Investigation report

C2/2010L

Aircraft accident at Siilinjärvi on 20 January 2010

Translation of the original Finnish report

OH-CHO

CESSNA TU206G

Onnettomuustutkintakeskus
Olycksutredningscentralen
Safety Investigation Authority, Finland

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SUMMARY

AIRCRAFT ACCIDENT AT SIILINJÄRVI ON 20 JANUARY 2010

An aircraft accident took place at 11.26 on Wednesday, 20 January at Siilinjärvi Lehdonkylä village. A Cessna TU206G aircraft on power line inspection flight hit the ground and was destroyed. The pilot of the aircraft and the passenger, a power line inspector, were slightly injured.

The aircraft took off from Kuopio aerodrome and reached the power line to be inspected about three minutes after take off at 30 – 90 meters above ground level. The pilot adjusted airspeed to 80 – 90 kt resulting in a clearly lower power setting as compared to normal cruising speed setting. Approximately two minutes after starting the power line inspection the pilot noticed that the engine was running unevenly and coarsely and at the same time was losing power. Despite measures taken, the pilot was unable to recover engine power resulting in reducing air speed and the already existing low altitude had to be diminished to maintain air speed. Soon the pilot realized that the flight would end in a forced landing and radioed this to the air traffic control. The pilot managed to maintain control over the aircraft so that fatalities were avoided during a forced landing into the forest. The aircraft was destroyed.

The investigation focused on the aircraft engine and equipment contributing to its running. The engine was disassembled but no mechanic fault or damage contributing to engine malfunction was found. The fuel system of the aircraft was working and the fuel used was clean and according to standards. In order to determine the factors related to the engine malfunction, a simulated flight was flown, simulating engine power settings used on the flight and monitoring engine behavior during adjustment of engine controls and using the magneto switch and electric fuel pump. Engine failure did not occur. During the investigation it was found out that the pilot did not have training or experience in low flying or power line inspection. The pilot's experience in the accident aircraft type can be considered low, too. During flight this became evident in lack of routine which led to pilot's inadequate performance during engine failure.

The accident was caused by engine failure during flight, which as a result of loss of power, led to unprepared forced landing. Engine failure was probably caused by too lean fuel mixture. The emergence of the situation was contributed by both the pilot's handling of the engine and low outer air temperature. The development of the failure into an accident was the result of the pilot's action as he failed to enrich the fuel mixture after the beginning of the engine failure. Contributing factors were the pilot's inexperience in low flying and the lack of needed training.

The investigation commission issued a safety recommendation to the aviation company to revise its flight manual regarding training requirements so that it includes the needed theory and flight training for low flying.

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ABBREVIATIONS

AD	Airworthiness Directive
CPL(A)	Commercial Pilot License, aeroplane
EASA	European Aviation Safety Agency
EASA Part-145	EASA maintenance organization
EGT	Exhaust Gas Temperature
EU	European Union
EU-OPS 1	European air operations requirements
ft	Feet
in	Inch
inHg	Inch of mercury
JAR	Joint Aviation Requirements
kt	Knot(s)
lb	Pound
QNH	Altimeter sub-scale setting to obtain elevation when on the ground
SB	Service Bulletin
USgal	US (liquid) gallon

SYNOPSIS

An accident occurred at 11.26 (all times are Finnish time, UTC+2 hours) on Wednesday, 20 January 2010 in Siilinjärvi Lehdonkylä village. A Cessna TU206G aircraft OH-CHO owned by Konekorhonen Oy, on power line inspection flight was destroyed on forced landing. The pilot and passenger, a power line inspector, were slightly injured. The aircraft had been manufactured by Cessna Aircraft Company in 1977.

Accident Investigation Board of Finland appointed an investigation commission on resolution number C2/2010L to investigate this accident. Investigator Juhani Hipeli was appointed investigator-in-charge accompanied by investigators Vesa Palm and Hans Tefke.

The aircraft was transported to Kuopio airport hangar for technical investigation on 21 January.

The investigation report was translated in English.

The draft report was sent for comments to Trafi Aviation (the Finnish Civil Aviation Authority), Finavia Corporation, the aircraft engine manufacturer Teledyne Continental Motors Inc and fuel supplier Shell Aviation and parties concerned. Comments were received by 17 August 2011.

The investigation was completed on 23 August 2011. The material used in the investigation is stored at the Safety Investigation Authority, Finland.

1 FACTUAL INFORMATION

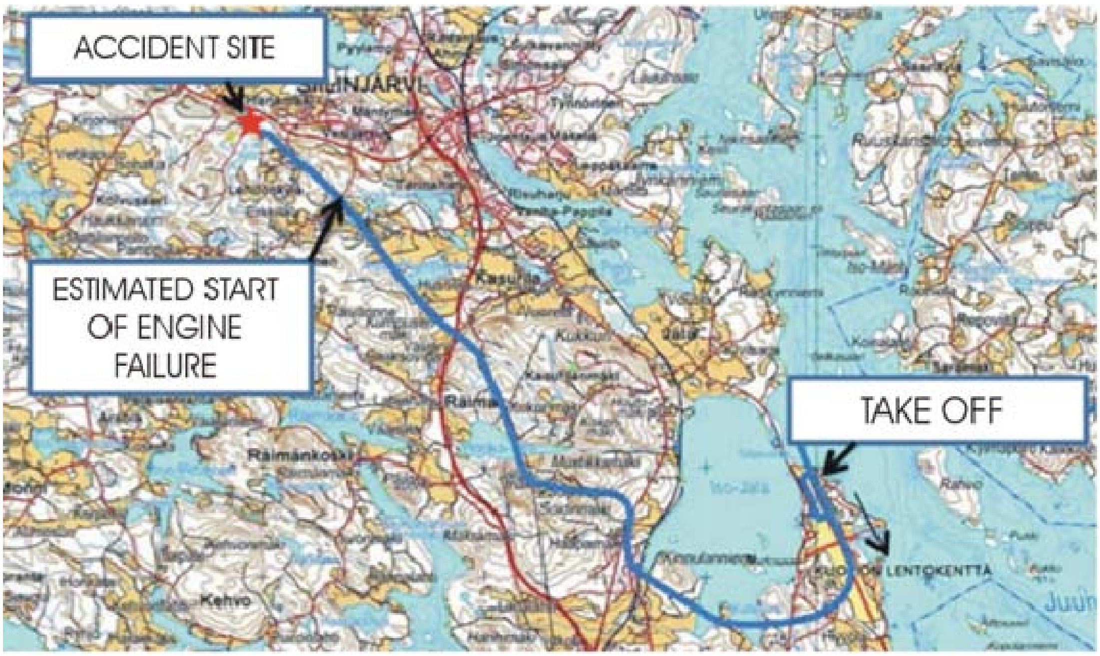
1.1 History of the flight

1.1.1 Preceding Events

The pilot and power line inspector inspecting frost and snow loads on power lines spent the previous day in Joensuu city. After normal preparations for flight they took off from Joensuu aerodrome on Wednesday, 20 January at 09.52. Power lines between Joensuu and Juankoski were inspected during the flight. Landing at Kuopio aerodrome took place at 10.39. The aircraft was refuelled and the crew made preparations for the next flight, the duration of which was planned for 3 hours and 40 minutes with landing at Kajaani aerodrome.

1.1.2 The Accident Flight

The aircraft took off at Kuopio aerodrome runway 15 at 11.20. After take off the pilot took a right turn towards the power line to be inspected, some 5 km west of the aerodrome between highway 5 and the so called old highway 5, currently road 559. According to the pilot he climbed to approximately 700 ft on QNH, equivalent of about 115 meters above the aerodrome level making it possible to fly over the hilly area between the roads. After reaching the altitude the pilot adjusted the speed at 80-90 kt, extended flaps 10 degrees and adjusted corresponding engine settings. Consequently the RPM was 2300 r/min, manifold pressure 19-20 inHg and fuel flow approximately 10-11 USgal/h.



Picture 1. The route of the accident flight (KTJ/Oikeusministeriö/MML)

Power line inspection was done by flying on its left side at about 100-300 ft (30-90 m) above ground level. The power line inspector observed the line on the right hand side of the aircraft while the pilot concentrated on flying the aircraft. After crossing highway 5 the power line continues North West, passing Siilinjärvi village in the west. In this area the terrain is lower than the hilly area before becoming higher again when approaching Lehdonkylä and Harjamäki. After passing the lower area, where the Siilinjärvi golf course is located, the pilot noticed the engine starting to loose its power. The engine RPM temporarily went down and running became very coarse. Speed started to slow down immediately. The pilot checked the magnetos and switched on the electric fuel pump but these actions did not stop the problem. As the aircraft lost altitude and the terrain was rising the flight path closed in on treetops rather rapidly. The pilot had time to send an emergency report (mayday) on the radio before contact with the trees.

Contact with the trees occurred very close to stalling speed, of which the pilot was warned by stall warning. As a result of the first strong contacts to aircraft's elevators and stabiliser, part of the right elevator was disengaged and finally the entire rear fuselage was torn off. Before hitting the ground the aircraft broke a pine tree and a spruce in two and felled two pine trees with their roots. As a result, the wings of the aircraft were severely mangled but the speed slowed down considerably. The aircraft hit the ground at a relatively low speed in a shallow dive. The aircraft fell on its left side and the right wing folded over the fuselage to the left but the cockpit was not deformed. The pilot and the power line inspector maintained consciousness all the time and left the cockpit immediately. The accident occurred at 11.26.

Picture 2. Accident site photographed from above in the direction of the flight path

1.1.3 Succeeding events

There was a strong smell of aviation gasoline at the site due to fuel leakage from wing tank. To minimise fire hazard, the pilot went back to the cockpit to close the fuel selector and turn off the main electricity switch. Due to a possible fire the pilot and power line inspector removed personal and work equipment from the aircraft. Neither of them was able to make a report of the accident to Emergency Response Centre (ERC). The pilot's cell phones were in his jacket pocket under the aircraft and the phone of the power line inspector could not be switched on.

The first report of the accident to ERC was made by an eyewitnessing skier at 11.31 from a near by house. The second report was made by a car driver who made an aural observation. The third report to ERC was made by another skier who skied to the accident site at 11.34, the pilot of the accident aircraft joined to this phone call.

After the arrival of Siilinjärvi rescue units and police to the accident site, external visual checks of the aircraft revealed no ice or frost on its wings, stabilizers or control surfaces.

Picture 3. The aircraft photographed against the flight path. The blue plastic sheet is for collecting the leaked fuel.

1.2 Injuries to persons

The pilot and the power line inspector suffered slight injuries to their bodies mainly from the crash.

Injuries	*Crew*	*Passengers*	*Others*
Fatal	-	-	-
Serious	-	-	-
Minor/None	1	1	-

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

Approximately 10 trees of different sizes were destroyed or damaged. Approximately 150-200 litres of aviation fuel leaked from the aircraft to the ground. To eliminate pollution damage environmental authorities removed the polluted soil and delivered it for further processing between 22 – 25 January 2011. The polluted soil was replaced by pure soil.

1.5 Personnel information

The pilot: Age 36

Licences: JAR Commercial Pilot, Aircraft CPL(A), valid until 12 Feb 2013

JAR Medical Certificate, class 1, valid until 14 Aug 2010

JAR Medical Certificate, class 2, valid until 14 Aug 2010

Ratings: JAR Limited Flight Instructor, Aircraft (FI[A]), valid until 31 Dec 2012

JAR Language Proficiency Rating, English, Class 4, valid until 40 Apr 2012

JAR Language Proficiency Rating, Finnish, Class 6, indefinite

JAR Radiotelephone Operator’s Certificate, indefinite

JAR Night Flight Rating, aircraft, indefinite

JAR MEP IR, piston engine single engine aircraft, land, valid until 31 July 2010

JAR SEP, piston engine single engine aircraft, land, valid until 31 July 2011

JAR SEP IR, piston engine single engine aircraft, land, valid until 31 July 2011

Training: Private Pilot 30 Aug 1998

JAR Airline Transport Pilot Course 10 Nov 2006

JAR Commercial Pilot 28 Jan 2008

JAR Limited Flight Instructor, aircraft 7 Dec 2009

Flight experience	*Last 24 hours*	*Last 30 days*	*Last 90 days*	*Total experience*
All types	5 h 18 min 2 landings	6 h 28 min 3 landings	9 h 37 min 10 landings	619 h 22 min 702 landings
Type Concerned	5 h 18 min 2 landings	6 h 28 min 3 landings	6 h 28 min 3 landings	58 h 56 min 29 landings

1.6 Aircraft information

1.6.1 Basic information

Cessna TU206G is a single-engine metal structure high-wing monoplane seating six with fixed landing gear.

Aircraft:

Type:	Cessna TU206G
Registration:	OH-CHO
Registration number:	920
Manufacturer:	Cessna Aircraft Company
Serial number:	U206-03634
Year of manufacture:	1977
Maximum take off weight:	1633 kg
Owner:	Konekorhonen Oy
Operator:	Konekorhonen Oy
Total flight time:	2162 h

Engine:

Type:	Teledyne Continental TSIO-520M9
Serial number:	830759-R
Manufacturer:	Teledyne Continental Motors Inc
Year of manufacture:	2007
Total running time: 192 h	
Fuel:	Aviation fuel Avgas 100 LL

Propeller:

Type:	McCauley D3A34C402/90DFA-10
Serial number:	768892
Manufacturer:	McCauley
Year of manufacture:	Overhauled 30 Dec 2007
Total running time:	192 after overhaul

1.6.2 Airworthiness

The registration certificate of the aircraft had been issued on 9 Jan 1998. The airworthiness certificate had been issued on 6 Aug 2008. The certificate of the review of airworthiness had been issued on 18 March 2009 and was valid until 18 March 2010.

A maintenance programme had been planned for the aircraft, and it had been approved by authority on 26 Aug 2009. The aircraft was under the company's own airworthiness organisation control. Flight operation manual for the aircraft in question had been approved and it was up to date.

1.6.3 Weight and Balance

The aircraft had been weighed on 10 Jan 2007 and its weight had been 2122 lb (962,4 kg) and balance 37,47 in. At take off the aircraft had 283 litres (204 kg) of fuel, and at the time of the accident approximately 273 litres (196 kg). In addition to the persons on board there was about 38 kg of materiel. Weight at take off was calculated at 2975 lb (1349,5 kg), the maximum being 3600 lb (1633 kg). Balance was within limits during the flight.

1.7 Meteorological information

Weather report at Kuopio aerodrome on 20 Jan 2010 at 10.50: wind 130 degrees, 2 knots (1 m/s), visibility over 10 km, clouds: BKN (5/8 – 7/8), 500 ft (150 m), BKN 20.000 ft (6100m), temperature -18 C, dew point -20 C, QNH 1042 hPa.

Weather report at Kuopio aerodrome on 20 Jan 2010 at 11.20: wind 140 degrees, 2 knots (1 m/s), visibility over 10 km, clouds: BKN (5/8 – 7/8) 20.000 ft (6100m), temperature -18 C, dew point -20 C, QNH 1042 hPa.

Weather report at Kuopio aerodrome on 20 Jan 2010 at 11.50: wind 150 degrees, 3 knots (1,5 m/s), visibility over 10 km, clouds: BKN (5/8 – 7/8), 500 ft (150 m), BKN 20.000 ft (6100m), temperature -18 C, dew point -20 C, QNH 1042 hPa.

Weather forecast at Kuopio aerodrome 20 Jan 2010 at 07.24 for 20 Jan 2010 from 06.00 to 21 Jan 2010 06.00: wind 130 degrees, 4 knots (2 m/s), visibility over 10 km, SKC.

Weather forecast at Kuopio aerodrome 20 Jan 2010 at 10.27 for 20 Jan 2010 from 11.00 to 21 Jan 2010 11.00: wind 130 degrees, 3 knots (1,5 m/s), visibility over 10 km, clouds FEW (1/8 – 2/8) at 500 ft (150 m), temperature -20 C.

Change of weather forecast at Kuopio aerodrome 20 Jan 2010 at 09.44 for 20 Jan 2010 from 10.00 to 21 Jan 2010 06.00: wind 130 degrees, 4 knots (2 m/s), visibility over 10 km, clouds FEW (1/8 – 2/8) at 500 ft, 40% probability temporarily 20 Jan 2010 from 08.00 to 21 Jan 2010 12.00, clouds BKN (5/8- 7/8) 400 ft (120 m).

According to Eastern Finland regional forecast, the weather was mainly clear or with few upper clouds. The forecast for the region's northern part, to which the area north of Kuopio belongs, was locally low clouds and weak snowfall. The forecast for the clear area was surface inversion and very low temperatures.

1.8 Aids to navigation

Aids to navigation had no effect on the incident.

1.9 Communications

The pilot and Kuopio tower communicated on frequency 120,150 MHz. Before OH-CHO took off, the controller gave a traffic advisory to helicopter OH-HEC conducting power line inspection in the Siilinjärvi area on OH-CHO's activity to create needed separation for special VFR. The controller gave the corresponding information to OH-CHO on the helicopter in the area. Also after the 11.20 take off of OH-CHO the controller and the air-borne aircraft informed each other of their locations.

At 11.25 the controller requested the location and altitude of helicopter OH-HEC to relay this information to OH-CHO. After receiving the report, the controller asked OH-CHO if it also had received the report. The controller did not get an answer to this, instead there was an emergency report (mayday) on the frequency and message “Mast, mas…”.

After this the controller tried to contact OH-CHO six times between 11.26.15 and 11.29.14 without success. The controller asked helicopter OH-HEC to look for OH-CHO on its presumed flight path. The helicopter headed too far to the south to Kasurilanmäki area and did not find OH-CHO.

At 11.44.57 the controller reported OH-HEC on the finding of OH-CHO and helicopters' search mission was terminated.

1.10 Aerodrome information

The main runway at Kuopio aerodrome is 15/33. The runway is asphalt-paved, 2800 m long and 60 m wide. The aerodrome elevation is 98 m (323 ft). The aerodrome has been certified as an instrument aerodrome.

1.11 Flight recorders

There were no flight recorders in the aircraft.

1.12 Wreckage and impact information

1.12.1 Accident Site

The accident site is located in the village of Lehdonkylä, coordinates N63 04,492' E 027 35,645'. The site is in the imminent vicinity of a recreation route, some 400 m north west of the Lehdontie road. The elevation above sea level is 141 m. The aircraft had hit 15 – 18 m high trees falling on the ground approximately 60 m after first impact with the trees. The accident site is sandy moor located in Harjumäki-Kasurila groundwater area, at the very core of the groundwater area.

1.12.2 Wreckage Inspection

Judging by the impact marks left by the trees on the aircraft, the aircraft's angle of attack had been rather high, consequently it did not hit the ground nose first. The aircraft lay almost on the place where it had hit the ground, turned slightly right from the flight path on its left side. As a consequence of the impact with the trees the right elevator and part of the stabilizer had been torn loose and fallen on the ground some 23 m before the aircraft's impact site. The tip of the left wing had been torn off to about half the length of the aileron and it had fallen on the ground some 9 m before the aircraft. The right landing gear wheel had fallen on the ground some 7 m before the aircraft. The counter weight part of the left elevator was about 7 m on the right side of the aircraft. One of the propeller blades had fallen on the ground some 5 m to the right of the aircraft. With the exception of some small parts, all other parts were in the immediate vicinity of the wreckage.

The engine covers of the aircraft had been torn and their front and lower parts had been bent inwards. The propeller hub had been torn and one blade had been torn loose. The attachment mechanisms to the hub had given in and one of the blades had been bent backwards against engine cover under the aircraft. Blade tips had signs of contact with the ground.

The left hand door had been torn loose and it lay on the ground on the left side of the aircraft. All seats were intact. At visual inspection the three point seat belts of the front seats were intact. As a result of an impact from above, the left hand side of the instrument panel had been partly broken and bent backwards. The main electrical power switch and electric booster pump switches were in the OFF position. The main power switch and the fuel selector were in the OFF position. The setting in both altimeters was 1041 hPa. There was a free standing electric heater in the right hand foot well of the cockpit. The light switches in the switch panel were on except for the landing light and the circuit breakers were on. There were loose aircraft items in the luggage compartment, among others engine cover, a tow bar, metallic stairs, an equipment box and bottles of engine oil. Personal luggage of persons on board and a laptop case had been removed from the aircraft and they were outside the aircraft.

There were considerable ruptures in the left wing caused by trees, both at the root and in the tip, to about half the length of the aileron. The wing had been twisted strongly upwards at its root. The wing was upright, supported by the strongly distorted wing strut, detached at its root by the impact with the trees. The tip of the wing had been detached in the impact earlier. The aileron was in its place; it was crushed at its tip and twisted approximately 40 degrees upwards. The operating rods and cords of the aileron were in their places. Steering cords had been seized into the wing root structure. The flap was in its place and fully extended. Fuel tank caps were in their places.

The right wing had been badly ruptured at the leading edge in the middle by impact with three trees. The wing was twisted at its root over the fuselage to its left side pressing the roof of the cockpit inward. The wing strut had been torn loose at its root. Ailerons and flaps were in their places. The operating rods and cords of the aileron were in their places. The operating cords of flaps were in their places and the flap was retracted. Fuel tank caps were in their places. Rescue personnel had collected approximately 80 litres of aviation fuel leaked from the wing tank.

Nose landing gear had bent under the aircraft and was totally separated. Left landing gear was in its place and was bent backward. Right landing gear was in its place, but its wheel had been separated already before the aircraft hit the ground.

The aft fuselage of the aircraft had broken and separated in front of the vertical stabilizer. The left stabilizer had been ruptured at its leading edge as the result of hitting a tree. The left aileron was in its place. The root of the right stabilizer had been ruptured as the result of hitting a tree and its tip had been totally torn off. The right elevator had been totally torn off. The vertical stabilizer and rudder were attached to the tail fuselage. The stabilizer had been ruptured when hitting a tree. Elevator rods and cords were functional and worked when tested. Rudder cords were functional and the rudder worked when tested. Elevator trim cords in the aft fuselage were functional. Trim tab was in its place in the entirely torn off right hand elevator.

A fuel sample from the fuel filter in the fuselage was taken before the aircraft was transported. The wings of the aircraft were removed for transport.

1.13 Medical and pathological information

First aid personnel gave a medical check to the pilot and power line inspector on the accident site. After this they were transported for doctor’s check to Siilinjärvi Health Centre. According to the checks they survived the accident with practically no physical injuries. After the checks they were dismissed from the Health Centre.

Police breathalyser check was 0 promille for both persons.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 Emergency Alerting

Kuopio Tower gave an imminent flight accident alert at 11.26 on a missing aircraft OH-CHO to search and rescue units at Kuopio aerodrome and Karelia Air Command. The alert was given by the Air Force Base sound and announcement system in the “imminent flight accident” form. The alert did not include details of the incident. The controller made an emergency report by telephone of an imminent flight accident to Emergency Response Centre (ERC) of Pohjois-Savo at 11.27.28. The report defined the imminent accident area south of highway 5, in the vicinity of Kuopio aerodrome and the centre of Siilinjärvi. At 11.29.16 the ERC alerted rescue units with corresponding geographical information concerning a minor imminent flight accident. In response five rescue units, an ambulance unit and police were dispatched from Siilinjärvi. The status of the emergency was changed into minor flight accident and the change was relayed to rescue units at 11.29.50. Air ambulance Ilmari was alerted from Varkaus at 11.29.51, but it was cancelled at 11.31.04 as the helicopter was occupied with another task. Kuopio Tower informed the Aeronautical Rescue Co-ordination Centre (ARCC) for Southern Finland (currently Aeronautical Rescue Co-ordination Centre of Finland) at 11.34.

The first eyewitness made an emergency report of the accident to ERC at 11.31.46 from a house close to the accident site. The eyewitness saw the accident as he was skiing on a recreation route very close to the aircraft’s crash site. This report at 11.33.57 gave the rescue units the exact site of the accident at Lehdontie in Siilinjärvi. The eyewitness told that he would stay at the site to guide rescue units at the cross roads of Lehdontie and the recreation route.

Another report to the ERC was made at 11.33.10 by a car driver who had made an aural observation. This information confirmed the location of the accident.

Third report of the accident was made at 11.34.40 by a skier skiing on the recreation route after meeting the crew at the accident aircraft. At the same time the pilot of the accident aircraft told ERC what had happened and the physical condition of the crew.

ERC reported the location of the accident to Kuopio Tower at 11.37. ERC informed the Accident Investigation Board of the accident at 11.47.

1.15.2 Search and Rescue Operations

After the imminent flight accident alert, rescue operations were started according to the standard procedures in Kuopio Air Traffic Control Emergency Manual (EFKU HPO 28.2.2006). Two aerodrome and four Karelia Air Command rescue units assumed readiness positions by the runway in accordance with Authority Cooperation Agreement. At 11.33 the Tower informed the units that the imminent accident is not at the aerodrome area, but in the direction of Siilinjärvi. Soon after this the Tower informed of the change of imminent accident into flight accident. The aerodrome and Karelia Air

Command units returned to their stations and began preparations for terrain search and rescue operations. After a while the Siilinjärvi rescue leader informed over VIRVE net (authority radio net) that the accident site has been found based on eyewitness observation and that the site is in Lehdontie at Siilinjärvi. The aerodrome command vehicle and two Karelia Air Command rescue units with snow mobiles left for the accident site. According to Kuopio aerodrome rescue service the absence of location information caused an estimated 5 minute delay. The command vehicle reached the site at about 11.40-11.45. For Karelia Air Command units the delay was estimated at 7-15 minutes. The units reached the site at 11.55.

After being alerted, the Siilinjärvi rescue units headed first toward Kuopio aerodrome and area south of highway 5 according to initial information. En route the information became more precise, first to area between the aerodrome and the centre of Siilinjärvi, then to Harjamäki area and finally to Lehdontie. The delay to rescue operation due to lack of location information was estimated at about 5 minutes.

The first Siilinjärvi rescue and medical units arrived at the accident site at 11.42. Rescue personnel met the persons involved in the accident in the vicinity of the wreckage and their physical condition was evaluated. Based on this the ERC was informed that no additional help was needed. After initial hearing by a police squad, which arrived at the site at 11.47, the crew was sent for additional physical inspection to Siilinjärvi Health Centre.

Actual rescue operations were not needed at the accident site. Due to leaked aviation fuel from the wing tank, fire fighting readiness was maintained. Rescue personnel collected some 80 litres of leaked fuel.

The aircraft's Emergency Locator Transmitter (ELT) had been activated by the impact with the ground and it had been received in the control tower. As a security measure the locator was located by Karelia Air Command command vehicle's direction finder and was turned off.

1.15.3 Rescue Aspects

The impact with ground took place at a shallow angle into a relatively thin pine and spruce forest. Contact with trees with resulting deformation and structural damage slowed the aircraft's speed considerably before impact. As proof of this two mid-sized pines were felled with their roots. Because the pilot piloted the aircraft all the way into the forest, the impact with the ground took place in an advantageous position. As a consequence of this, the cockpit maintained its shape. Both the pilot and the power line inspector were held in their seats by the seatbelts and therefore survived the accident with minor injuries.

Despite the leaked fuel from broken fuel tank there was no fire. Both persons vacated the aircraft immediately as a precaution for fire. Soon after this the pilot went back to close the fuel valve and turn off the main electric switch.

With the help of the eyewitnesses the rescue personnel was guided quickly to the accident site. Rescue personnel inspected the physical condition of the crew on site. The crew were given warm clothes as part of their outerwear was under the wreckage. Outer air temperature at the time of the accident was -18 degrees Celsius, going down to -28 degrees Celsius during the evening and night.

The loose items in the aircraft's baggage compartment did not cause injuries to the crew.

1.16 Test and research

1.16.1 Technical Research

The fuel filters of the fuel distributor and fuel injection governor were checked before transporting the aircraft into the warmth of indoors. The filters were clean and free of water and ice. Also the engine air filter was checked and found clean and dry.

The Engine

The engine turned when cranked by hand on the propeller. The ignition switch worked normally and the ignition timing was right when tested. Trigger mechanisms of both magnetos functioned normally.

The magnetos with their ignition wiring were removed from the engine for testing. Departing from the manufacturer's manual, the test run was done using the engine's own spark plugs. They were slightly smutty and partly sooty but looked functional. The lower plugs of cylinders number 2, 4 and 6 were full of engine oil, because the wreckage had lain on its left side. For test run the oily lower plugs were cleaned with petrol. In the test run the magnetos produced normal spark to the plugs, excluding cylinder nr 5, the ignition wire of which had been cut off in the accident.

The engine cylinders were tested for bypass when cold. Bypasses and observations were following: cylinder nr 1; 20%, nr 2; 26%, nr 3; induction valve leakage, nr 4; 32%, nr 5; induction valve leakage 80%, after disengagement of the rocker switch induction valve leakage 35% and nr 6; 80%, after moving the exhaust valve 40%.

The upper valve gear housings of cylinders nr 5 and 6 had been broken in the accident and the gears had suffered minor damage limiting the valve movement when the rocker levers were in place. Deformation was detected in the outer spring of induction valve in cylinder 5. The lip seal of the valve guide had been destroyed and the body of the guide was oval. There were residues of the lip seal between the valve safety wedges. There were signs of chafing from the safety wedges at the end of the valve. Neither valve hydraulic unit had free movement.

According to the manufacturer's service bulletin, no leakage past the valves is allowed. The cylinders of the engine were removed for closer examination. On the chuck surfaces of valves in all cylinders there was point-formed corrosion, as well as on exhaust valves' sealing surfaces. Peening had caused a groove on the sealing surfaces of the induction valves, which diminished sealing. With regard to the age of the engine and its running time, the valves and their chucks were in poor condition. On the walls of the cylinders there was point formed corrosion, which in its part weakened the sealing between the cylinder wall and the piston rings. All piston rings were undamaged and assembled correctly. There was nothing to comment on the pistons, connecting rod or crank mechanism, with the exception of surfaces of the pushers of the hydraulic units, which had slight point formed corrosion.

The connections between controls in the cockpit and the engine were functional. All oil and fuel hoses and pipes were intact and secured. At visual inspection there was nothing to comment on the condition of the engine bay equipment and components disregarding the damage caused by the crash.

Exhaust gas supercharger was inspected visually. The wings of the supercharger and turbine were intact and clean. The axel rotated easily when tested by hand. Suction air and manifold tubing were functional. The exhaust gas pipe had been partly destroyed in the crash. Except for the damages suffered, the exhaust gas pipe was intact and the inside colouring was normal.

The Propeller

There were rotation marks on the rear disc of the propeller hub. One blade had been totally separated. The hub was broken and its bearings and feathering mechanism had been destroyed.

Fuel System

The right wing tank was in its place and it was clean. The front finger filter of the tank was loose at the bottom of the tank, the rear one was in its place. The filters were clean. There was nothing to comment on the left wing tank.

The right collector tank had some 1,5 litres of gasoline with sediment. The sediment was rust-like and rust coloured dust or sand. There was no visually detectable water in the tank.

The left collector tank had some dull-coloured gasoline including some dust and about ten small items of trash. There was no visually detectable water in the tank.

The electric fuel pump had HI-LOW-EMERG positions. The fuel pipes from the left collector tank to the distributor were functional. The maximum output of the electric fuel pump with the mixture fully rich and throttle fully open was 15 USgal/h. The electric fuel pump pressurized the MANUAL PRIMER line. In the cockpit the MANUAL PRIMER pump was not secured. Based on conducted tests, not securing the pump had no effect on the functioning of the fuel system.

The electric fuel pump switch is two-piece. The right side is yellow START switch. It activates the low power of the electric pump for normal start up and engine failure. The left side is a red EMERG switch. It is a spring loaded switch, which when held pressed, produces maximum fuel flow. In this position, when the engine is running normally, the fuel flow is so high that the engine stalls due to too rich mixture. The investigation of the fuel system revealed that the spring of the EMERG switch was partly misplaced and consequently it was possible for the switch to remain in the HIGH position, even when it was not pressed. This malfunction occurred occasionally.

The engine fuel pump produced fuel flow when rotated by hand.

Inspection of the Fuel Injection Components

The fuel system components of the engine were removed and tested at Patria Aviation Component Department at Halli 13 – 14 Apr 2010. The components of the fuel injection system were tested from idle to maximum power setting. The fuel flow from all fuel nozzles was found to be even. No air or fuel leakage was found. The functioning of the fuel governor and pump was normal and in accordance with the recommended values of the manufacturer.

The test simulated the functioning of the engine fuel system on the settings used on the accident flight. The components of the fuel system were set to correspond to the engine running at 2300 r/min with manifold pressure at 19 – 20 inHg and fuel flow leaned to about 10 USgal/h. At full throttle with manifold pressure at 29,9 inHg, the fuel flow was 14,5 USgal/h and with manifold pressure 37,0 inHg the corresponding value was 18,0 USgal/h. When the mixture was set at full rich, the corresponding values were 22,0 inHg and 28 USgal/h.

Determining the Position of the Flaps

The position of the flaps at the time of the accident was determined by its mechanical spiral/screw activator. Judging by the position of the activator the flaps were retracted at the time of the accident.

1.16.2 Maintenance of the Aircraft and Control of Airworthiness

The aircraft had a maintenance plan (OH-CHO-MP1), approved by the Finnish Civil Aviation Authority (currently Trafi Aviation) on 26 Aug 2009. In the maintenance plan the control organisation of airworthiness was Konekorhonen Oy. The maintenance plan had been revised, version nr 01, which had been approved on 26 Aug 2009.

Maintenance and repairs had been ordered according to the maintenance plan. The work ordered had been carried out by Konekorhonen Oy (maintenance organisation licence nr FI.145.0011). Maintenance certificate on services done had been given. The latest maintenance, 100 h and annual inspection, had been done on 27 Nov 2009. The next scheduled maintenance would have been at running time 2206 h or 27 Nov 2010 at the latest.

There were no open or postponed defects. The autopilot engagement switch had a text "AUTOPILOT NOT IN USE". A defect "autopilot not in use" had been opened in the postponed defects list. The defect had been closed on 5 March 2007. As a reference for closing the defect there was a note "MEL change page 9". However, the autopilot system was still in the Minimum Equipment List (MEL).

The flight from Joensuu to Kuopio had not been logged in aircraft logbook, nor had the log page been opened. Only the flight time and number of landings had been transferred from the previous page. There was no note of inspection before flight for the flight Joensuu - Kuopio or for the flight onwards from Kuopio.

The situation concerning the time control of components, Airworthiness Directives (AD) and manufacturer's Service Bulletins (SB) of the engine was checked. The checks brought out nothing to comment.

1.16.3 Simulation Flight

In order to find out the factors related to the engine failure a simulation flight was flown on 10 June 2010 with a Cessna TU206 with wheeled pontoons and the same engine type as on the accident aircraft. The purpose was to simulate the en route power settings of the accident flight and monitor the engine's behaviour when engine controls were adjusted and when using the magneto switches and electric fuel pump. The weather during the simulation flight: wind 150 degrees, 6 knots, temperature +18 degrees Celsius, dew point 7 degrees Celsius and QNH 1016 hPa.

Five different simulations were done during the flight. The airspeed was maintained at about 90 kt in 200 – 300 ft/min glide to compensate for the drag of the pontoons. The mass of the aircraft was made corresponding to that of the accident aircraft by refuelling 140 litres of fuel.

As the starting point for the first flight the same flight parameters and engine settings that the pilot of the accident flight had used were set: speed about 90 kt, manifold pressure 19 inHg, revolutions 2300 r/min and fuel flow 10 USgal/h. In the next test the fuel flow was reduced to 8 USgal/h and in the third to EGT peak value, which was 7 USgal/h. After the starting settings, manifold pressure was increased by opening the throttle slowly to maximum, until 35 inHg. The engine behaviour and engine gauges gave no sign of failure. With lower fuel flow values the engine sounded more constrained and due to lean mixture did not give power.

In the fourth test, after the starting settings, the electric fuel pump was switched on to full power, EMERG setting. Engine revolutions fell to 2100 r/min and at the same time the engine sound became harsh and uneven. The fuel flow increased to 16 USgal/h and manifold pressure by 1 - 2 inHg. The engine did not stall or give banging sounds (eventual banging could not anyway be heard in the cockpit). When the fuel pump was released to low pump setting, the fuel flow decreased to 12 USgal/h and the engine sound returned to normal. When the magnetos were tested, a slight difference in the engine sound could be distinguished when selecting between two and one magnetos.

Also in the fifth test, after the starting settings, the electric fuel pump was switched on to full power in the EMERG position. The engine revolutions fell to 2200 r/min and fuel flow increased to 16 USgal/h. The engine ran coarsely and sounded uneven. When manifold pressure was increased to 30 inHg, the revolutions increased to 2300 r/min and fuel flow to 25,5 USgal/h. At the same time the engine ran better and produced power.

1.16.4 Examination of the Fuel Samples

Before the accident flight the aircraft had been refuelled at Kuopio aerodrome with 214 litres of aviation fuel. Fuel samples taken from the refuelling device and the fuel storage were examined by equipment and means available to the investigators with the following results:

- Sample from the refuelling device; temperature +12,2 degrees Celsius, specific weight 0,710, colour and odour normal, no impurities or water could be seen. When tested with Kolor kut, the result was negative, meaning that there was no water in the sample.

- Sample from fuel storage: temperature +13,0 degrees Celsius, specific weight 0,710, colour and odour normal, no impurities or water could be seen. When tested with Kolor kut, the result was negative.

1.16.5 Satellite Locator

The aircraft had a Garmin GPS III Pilot satellite locator. Based on information stored in the locator’s memory the progress of the flight could be analysed.

1.16.6 Training and Experience of the Pilot

The pilot had begun his flying as a private pilot in 1998. He had started his training for commercial flying in 2006 in Finland and complimented it abroad during years 2007 and 2008 so that he received his Commercial Pilot Licence in February 2008. The pilot worked as an apprentice in maintenance activities at Konekorhonen Oy in the summer of 2008 and started his actual work as a pilot in the company in 2009. At this time his total flight experience was over 300 hours, mainly with single engine land aircraft.

The pilot started flying with the accident aircraft type (C206) at Konekorhonen Oy in February 2009. According to him, he had received no actual type training for the aircraft; familiarization was done through self study of the flight manual and by flying one familiarization flight with the responsible manager of the company. Before starting power line inspection flights in January 2010, the pilot’s experience on the C206 was about 55 flight hours, consisting mainly of game counting and vaccination dropping flights. By this time his total flying experience had increased to a bit less than 600 flight hours, consisting mainly of flying single engine Cessna 172 and twin engine 401.

The pilot flew his first power line inspection flight two days before the accident. He had received no training for power line inspection flights. Preparation for line inspection work was done by studying the company's Flight Operation Manual LO 7, special work instructions for inspecting aerial lines. Before the accident he had flown three line inspection flights with total flight time of about 6 hours. Before this he had flown the accident type in September 2009.

The pilot told that his low flying experience, experience of flights below the minimum altitude of 150 metres according to Flight Rules, was only 1 - 2 flights at 400 – 500 feet (120 – 150 metres). These flights were part of his commercial pilot training in Sweden.

According to the responsible manager of the company, a line inspection flight was flown with the pilot after the accident. The pilot tended to follow the contours of the terrain which makes flying difficult, causes need for power adjustment and increases risk of colliding with obstacles.

1.17 Organizational and management information

1.17.1 General

Konekorhonen Oy was founded at Tikkakoski in 1979. The company's multiple aviation services include aviation, airworthiness control, aircraft maintenance, repairs and spare part services and sale of aviation related products. Company's main line of business is maintenance and repair services of aircraft. The company has facilities in three locations: Tikkakoski, Hyvinkää and Helsinki-Malmi. The main facility is in Tikkakoski.

The total number of personnel of Konekorhonen Oy is 22. The company has one full time and two part-time pilots. The rest of the employees are technical personnel. The company's flight operations are flown with three single engine and two twin engine aircraft. In 2009 the company's flight operations were solely operations according to aerial work permit. Flight operations are about 15 – 20% of the company's business volume.

The first Air Operations Certificate (AOC) in accordance with EU-OPS 1 of Konekorhonen Oy for commercial air transport had been issued on 14 July, 2008, and it was valid until 30 September 2009. The second EU-OPS 1 AOC was issued on 29 September 2009. It was valid until 30 September 2010. The certificate included also approval for aerial work, among others with the accident aircraft. Aerial work permit includes game counting, aerial photography and inspection of aerial lines. The company flies also search and rescue and fire surveillance flights. SAR flight operations are conducted mainly in cooperation with authorities.

According to the Air Operations Certificate of Konekorhonen Oy, the organisation has to include responsible manager, quality manager, flight operations manager, maintenance operations manager (airworthiness manager) and on the responsibility of the same person training manager and ground operations manager. The main line of business of the company's flight operations is aerial work. The Civil Aviation Authority has authorised the same responsible persons to manage aerial work as in the Air Operations Certificate for commercial air transport. The authorisation of aerial work is based on OPS M1-23 of Aviation Regulations. It stipulates that the operator of aerial work has to appoint a responsible manager responsible for overall operations, an air operations manager responsible for flight operations and a manager responsible for aircraft maintenance operations and airworthiness control.

Konekorhonen Oy has the required (EU-OPS) flight operations manuals for flight operations; Operations Manual Part A, (OM-A), aircraft specific type manuals (OM-B), Jeppesen approach and route charts (OM-C) and training manual (OM-D).

1.17.2 Flight Operations

The responsible manager of Konekorhonen Oy is responsible for the marketing, sales and recruiting of the company. He has the overall responsibility for prevention of accidents and flight safety programme and the functioning of the quality system. According to the responsible manager, in practice in flight operation matters he is a link to flight operations manager, whose office is in Hyvinkää. Flight operations are mainly conducted from Tikkakoski.

The duty of the flight operations manager on his part is to see to it that flight operations are conducted economically, their coordination and maintaining the operations in the company's portfolio. Flight operations manager is also responsible for the safety of flight operations and that the company's approved procedures and authorities' directives are followed. He also needs to make sure that the pilots of the company have valid licences, ratings and training. The current flight operations manager of the company is an aviation enthusiast.

Briefing for aerial work takes place in the beginning of the season. According to the flight operations manager, the responsible manager of the company and training manager give the briefings. During operation the pilots report to the company's leadership. The character of flight operations is often busy, but according to the pilot in the accident, this has not affected flight safety. The pilots are themselves responsible for controlling their working hours and reports on them are sent weekly to the company's training manager. The accident flight was briefed to the pilot by the company's responsible manager by phone. The pilot of the accident flight thought that flight operations manager takes very little part in managing the operations.

Konekorhonen Oy has a Flight Operations Manual LO 7 for inspection of aerial lines in accordance with the aerial work permit.

1.17.3 Maintenance Operations

Konekorhonen Oy has a licence for continuous airworthiness organisation and a maintenance organisation licence in accordance with EASA Part 145. Maintenance Manager is responsible for the continuous airworthiness control of the company's aircraft. In the company's OM-A the person's title is Continuous Airworthiness Manager.

The continuous airworthiness control of Konekorhonen Oy is focussed on keeping the maintenance programmes of aircraft in own operation up to date and assessment and adoption of new requirements (AD/SB revisions). Airworthiness control is responsible for time control of maintenance requirements and for ordering maturing work from own EASA Part-145 approved maintenance organisation. Completed work is received and time control is updated.

1.17.4 Training Operations

The training manager is responsible for the training of flight crews. According to Konekorhonen Oy's view, there are no clear links between the training required for commercial flight operations and aerial work. Training requirements for line inspection flights are included in the company's Flight Operations Manual LO 7. According to the company's responsible manager, Konekorhonen Oy does dot give special training for line inspection operations because LO 7 is quite unambiguous. However, there is a requirement in the manual that training has to be given to pilots who have not earlier flown line inspection flights for Konekorhonen Oy. According to the accident flight pilot, he had not been given the minimum of one hour basic training theory nor the basic training flight for line inspection as stipulated in the manual. According to the pilot, he familiarized himself with the LO 7 manual on his own. According to the company's training logbook, the pilot had been given refresher training on flight procedures in accordance with the flight operations manual. The responsible manager of the company flew a familiarization flight with the pilot on the accident aircraft in February 2009.

1.17.5 Quality Operations

The duties of Konekorhonen Oy's quality manager include making sure according to updated quality programme that the company's operation abides by Authority's directives and that the company's procedures and quality system is followed according to them. In addition to this, it is his duty to make sure that corrective measures to deviations are taken within set time limits. The quality manager reports direct to the responsible manager. The quality manager's office is in Hyvinkää.

According to its quality policy, Konekorhonen Oy has set an objective to maintain such flight safety level that it prevents accidents and serious danger to personnel and materiel. The company strives for this objective by abiding by the directives of the National Aviation Authority, European Union (EU) and European Aviation Safety Agency (EASA).

In its own quality system Konekorhonen Oy complies with the International Standardization Organization, ISO 9000 quality management system. The performance of the operation is monitored by internal and external auditing. The external auditing is performed by Den Norske Veritas, NVD Oy/Ab.

The investigation commission inspected the quality plan of Konekorhonen Oy starting from 2006. According to the inspected auditing reports two planned flight operations audits had not been done. With that exception the quality plan had been well adhered to.

There were some minor deviations in internal operation, mainly in the documents. Deviations or trends directly affecting flight safety could not be identified.

In the Civil Aviation Authority's flight operation inspection (EU-OPS 1 Commercial Flight Operations) on 18 September 2009, two serious deviations concerning training manual and the company's quality training were made. In addition to this, the Civil Aviation Authority found ten minor deviations in the company's operation. The most meaningful from flight operations point of view were, among others, defects in the monitoring procedures of the company's pilots' licences, ratings and currency of training and the pilots' work and flight working time. Land and flight training and their logging could not be fully verified. The corrective measures taken by Konekorhonen Oy after the 18 September 2009 flight operations inspection have been found satisfactory by the Civil Aviation Authority.

1.17.6 Accident Prevention and Flight Safety

The accident prevention and flight safety programme are in the company's OM-A, subparagraph 2.3. The flight operations manager is responsible for keeping it up to date. The realization of Konekorhonen Oy programme is based on a functioning reporting system and training of personnel. The reporting responsibility of accidents and serious danger situations, based on Aviation Regulation GEN M1-4, has been defined in OM-A paragraph 11. The reporting responsibility of the aircraft commander to Accident Investigation Board is missing from the paragraph.

There have not been many incidents belonging to reporting responsibility category in Konekorhonen Oy operations. A privately owned seaplane (Cessna A185E), registered to the company's use, had a flight accident in 2005 and in 2001 an engine failure to a Hughes helicopter. In addition, the company has reported to the Civil Aviation Authority a few small damages to their aircraft caused by bird strike.

The pilots of Konekorhonen Oy report little of their own mistakes. There are about 5 – 10 verbal reports annually. According to the quality manager, there is still room for development in the company's reporting system. The fact that you are not financially responsible for your own mistakes has been emphasised in reporting.

According to the leadership of the company, flight safety matters are efficiently managed and the leadership is well aware of the safety level.

The pilots of the company are informed of flight safety matters in annual training sessions and always, when needed. Matters reported in writing are filed. The pilots can familiarize themselves also with other material in the briefing as needed. According to the pilot of the accident flight, there is no regular flight safety activity for personnel in the company.

1.17.7 Power Line Inspection Operations

In the aerial line inspection flights Konekorhonen Oy operates in cooperation with power supply systems operator Eltel Networks Oy. In practise Konekorhonen Oy provides an aircraft with crew, and the actual inspection is done by a Eltel Networks Oy line inspector on board the aircraft.

The flight inspection operations of aerial lines have been regulated by Eltel Networks Oy directive J8.12, Flight Inspection of Aerial Lines, and by Konkorhonen Oy's Flight Operations Manual LO 7, Special Work Manual for Inspection of Aerial Lines. Eltel Networks Oy's directive gives general guidelines for inspection of aerial lines and safety instructions including instructions for the line inspectors for eventual forced landing. The Flight Operations Manual of Konekorhonen Oy includes requirements for the pilot's experience level and training and instructions for the execution of line inspection flight.

Konekorhonen Oy's requirements for pilot flying line inspection flights is commercial pilot licence CPL(A) and 600 hours of flight experience. A lesser experience can, on case by case basis, be approved by the flight operations manager and the responsible manager. Type-related, Cessna 206G, flight experience requirement is 5 hours. Training requirement is at least one hour of theory training and one training flight with the flight operations manager or a pilot assigned by him.

According to the flight operations manual, weather minima according to the flight rules and the aircraft's flight manual specifications are to be followed. The minimum altitude for line inspection work is 100 ft AGL (30 m above ground) over an uninhabited or thinly populated area. Over densely populated area the minimum altitude is 300 ft (90 m) AGL. Flight rules' altitudes are used on en route legs.

According to the flight operations manual, line inspection flights are flown on the left hand side of the aerial line so that the line inspector sees the line at about 45 degrees angle sloping downwards. About 100 – 300 ft altitude above ground is maintained depending on the height of the lines. The manual gives as an example for Cessna TU206G aircraft minimum speed in calm weather 85 kt, in moderate turbulence 95 kt, and in heavy turbulence 100 kt. As for configuration, flap 20 degrees is recommended. Engine revolution and fuel mixture settings are to be done according to flight manual.

1.18 Additional information

The accident investigation commission requested comments on the possible contributing factors on the engine failure both from the aircraft's engine manufacturer, Teledyne Continental Motors Inc, and the fuel supplier, Shell Aviation. Special focus was on finding whether the used power setting is applicable for continuous use, factors related to the leaning of the mixture, factors related to the fuel and the effect of the low outer air temperature on the functioning of the engine.

According to the engine manufacturer's answer, the power setting used on the accident flight was within the engine's normal operating envelope, but on its low side. The engine manufacturer did not answer other questions; they requested doing a more detailed examination by themselves as a prerequisite to eventual additional answers.

According to Shell Aviation's answer it is typical for the fuel used, Avgas 100LL, in cold weather and lean mixture that the cold engine intake air, which is thicker than warm air and holds more oxygen, leads to leaner mixture at the same fuel flow. Based on these, during the warm weather simulation flight the fuel mixture has been richer than on the accident flight, thus explaining the results from the simulation flight.

2 ANALYSIS

2.1 Condition of the Aircraft and Airworthiness

The technical examination of the aircraft focussed especially on the inspection of the aircraft engine and fuel system. Also the steering system was examined and found to be functional before the accident. The pilot told he had piloted the aircraft till the end.

According to the pilots understanding, the aircraft engine had a failure which led to loss power during flight. Also the line inspector on board detected the failure. The eyewitness and the driver making the aural observation heard strong banging from the engine. The engine was disassembled but no mechanical fault or damage that could have caused a failure was found. The ignition mechanism of the engine and the fuel system of the aircraft and engine were inspected and found functioning. The fuel equipment was clean with the exception of the rust coloured sediment in the right collector tank. There was no water in the filters or in the fuel. The unlocked MANUAL PRIMER fuel pump had no effect on fuel feed.

The damages found in the induction valves and early wear and corrosion in the exhaust valves and cylinders do not cause serious failure or such change in the engine behaviour that it could be detected by the pilot. The early wear and corrosion may be the consequence of the manufacturer changing material in the parts and/or production methods.

The maintenance and repairs of the aircraft had been performed by Konekorhonen Oy in accordance with the maintenance programme. As far as the continuous airworthiness control and maintenance are concerned, no facts with negative contribution to the airworthiness of the aircraft were found. The investigation commission views that the out of service autopilot should either have been removed or repaired. The pre-flight checks concerning flights on 20 January 2010 and the flight from Joensuu to Kuopio were not logged in the aircraft log book. On behalf of the missing logging the aircraft was not airworthy.

The investigation commission's understanding is that the condition of the aircraft was not a factor in the accident. Factors related to the engine failure are dealt with separately in the analysis.

2.2 The Accident Flight

After take off the pilot started homing in on the power line to be inspected at the same time climbing to about 700 ft on QNH. In the first stages of the flight the altitude was about 100 m AGL, but when approaching the line, over the hills, some tens of metres. The pilot's targeted line inspection altitude was 100 – 150 ft (30 – 45 m). As the needed climb was only 400 ft, the pilot said he adjusted the air speed and corresponding engine settings immediately after reaching the altitude. He told he had done the setting according to flight manual's en route performance chart and exhaust gas temperature gauge.

The pilot reached the line about three minutes after take off on the south side of lake Honka-Jälä. In this area the terrain height is about 140 – 160 metres above sea level. From here to about 3 km to the north the line to be inspected turns to North West, and the terrain goes down 40 – 60 metres for about 3 km, rising again about 40 metres when approaching the site of the accident. According to the pilot, he aimed to follow the line at constant distance and altitude, but during the glide the altitude and airspeed tended to grow somewhat. He did not consider this inconvenient, because the terrain in front rose again. The increase of airspeed in glide was natural because the pilot had not extended the flap although he initially thought he had.

As the terrain after passing the Siilinjärvi golf course started again to rise, the pilot noticed that the engine revolutions decreased and the engine was running unevenly and coarsely. Due likely to low (the pilot's estimate 45 m) altitude and air speed, the pilot first carefully increased throttle (throttle lever about 1 cm forward). This, however, did not affect the engine running. According to the pilot, he thought that there was an ignition failure and therefore he next tested the magnetos. As no change took place, he engaged the electric fuel pump to ON position to low power. For an inexplicable reason the pilot did not enrich the mixture. According to the pilot, the running of the engine did not return to normal but the engine kept running all the way to the ground. The pilot was completely sure that he did not move the throttle lever after leaning the mixture before the start of the engine failure.

During the final stages of the flight the pilot gave a distress report (mayday) over the radio of inevitable forced landing. His understanding was that he had repeated the report. During the last part of the flight the pilot concentrated on doing a controlled forced landing and succeeded in avoiding injuries to personnel. According to information from the pilot and persons making aural observations it can be estimated that after the start of the failure the aircraft flew for some 40 – 60 seconds, approximately 1,7 – 2,4 km.

2.3 Training Background and Experience of the Pilot

As he began the line inspection flights two days before the accident, the pilot had no actual training or experience whatsoever needed for low flying (altitude clearly below 150 m), strictly required by valid directions if they had been followed. When asked, the pilot thought that his readiness to begin line inspection flights was adequate, but said that reflecting after the accident he would have wanted more training. The pilot said that he was anxious when starting line inspection flights, because low flying was a new working environment for him. In addition to low altitude, the flying takes place at a clearly lower airspeed than cruise speed and in his view the flights may be flown also in fairly bad weather conditions.

The investigation commission's understanding is that the pilot was not qualified for line inspection flights. The pilot said that he did not like the flights because of the low altitude and airspeed. Due to lack of training, the pilot did not know low flying principles or the risks it involved. Deficiencies were identified also in the company's procedures when he flew a line inspection flight after the accident. The pilot tried to follow the terrain, which makes flying difficult, causes need to adjust power setting and increases the risk of collision with obstacles. The Investigation Commission presumes that the company has to give the pilot the additional and special training the flying requires, and also control that the needed skill level is maintained.

2.4 Pilot's Action

The pilot considered low flying with one man crew a risk, but tried to control the risk by doing the preparations well. The pilot had done the route preparations the night before the accident. Before take off from Joensuu he had studied weather information and other relevant information. After a thorough preparation the pilot said he had taken off with trustful mind.

It became apparent in the pilot's interviews that his type knowledge and experience with the accident aircraft type was relatively limited. On the basis of the interview the investigation commission cannot be certain of how the pilot leaned the mixture after reaching the cruising altitude. The pilot said that when he leaned the mixture, he had referred to both the flight manual's cruise performance chart and EGT gauge. The performance chart does not include the combination of revolutions and manifold that the pilot used or the corresponding value for fuel flow. The pilot said he had concluded his target fuel flow value with the help of the chart. He was not quite sure whether or not he had adjusted the mixture with the help of the EGT gauge to find the highest temperature of exhaust gases, the EGT peak. It is the understanding of the investigation commission that leaning the fuel flow by estimation may lead to too lean mixture and consequently engine failure.

Pilot's actions after the engine failure were not in accordance with the flight manual. The pilot increased power a little, but did not enrich the mixture. For this reason it is likely that the mixture became too lean causing an engine failure or maintaining an already existing running failure. According to the flight manual, after securing the fuel flow (there is fuel in the fuel tank in use) adjust mixture to rich and engage electric fuel pump for 3 - 5 seconds with the throttle lever in the half open position. After that the magnetos are checked: BOTH, L or R positions and throttle is increased slowly. As the failure occurred below 50 metres altitude and at about 80 – 90 kt airspeed, conducting the actions required by the failure quickly is a very demanding undertaking.

Forgetting the use of the flaps indicates the pilot's uncertainty, although he recalled to have chosen flaps to 10 degrees. The pilot told he had used the flap on a previous flight because it had made observation to front sector easier because of an advantageous attitude. The use of flaps is instructed in the company's flight operations manual's example at 20 degrees in paragraph 4.6.1 General.

The pilot's action indicates that many aspects in his readiness for the flight were insufficient. His performance shows inexperience and lack of routine with the aircraft type and line inspection flights at low altitude. The pilot's performance may have been distracted by the fact that the failure occurred in a situation demanding to him.

2.5 Engine Failure

The technical inspections of the aircraft and engine did not bring out a fault that could have caused the engine failure. According to the pilot the engine failure began suddenly without the engine settings being changed after adjustment to cruise power setting (2300 RPM, 19 – 20 inHg and 10 – 11 USgal/h). The following deals with some factors to be taken into account relevant to the occurrence mechanism of engine failure.

The most important factor affecting engine running and power is the mixture of fuel and air burning in the cylinders on various power settings and in various circumstances. Too rich or too lean fuel mixture causes engine running failures. Running failures caused by too lean mixture are coarse running, banging in suction and exhaust pipes, considerable loss of power and sudden stalling of the engine. Close to the maximum power setting also knocking and overheating are possible. The burning speed of the mixture slows down as the mixture gets leaner. As the burning speed slows down too much, the mixture keeps on burning when the exhaust and suction valves are momentarily simultaneously open and causes the earlier mentioned running failures. Too rich mixture causes coarse running, considerable loss of power or engine stalling. This situation usually incurs black smoke and the exhaust pipes get sooty.

In cold weather the same fuel flow produces leaner fuel mixture than warm weather. Colder air is denser and causes the leaning of the fuel mixture because of its higher oxygen content. To maintain the same mixture in cold weather the fuel flow should be increased or manifold pressure decreased. In cold weather disturbance of the burning of lean mixture is more likely, because the fuel gasifies poorly in low temperatures. Because of poor gasification the mixture of fuel and air remains leaner. Running failures caused by too lean mixture appear during very cold temperatures. This phenomenon appears in aviation engines with carburettors.

On cross-country flight and especially on low power setting flights the mixture has to be leaned. Leaning is done either by the aircraft's flight manual cruise charts or, more accurately according to EGT gauge. Using the leaning procedures recommended for each engine type in the flight manual, the power setting usually gives the best power or best fuel economy. According to the flight manual of Cessna TU206G, the recommended procedure to lean the fuel mixture is to enrich the mixture from the EGT peak value by 50 degrees Fahrenheit. The best economy is produced by leaning to peak value.

The pilot was not quite sure how he had leaned the mixture on the accident flight. He thought that he had adjusted it according to fuel flow gauge to 10 – 11 USgal/h. The value is not in accordance with the flight manual and by this information one cannot conclude how close to EGT peak value it was. If leaning leads close to the EGT peak value, engine failure is possible if the fuel mixture for some reason leans further. This may take place in valleys due to colder outer air temperature. The forecast for Eastern Finland was surface inversion and very cold temperatures. In these conditions the temperature difference between higher and lower areas may be several degrees. The eyewitness and aural observations of strong engine banging suggest too lean a fuel mixture.

If manifold is increased, i.e. the throttle lever is moved forward, in temperature conditions such as on the accident flight already before the occurrence of the engine failure, the fuel mixture becomes leaner and probably causes engine running failure.

A simulation flight was flown with an aircraft with similar engine as in the accident aircraft to produce an engine running failure. The flight simulated the situation on the accident flight as described by the pilot, but a similar engine failure did not appear. The most significant difference between the accident flight and the simulation flight was outer air temperature. During the accident flight it was -18 degrees Celsius and during the simulation flight +18 degrees Celsius. Due to the higher temperature the accident flight fuel flow setting used on the simulation flight gave richer mixture. Because of the richer mixture engine running failure did not appear on the simulation flight.

The accident investigation commission considers it likely that the engine running failure was caused by too lean fuel mixture. During the flight this became evident in the form of power loss and banging in the exhaust pipe. The condition was caused by the pilot's action in handling the engine and low outer air temperature. That the engine failure developed into an accident was mainly caused by the fact that the pilot never enriched the fuel mixture. This can be considered the main reason for the engine running not to return to normal.

2.6 Search and Rescue

Kuopio tower started the search and rescue operations for OH-CHO by giving a danger alert at Kuopio aerodrome and making an emergency report to Emergency Response Centre (ERC) of Pohjois-Savo. Due to the lack of the site's location information the aerodrome and Karelia Air Command rescue units initially took positions in the vicinity of the runway in accordance with standard procedure. The units alerted by the ERC from Siilinjärvi headed first toward the area south of Kuopio aerodrome and highway 5, following the partly inaccurate information they had received. The ERC received the actual location of the site about six (6) minutes after the accident from the eyewitnesses. The rescue units received the in formation about two minutes later. The first rescue units from Siilinjärvi reached the site at 11.42, approximately 16 minutes after the accident and about 10 minutes after the eyewitness made his report to the ERC. Kuopio aerodrome and Karelia Air Command units reached the site between 11.40 – 11.55.

Efficient search and rescue operations were delayed by the insufficient site information in the first alert information. The controller determined the imminent accident area based on the flight plan and the information the pilot had given by phone before the flight. The site was determined to be in the area of the starting point for the line inspection from where the aircraft had flown a few minutes northward. Afterwards the Kuopio controllers understood that a more accurate determination of the accident area could have been made in the first place with the help of the radar display showing the last likely position of the aircraft. After hearing the accident site location over the VIRVE net, the controllers located the accident site on the map to guide a helicopter for aerial search to the site. Because the rescue units reached the site fairly quickly, the helicopter search mission was terminated.

The delay to begin the rescue operations caused by the determination of the accident site cannot be considered meaningful. Due to the quick action of the eyewitness, rescue units reached the accident site quickly although the need for actual rescue actions was minor. The response time of rescue operations was good and despite the cold conditions all necessary actions, e.g. collection of leaking fuel were carried out irreproachably. The rapid action by the environmental officials prevented possible environmental damage, they removed the soil contaminated by the aircraft fuel and replaced it with pure soil.

2.7 Organizational and Management Information

Konekorhonen Oy had valid authority approvals for both commercial flight transportation and aerial work. As the company's aerial work certificate had been approved as part of flight operations, the investigation commission has evaluated the company's aerial work management and realization as an integral part of the flight operations certificate.

The management and execution procedures of operations have been adequately described in the company's operation manuals. During the investigation it has become clear that as the company's operations are scattered over three different locations, especially the management of flight operations poses great challenges and the job descriptions in the operation manual OM-A are not realized in the described manner. According to the investigation commission's understanding, the flight operations manager of Konekorhonen Oy has not participated in the management of the aerial work in an adequate manner. In practise the company's responsible manager and training operations manager have been responsible for it. The supervision of the aerial work training of the accident flight pilot has been inadequate. It is the responsibility of the flight operations manager. One hour's basic training theory and aerial lines inspection training flight have not been given. The pilot has only been given the refresher training on flight procedures in accordance with the flight operations manual. Taking into account the challenging nature of low flying line inspections, the investigation commission's understanding is that the pilot of the accident flight did not have adequate experience for line inspection operations.

It is the investigation commission's understanding that the company's training organisation has failed in not giving the accident flight's pilot the basic theory and flight training required by the flight operations manual.

In the Civil Aviation Authority's audit of the company in 2009 two serious and ten minor deviations were found. Although the audit was focussed on the company's commercial flight operations, the investigation commission's understanding is that the defects reflected on the management and culture of the company's aerial work degrading the company's attitude towards flight safety.

It is the investigation commission's understanding that the quality system of Konekorhonen Oy has not been fully successful in its internal auditing. Although the company's quality control plan had been executed in 2009 partly in a commendable manner, the management oversight and especially the planned flight operations audits had been omitted.

3 CONCLUSIONS

3.1 Findings

1. The pilot had a valid licence and ratings required by the operation.

2. The registration and airworthiness certificates and required insurances were valid.

3. The aircraft was not airworthy due to missing logging in the logbook.

4. The engine of the aircraft was disassembled, but no mechanical fault or damage causing running failure could be found.

5. It is the investigation commission's understanding that the condition of the aircraft was not the cause of the accident.

6. The pilot had not received training for line inspection flights or low flying. In practice, the pilot did not have the needed training or experience for low flying.

7. According to the company's flight operations manual LO 7, pilot's training requirement for line inspection flights is at least one hour's theory training and one training flight with the flight operations manager or a pilot assigned by him.

8. Before the accident the pilot had flown three line inspection flights, amounting totally to about six hours.

9. When beginning the line inspection flights the pilot told he had been anxious as he felt that low flying was a new working environment for him.

10. The pilot was not sure whether he had adjusted the fuel mixture by the EGT gauge to seek the maximum peak temperature or not.

11. The aircraft's flight manual performance chart does not have the combination of revolutions and manifold nor the corresponding fuel flow value that the pilot had used. The pilot told he had concluded the target fuel flow value with the help of the chart.

12. Compared to standard conditions, to maintain the same mixture, fuel flow has to be increased or manifold pressure decreased in cold weather.

13. It is the investigation commission's understanding that using estimated fuel flow to lean the mixture may lead to wrongly leaned mixture and cause engine failure.

14. The pilot set the airspeed and corresponding engine settings immediately after reaching altitude.

15. The pilot did not extend flaps, although the flight manual recommends 20 degree flap setting.

16. The altitude of the flight path went down at its maximum approximately 60 metres to the lowest point of the terrain and rose from there to about 40 metres to the accident site.

17. As the terrain started to rise the pilot detected that the engine revolutions decreased and the engine was running unevenly and coarsely.

18. After the failure started the pilot increased power slightly, but did not enrich the fuel mixture. This makes it likely that the mixture changes to too lean causing engine failure or maintaining an already existing failure.

19. The pilot's actions after the beginning of the engine failure were not according to the flight manual.

20. The running of the engine did not return to normal after the beginning of the failure. The engine was running until the impact with the ground.

21. The aircraft was destroyed in the unprepared forced landing.

22. The pilot and the line inspector suffered minor injuries to their bodies mainly form the impact.

23. It is the investigation commission's understanding that the pilot was not qualified for line inspection flights because he did not have the training for line inspection flights or low flying.

24. Kuopio tower started imminent flight accident danger and flight accident alerts suspecting that OH-CHO possibly had hit the ground.

25. The Emergency Response Centre of Pohjois-Savo started imminent flight accident danger and flight accident alerts at the right response time.

26. The start of efficient search and rescue operations were delayed because of insufficient location information in the first alert.

27. Afterwards the Kuopio controllers understood that a more accurate determination of the accident area could have been made in the first place with the help of the radar display showing the last likely location of the aircraft.

28. The delay to begin the rescue operations caused by the determination of the accident site cannot be considered meaningful. Due to the quick action of the eyewitness rescue units reached the accident site quickly.

29. The first rescue units reached the accident site 16 minutes after the accident.

30. The rapid action by the environmental officials prevented possible environmental damage, they removed the soil contaminated by the aircraft fuel and replaced it with pure soil.

3.2 Probable causes and contributing factors

The cause of the accident was engine failure during flight, which, as a consequence of loss of power, led to unprepared forced landing. The engine failure was likely the consequence of too lean fuel mixture. Contributing factors to the incident were the pilot's action in handling the engine and low outer air temperature. That the engine failure developed into an accident was caused by the fact that the pilot did not enrich the fuel mixture after the beginning of the engine running failure.

Contributing factor was the pilot's inexperience in low flying and the absence of the needed training.

4 SAFETY RECOMMENDATIONS

4.1 Safety actions already implemented

The investigation commission has no knowledge of already implemented safety actions.

4.2 Safety recommendations

1. Line inspection flights are flown low and at lower speed than normal cruise speed. The precondition for the safe execution of the flights is adequate training that takes into account the special features of low flying.

The investigation commission recommends that Konekorhonen Oy revises its flight operations manual LO 7 pilot training requirement so that it includes the needed theory and flight training for low flying.

Helsinki, 23 August 2011

Juhani Hipeli Vesa Palm

Hans Tefke

SUMMARY OF COMMENTS

The investigation report has been modified to the appropriate extent in accordance with comments received.

The fuel supplier focused in its comments on how leaning of the fuel mixture affects engine malfunction.

The environmental official of the Siilinjärvi municipality proposed that the critical location of the crash site with regard to the environment be added to the investigation report as well as the rescue and follow-up actions to prevent environmental damages. In addition the environmental official regards it necessary that the pilot is expected to possess special training for power line inspection flights.

The Emergency Response Centre (ERC) of Pohjois-Savo brought up the fact that alerting even with insufficient location information makes the first start quicker, because the majority of the Siilinjärvi fire fighters receive the alert at their homes. The location information can be updated in the mean time as they arrive at the fire station.

In its comments Finavia Corporation emphasized the fact that the Kuopio Tower reported the incident to the ERC some time before the first observation report. In addition, Finavia Corporation stated that in this situation the ATC was not responsible for giving separation clearances for the aircraft and that traffic advisories or communication between aircraft do not create separation.

According to the Flight Operator, the pilot had adequate training for low flying and the missing of a training flight in accordance with LO 7 did not contribute to the accident as the stalling of the engine belongs to basic training. The Flight Operator further emphasized that the deviations detected by the Civil Aviation Authority in its inspection in the autumn belonged to operations according to EU-OPS, which at that time had not been started. The defects found in the inspection were partly due to the sick leave of the official supervisor, which delayed authority comments during the approval process. The Flight Operator wants to emphasise that the accident flight was not an EU-OPS operation. The Flight Operator also pointed out that the Investigation Commission did not hear the supervisor of the line inspection flight flown to the pilot after the accident.

In addition, answers were received from the engine manufacturer, the aircraft manufacturer, National Transportation Safety Board NTSB, Siilinjärvi fire station, Karelia Air Command, the flight service customer, Trafi Aviation (CAA Finland) and European Air Safety Agency (EASA). They had nothing to comment.