescue Coordination Centre Southern Norway, Stavanger
kt	knot(s) –Nautical Mile(s) (1 852 m) per hour
lb	Pound(s) (0.454 kg)
LDG	Landing gear
MHz	MegaHertz
METAR	Meteorological Aerodrome Report
ml	milliliter
NTSB	National Transportation Safety Board
psi	Pounds per square inch
QNH	Altimeter pressure setting to indicate elevation amsl
rpm	Rounds per minute
RWY	Runway
UTC	Coordinated Universal Time
V	Volt
VFR	Visual Flight Rules
VHF	Very High Frequency (30 – 300 MHz)