Amateur-built Aircraft Accident in Tikkakoski on April 17, 2022

L2022-02

SYNOPSIS

Pursuant to section 2 of the Safety Investigation Act (525/2011), the Safety Investigation Authority of Finland (SIAF) decided to investigate an aviation accident that occurred in Tikkakoski on April 17, 2022. An amateur-built Monnett Sonerai I airplane impacted wooded terrain and the pilot sustained fatal injuries.

Master of science in engineering, flight instructor Olli Borg was appointed the investigation team leader. The appointed team members were special investigator Juho Posio, aircraft mechanic Mikko Raatikainen and aircraft mechanic Jouni Rautio. The investigator-in-charge was Chief Air Safety Investigator Janne Kotiranta.

Neste Oil Engine Laboratory tested fuel samples and produced a report. Konekorhonen assisted in the testing of the magneto and the ignition harness. The tachometer was examined and functionally tested at Insta ILS. A weather forecast model was provided from the Finnish Meteorological Institute. The Aircraft Maintenance Flight of the Border Guard's Air Patrol Squadron assisted in the testing of the engine covers.

The purpose of a safety investigation is to promote general safety, the prevention of accidents and incidents, and the prevention of losses resulting from accidents. A safety investigation is not conducted in order to allocate legal liability. The safety investigation examines the course of events, their causes and consequences, search and rescue actions, and actions taken by the authorities. The investigation specifically examines whether safety had adequately been taken into consideration in the activity leading up to the accident and in the planning, manufacture, construction and use of the equipment and structures that caused the accident or incident or at which the accident or incident was directed. The investigation also examines whether the management, supervision and inspection activity had been appropriately arranged and managed. Where necessary the investigation is also expected to examine possible shortcomings in the provisions and orders regarding safety and the authorities' activities.

The investigation report includes an account of the course of the incident, the factors leading to the incident, and the consequences of the incident as well as safety recommendations addressed to the appropriate authorities and other actors regarding measures that are necessary in order to promote general safety, prevent further accidents and incidents, prevent loss, and improve the effectiveness of actions conducted by search and rescue and other authorities.

An opportunity is given to those involved in the accident and to the authorities responsible for supervision in the field of the accident to comment on the draft investigation report. These comments have been taken into consideration during the preparation of the final report. A summary of the comments is at the end of the report. Pursuant to the Safety Investigation Act, no comments given by private individuals are published.

The investigation report was translated into English by TK Translations.

The investigation report and its summary were published on the SIAF's internet page at www.sia.fi on 7th June, 2023.

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Cover photo: SIAF

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1 FACTUAL INFORMATION

1.1 History of Flight

The pilot of an amateur-built airplane, registered OH-XMA, was departing on a personal flight from Jyväskylä aerodrome, located in Tikkakoski township, on April 17, 2022. He had planned to fly at least one traffic circuit followed by a touch-and-go. His further intentions are unknown. At 1919 h he called on the Jyväskylä local control frequency[1] that he was taxiing from the hangar toward the approach end of runway 12. At 1922 h he reported lining up on runway 12, and at 1922 h he called beginning takeoff from runway 12 to the traffic circuit.

At 1925 h he reported joining right downwind for runway 12 via a right-hand turn[2]. At this point, the airplane's estimated altitude was approximately 150 m above ground level, which was significantly lower than the altitude prescribed in the aerodrome visual approach chart. However, the pilot was known to fly the traffic circuit at a low height. While on downwind, at approximately 1926 h, the engine experienced rough running and cut out. The pilot attempted to glide to the airfield area but had to force-land in wooded terrain to the southwest of the aerodrome approximately 300 m from the airfield area boundary. The airplane impacted trees and the pilot sustained fatal injuries. The airplane was damaged beyond repair.

Several persons witnessed the flight. However, their reports concerned changes in, and fading of, engine sound and the turning of the aircraft toward the airfield area. Some statements were about another airplane that had been observed in the same location before the accident. Also, witnesses' statements of engine sound were inconsistent. None of the witnesses saw the forced landing and could therefore not say whether the airplane made it to the airfield or not. Its estimated flight track, based on the witnesses' observations, is shown in figure 1.

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[1] EFJY TWR (118.000). The local control facility was closed at the time of the accident, but pilots could broadcast traffic advisories on the local control frequency.

[2] The downwind leg of the traffic circuit is reciprocal to the landing direction and runs parallel and to one side to the runway. At the end of the downwind leg, a turn is made to position the aircraft for landing on the runway. In a typical traffic circuit, all turns are flown as left-hand turns. If the turns are flown as right-hand turns, the term *right downwind* is used.

Figure 1. The estimated flight track of OH-XMA. **Key: 1.** Initial radio call at 1919 h. **2.** Reports at holding point A at 1922 h. **3.** Reports takeoff from runway 12 at 1924 h. **4.** Reports right turn at 1925 h, estimated position. **5.** Engine cuts out, estimated position. **6.** Accident site. (Photo: Orthoimage ©National Land Survey of Finland 2/2023, annotated by SIAF)

1.2 Post-accident Events

Eyewitnesses in the vicinity of aerodrome observed anomalies in the maneuvers and engine sound of the accident airplane. One eyewitness called a local recreational pilot, who went to check whether the accident airplane had returned from the flight, and upon noticing that the airplane was not in its parking position he initiated aerial search at 1958 h. He called the accident airplane several times but could not establish radio contact. He continued search in the aerodrome control zone for 20 min until he was running low on fuel and returned to land. When an eyewitness learned that the pilot had failed to locate the accident airplane, he reported a missing aircraft to the emergency response center (ERC) at 2024 h.

The recreational pilot departed on another airplane at 2026 h to resume search in the control zone. He located the accident airplane at approximately 2030 h and returned to land. After landing, at 2034 h, he called the ERC and explained that the missing airplane had been found.

1.3 Survival Aspects

The ERC at Vaasa received an initial notification of a missing aircraft at 2024 h. At 2034 h, a call was received indicating that the aircraft had been located on military property during aerial search conducted by a recreational pilot on his own initiative. The ERC initiated a prescribed procedure for a serious aircraft accident (task code 232A). The response included four rescue units, an on-duty fire officer, two paramedic units, an ambulance helicopter, a paramedic field supervisor, an air force aircraft rescue and firefighting unit and two police patrols.

A military police patrol was the first responder to reach the accident site, and it guided the rescue units to the accident airplane. The pilot was found in the cockpit. He was pronounced dead by paramedics. The pilot had died on impact as a result of serious chest and head injuries. The rescue and paramedic units were released and command and control was transferred to the police operational commander. The accident site was secured to in order to preserve evidence for accident investigation.

The pilot carried in his breast pocket a manually operated emergency locator transmitter (ELT) that had not been activated. An activated ELT could have guided the rescue units direct to the accident site, but in this accident delayed response was not a factor considering the survival aspects.

1.4 Injuries to Persons and Damage to Aircraft

The pilot was fatally injured. The airplane was damaged beyond repair, and approximately 35 l of fuel had leaked out into the ground.

2 BACKGROUND INFORMATION

2.1 Environment, Equipment, and Systems

2.1.1 Aerodrome Information

Jyväskylä aerodrome is located in the township of Tikkakoski approximately 18 km from the town center. It is operated by Finavia, and air traffic control services are provided by Fintraffic ANS. The aerodrome has a single 2,601 m x 60 m asphalt runway designated 12/30. The aerodrome is used for recreational, commercial and military aviation. The local control facility was closed at the time of the accident. The airspace was therefore uncontrolled, but pilots could broadcast traffic advisories on the local control frequency.

2.1.2 Aircraft Information

The accident airplane was a Monnett Sonerai I, a single-seat mid-wing amateur-built kit plane designed in the United States, powered by a single piston engine and equipped with a tailwheel landing gear. The fuselage, stabilizers, elevators and rudder are of fabric-covered tubular steel construction. The engine is enclosed in a glass fiber cowling. The wings and full-length ailerons have a riveted aluminum structure.

Figure 2. OH-XMA before the accident. (Photo: Airplane owner)

The accident airplane was built in 1998 under serial number 123. It was used on test flights until it was inspected in 2004. It was entered into the civil aircraft register in 2005 as an experimental and recreational category airplane. It had accumulated a total of 97 h 2 min of flight time and 251 landings by the accident flight.

The latest weight and balance form showed that the basic empty weight of the airplane was 241 kg. The pilot's weight in winter clothing was approximately 90 kg. It was estimated that the airplane carried approximately 27 kg of fuel on takeoff. The estimated takeoff weight was, therefore, 358 kg.

Engine

The airplane was powered by an air-cooled opposed-piston Volkswagen engine modified for aircraft use and fitted with a single Slick magneto with an impulse coupling. The original displacement of 1,600 cm^3 had subsequently been increased to 1,700 cm^3 by fitting upgauged cylinders and pistons. Neither a starter motor nor an alternator was installed.

The engine instruments included oil temperature and pressure gages, cylinder head and exhaust gas temperature gages, an inlet air temperature gage, and a tachometer.

An aluminum-cast carrier support, manufactured by Monnett, was installed at the front end of the engine to provide support for the propeller shaft mounted on the front end of the crankshaft and incorporating an integral propeller mounting flange at its forward end. The engine was attached to the tubular engine mount via a four-lug aluminum adapter plate that was installed to the aft end of the engine and on which the magneto was mounted.

Propeller

The engine drove a wooden fixed-pitch 52” x 44” Ray Hegy propeller that had accumulated 97 h 2 min of flight time by the accident flight.

Magneto

The Slick 4230R magneto was fitted with an impulse coupling[3]. Crankshaft rotation was transmitted direct to the magneto via a plastic drive coupling. The magneto had accumulated 97 h 2 min of flight time by the accident flight. It had been overhauled on October 29, 2019, by which time it had accrued 70 flight hours.

Ignition Leads and Spark Plugs

The engine was fitted with a Slick ignition harness and Champion REL-37B spark plugs. Both are used extensively in aircraft applications.

Carburetor and Inlet Ducting

The Zenith 1617 single-throat updraft carburetor incorporated a manually operated throttle valve. No accelaration pump was installed, and in-flight mixture control was not available. The carburetor was located separately beneath the aft end of the engine. Fuel-air mixture was supplied to the cylinder head inlet ports via long inlet ducts that were not in direct contact with the engine.

[3] An impulse coupling retards ignition and produces an intense spark to assist in engine starting.

Figure 3. On the left: the carburetor and the Y-junction of the inlet ducting. On the right: inlet ducts leading to the cylinder heads. (Photo: SIAF)

A carburetor inlet air heating system incorporated a flap that was cable-operated manually from the cockpit to shut off the flow of incoming cold air from the engine air filter to divert hot air from a heat exchanger mounted on the exhaust pipe of one of the cylinders. The inlet air temperature gage received a signal from a sensor mounted above the carburetor at the Y-junction of the inlet ducting approximately 10 cm from the carburetor venturi.

Fuel System

The fuel tank was in the forward fuselage forward of the instrument panel. No fuel pump was fitted, and fuel was gravity-fed to the carburetor. The fuel line incorporated a shut-off valve, a water drain valve and a firewall-mounted filter.

2.1.3 Aircraft Documents

The airplane's last airworthiness review had been on November 8, 2019, and it had been issued a permit to fly. The most recent weighing had been on November 9, 2019. The airplane was covered by a valid liability insurance and had a valid radio license. Its annual maintenance and an annual inspection had been signed off on September 4, 2021. An altimeter pressure test[4] had been carried out on September 7, 2019. The documents indicated that the airplane was airworthy at the time of the accident.

Weight and Balance Form

Inconsistencies were found in maximum takeoff weights. The original design maximum takeoff weight was 340 kg, but the flight manual dated on October 26, 2004, states that this weight was 362 kg. The latest weight and balance form, issued in 2019, gives maximum takeoff weight as 340 kg.

An application for an increase in takeoff weight from 340 kg to 362 kg had been submitted in 2005, but the competent authority had found that the actions carried out did not meet the

4 In a pressure test the accuracy of an altimeter is verified in a vacuum test chamber.

applicable requirements. Documents indicate that a subsequent application, submitted in 2019, had also been rejected.

Flight Test Reports and Flight Manual

The accident airplane's flight test reports include observations of stall characteristics and in-flight engine restart. They also contain a remark of low airspeed readings.

Flight tests conducted in 1998 showed that indicated stall speed (V_i) varied between 65 km/h and 72 km/h depending on aircraft weight during the stalling tests.

Stalls had been uneventful, and control could be maintained during a partial stall with full aft stick applied. The airplane had demonstrated left wing drop during stall. Indicated stall speed with the engine running at less than maximum power at 2,000 r/min was 72 km/h. Under these conditions, stall had been more abrupt, and the airplane had shown a tendency to drop the left wing. Spin tests had showed that the airplane was spin resistant.

The test flight program had also included a restart test in which the engine was shut down at 115 km/h indicated airspeed. Propeller rotation had stopped at 95 km/h indicated airspeed and resumed at 170 km/h indicated airspeed.

An error of approximately 20 km/h in altimeter reading had been discovered and subsequently rectified. Therefore, that the above-mentioned speeds are lower than the respective actual airspeeds.

The flight manual includes an approach and landing checklist. Emergency checklists contain procedures for a power-on and power-off forced landing. Both procedures involve the application of inlet air preheat.

APPROACH AND LANDING

1. Approach speed 115-130 km/h.
2. Plan approach to maintain at least 2,000 r/min continuous power to prevent sudden engine cooling.
3. Use inlet air preheat during approach and descent if carburetor icing is apparent. Monitor inlet air temperature.
4. Maintain 115 km/h approach speed until flare.
5. Make three-point landing.
6. Avoid rapid directional changes during rollout.
7. Landing on main gear is permitted. Avoid heavy braking.

Figure 4. OH-XMA’s approach and landing checklist.

POWER-OFF FORCED LANDING

1. Check fuel valve “open”.
   - ➔ Ignition switch “on”
   - ➔ Inlet air preheat pull to “warm”
2. Slow to 115 km/h approach speed.
3. As long as propeller windmills attempt restart by manipulating throttle.
4. If no restart:
   - ➔ Fuel valve pull to “closed”
   - ➔ Ignition switch “off”
5. Select larges and most suitable area for landing. LAND INTO WIND if possible.
6. Land with full aft stick.
7. Apply maximum braking after touchdown.

Figure 5. OH-XMA’s power-off forced landing checklist.

2.1.4 Wreckage and Impact Information

A birch tree broken near the top was located at the edge of a parking lot approximately 50 m from the accident site. Flakes of red paint from the accident airplane were found at the same location. The top of the tree, less than 2 m long and a few centimeters in diameter, was located approximately 10 m beyond the point of the initial tree impact. The airplane had then struck a pine tree, severing it about 10 m above the ground. It also impacted another pine tree, on which the pilot's headset was found at about 7 m above the ground. The airplane came to rest in a right wing low attitude, supported by the severed tree.

Figure 6. The impact severed the pine tree on which the airplane came to rest. The pallet was brought to the site after the accident. (Photo: Police)

Figure 7. The airplane came to rest supported by a severed tree. The propeller blades broke off near the root, and the spinner exhibited denting. The cowling was impact-damaged. The forward right-hand exhaust was bent. (Photo: SIAF)

Fragments of the shattered canopy were located across the accident site. The instrument panel had displaced aft, and the upper part of the fuel tank was breached. The control column grip had separated. The main switch and the ignition switch were set to OFF. The throttle was in a position that broadly corresponded to a cruise power setting. Inlet air preheat was deselected, and the fuel shut-off valve was open. However, the exact pre-impact positions of the controls remained undetermined due to the damage.

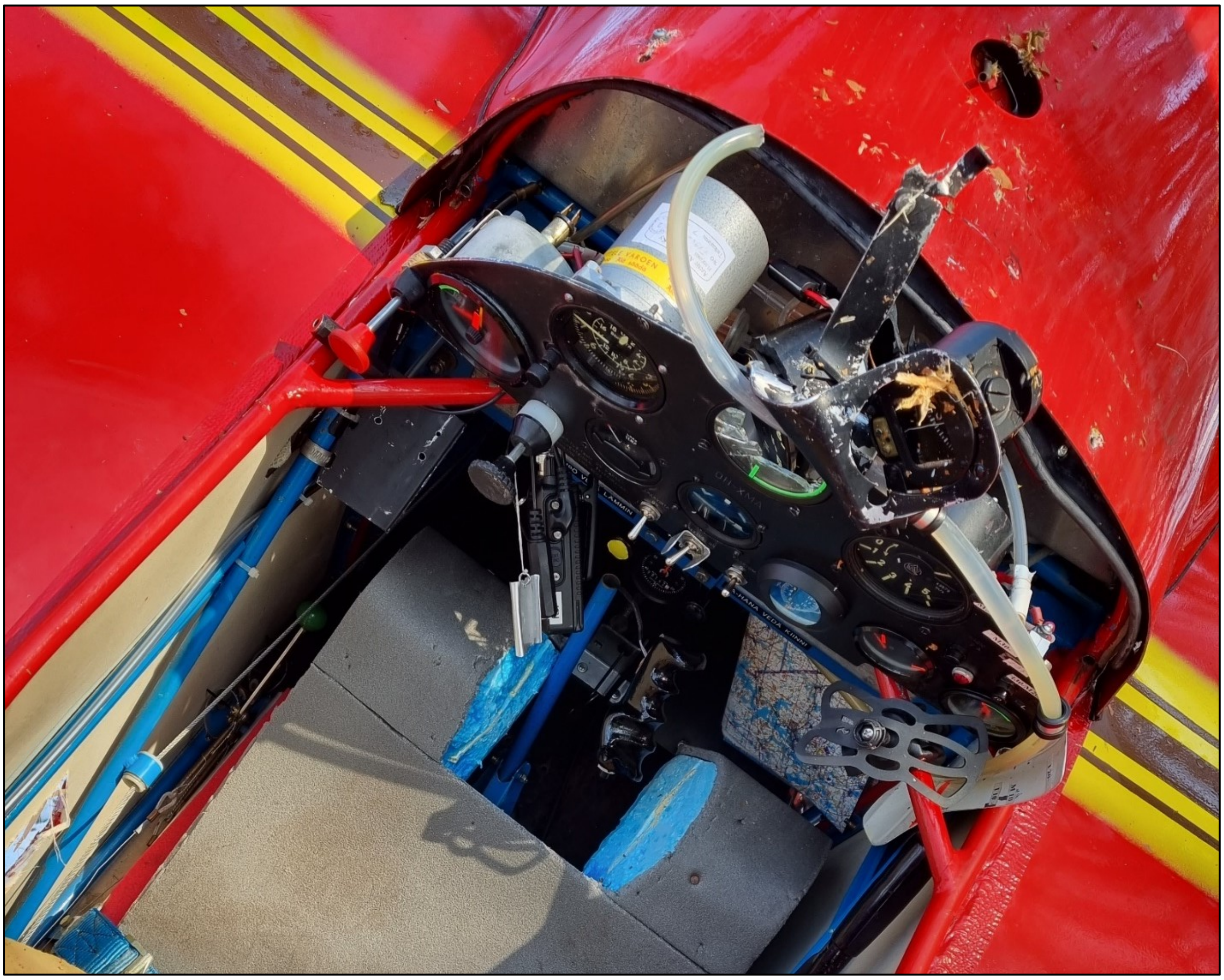

Figure 8. The cockpit. The instrument panel is displaced aft. The control stick grip has separated. The airspeed indicator and the compass have dislodged. (Photo: SIAF)

A strong odor of motor gasoline was evident at the accident site. Although most of the fuel had leaked out of the breached tank and into the ground, a sample could be drained from the fuel system for analysis. The sample tested negative for water during the on-site examination.

Deformation of the fuselage behind the cockpit was evident. The wings exhibited buckling and denting. The rudder and the elevators were intact. The flight controls could be moved, but the aileron control pushrods had bent and partly fractured behind the seat back. The landing gear remained attached, although the right-hand gear showed rearward bending near its attachment.

The propeller was broken into several sections at the root and the fracture surfaces exhibited grainwise separation. The separated sections were located at the accident site. The tips and leading edges of the blades displayed no signs consistent with a tree strike. The damage suggested that the propeller had not been rotating during tree impact. The propeller hub remained attached to the engine.

The upper cowling showed abrasion that extended all the way to the cockpit, while the underside of the lower cowling was split to the right of the fuselage centerline. The engine air intakes and their fairings were fragmented. The operating cable of the inlet air preheat system had fracture-separated from its housing in the lower cowling.

The airplane was removed to a nearby hangar for further investigation after the on-site examination was completed.

The engine could be rotated from the stubs of the propeller blades but distinctive resistance to rotation was evident. The cylinders produced compression when the engine was rotated by hand. An external inspection of the engine revealed no signs of pre-accident damage, and no significant oil leak was noted. The engine mount was bent aft, and its upper part was fractured.

The ignition system was inspected during the on-site examination both visually and with a magneto timer, and no anomalies were found. The wires were intact, and magneto timing to the engine was correct. Although the toggle of the magneto switch had bent on impact, the switch operated normally and grounded the magneto with no discrepancies noted. The wire from the switch to aircraft ground was pinched between the fuselage and the fuel tank, and its insulation was breached due to chafing. A wire that transmitted a signal from the magneto to the tachometer was connected to the same terminal as the ground wire. The signal wire was undamaged, and the wire did not ground the magneto during testing. The spark plugs displayed carbon fouling and sooting but no debris or mechanical damage was noted. The exhaust system exhibited sooting. Soot residue was found on the cowling around the rear left-hand cylinder exhaust.

The carburetor was in place and intact. A piece of bark was recovered from the venturi. The operating lever of the throttle valve, located inside the inlet elbow, had fracture-separated from the carburetor body. The carburetor was removed before engine removal. A small amount of fuel was drained from the carburetor during disassembly.

The fuel system was dismantled between the tank and the carburetor. The system was undamaged, and no evidence of blockage or in-flight leaks was evident. A small amount of debris was found in the tank outlet filter and in the firewall-mounted filter, but the debris was insufficient to cause filter blocking.

2.1.5 Electrical Installation

The tachometer received an engine speed signal from the magneto via a wire connected to the ground terminal on the capacitor. Therefore, a tachometer fault could have resulted in magneto grounding and engine cut-out.

Wires of various types and of inconsistent quality were found in the electrical installation. A wide variety of connectors had been used for the splicing and connecting of wires. Some of these connectors were unshielded and unsuitable for aircraft use. Wires were routed and attached in such a way that allowed pinching and chafing against aircraft structure and between wires.

Figure 9. Electrical connections to the instrument panel. (Photo: SIAF)

2.1.6 Engine Damage

Ignition System

The magneto was functionally tested in the facility of Konekorhonen using the ignition harness and spark plugs removed from the accident airplane. It operated normally during a test run, producing consistent and high-quality ignition to all four spark plugs at all rotational speeds. The impulse coupling operated correctly at low speeds and disengaged within the specified speed range. Magneto temperature remained normal throughout the test run. The impulse coupling alone provided good, positive ignition. The ability of the magneto to produce sufficient ignition voltage was tested by increasing the air gap in accordance with the maintenance and repair manual to a value greater than the normal spark plug electrode gap. The test run, component measurements and the above-mentioned tests indicated that the magneto was serviceable.

Minor damage was found in the distributor gear and in the plastic distributor housing. This damage had probably occurred during magneto installation, when attempts had been made to rotate the engine or the magneto with the locking pin installed. However, the damage had no adverse effect on magneto operation.

A visual inspection of the ignition harness revealed no damage, and the harness was attached and supported properly. Connections between the harness and the spark plugs had been made in accordance with good working practises, and they were clean and undamaged. The plastic spiral binding of the rear left-hand cylinder ignition lead showed melting damage over a small area adjacent to the attachment clip. The damage was traced to the installation of the binding in a hot location close to the cylinder exhaust. However, the lead and the clip were found free of thermal damage.

The ignition leads and spark plugs were tested at Konekorhonen using special test equipment. The function of the ignition harness and the spark plugs was also verified during the magneto test run. The tests indicated that the ignition leads and the spark plugs were serviceable.

Carburetor

Apart from the fractured throttle valve shaft, no external damage was found in the carburetor. The nature of the fracture surface suggested that the damage had occurred on impact. Valve position on the shaft in the carburetor air inlet is slightly nonconcentric, and the shaft incorporates a detent that prevents free valve movement. The shaft is also spring-loaded to the open position. Had the damage occurred in flight, the valve would have remained open, and the damage would not have resulted in engine cut-off.

The valve operating lever and cable were undamaged and in their correct position. The cable was disconnected from the carburetor. Free valve operation over the entire range of movement was verified, and no anomalies were found in the valve or in the shaft.

The carburetor was disassembled and inspected for blockages or other discrepancies. No foreign material was found in the inlet passageways or within the carburetor body, apart from a piece of bark that was recovered during the on-site examination and had probable migrated into the venturi upon the impact with the pine tree.

The float halves were undamaged, properly sealed, and no deformation was noted. The float arm and the needle seat were undamaged, and no deformation was noted. The float moved freely on its shaft. The needle was in good condition and moved freely. Correct fuel level was obtained in the float chamber during carburetor testing. The functional test revealed no anomalies.

The nozzles were free of contamination, and the internal passageways leading to the nozzles were clean. The nozzles were correctly fitted and properly tightened. The adjustable needle of the main nozzle was correctly fitted, undamaged, and within the normal adjustment range.

The venturi[5] was found in its correct position and in good condition when the carburetor was disassembled. No evidence of a carburetor fire or other damage was found.

The carburetor was found generally serviceable. The reason for the engine cut-out could not be traced to the carburetor.

[5] The venturi is the narrowest section of the carburetor throat, where the air velocity increases and the air pressure decreases. In the carburetor of the accident airplane, the venturi is a separate sub-assembly mounted in the carburetor throat.

Propeller Shaft Assembly

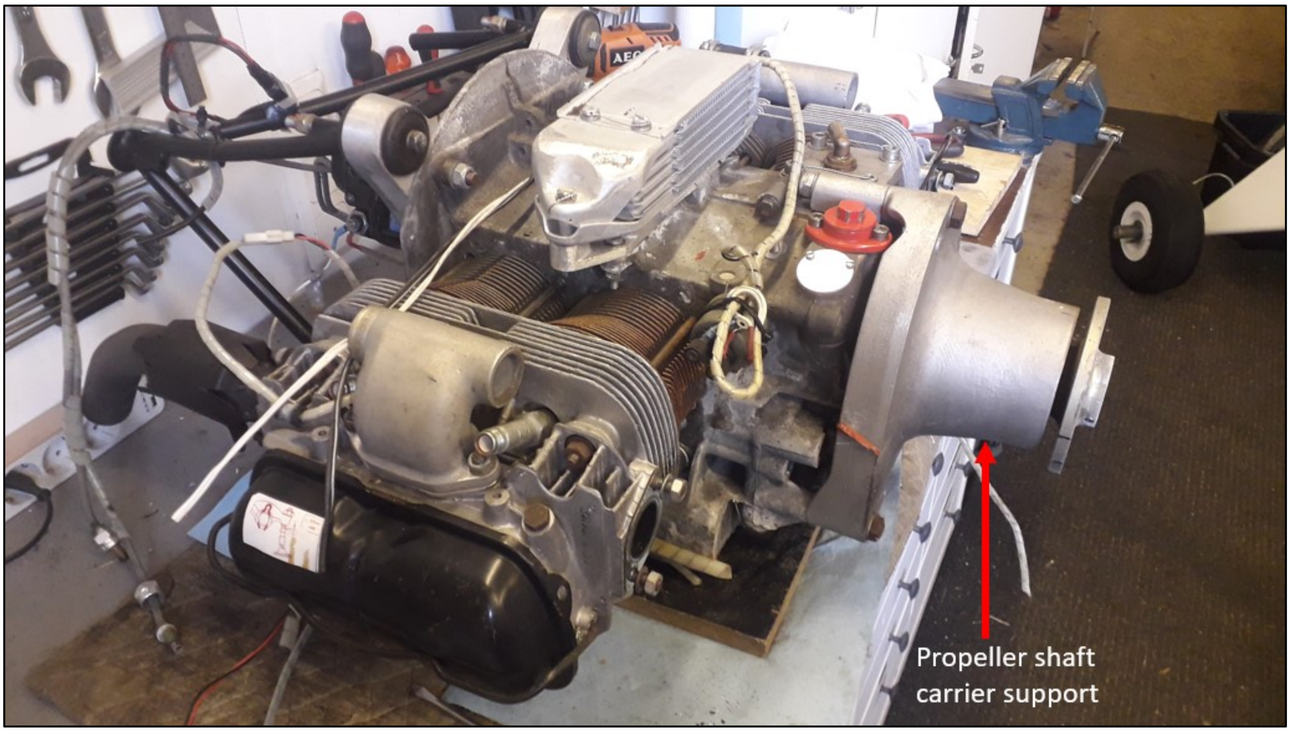

Figure 10. The engine of the accident airplane. The red arrow points at the propeller shaft carrier support. (Photo: SIAF)

Considerable resistance to rotation was evident when the engine was rotated by hand before disassembly. The cause of this resistance was traced to the propeller shaft and its carrier support. After the attachment of the support to the engine was loosened, resistance was no longer evident. It is likely that the support had moved slightly on impact. No deformation was found in the crankshaft or the propeller shaft. Dust corrosion was noted around the mating surface of the support bearing and the propeller shaft, and surface roughness was evident on the shaft where it had been in contact with the bearing. Detailed examination revealed that the shaft had moved relative to the bearing, and as a result material had worn off from the bearing inner diameter and the shaft surface. No other anomalies were found in the bearing. The depth of abrasion wear on the shaft was 0.13 mm. It was found that the movement of the shaft relative to the bearing was caused by excessive end float of the crankshaft. The lengthwise movement of the crankshaft had imparted similar movement to the propeller shaft. Additional wear could have resulted in the loss of propeller shaft support, in which case the rotation force of the propeller could have led to the breakdown of the connection between the propeller shaft and the crankshaft.

The airplane's maintenance records contained no entries regarding the bearing or its maintenance requirements. Although self-lubricating bearings are generally maintenance-free, it should be noted that in this case the lubricant was approximately 30 years old. Maintenance records contained no remarks concerning play between the bearing and the propeller shaft.

Figure 11. The propeller shaft and propeller mounting flange. Abrasion caused by the contact with the bearing and dust corrosion are apparent around the left-hand end of the shaft. (Photo: SIAF)

Engine Disassembly and Inspection

All cylinders produced normal compression and were in good condition. The inlet ducting and its fittings and seals were intact.

The valve covers and gaskets were undamaged, and the clips were correctly fitted. The valve mechanism was clean and well oiled, and no loose items were found. The mechanism functioned normally when the engine was rotated, and valve clearances were within the normal adjustment range. The clearances between the valve stems and the inner guide diameter were within the normal values. No excessive carbon deposits were found on the stems or the guides. The valves could be hand-operated without any difficulty. Valve movement and clearance were also inspected after heating the covers to the normal operating temperature. Valve leak tests were carried out with the cylinder heads removed.

A visual inspection of the cylinder heads revealed no damage. No cracks were found in the combustion chambers or in the cylinder heads. The inlet and exhaust ports were inspected visually, and no anomalies were found. The mating surfaces of the cylinder heads and the cylinder blocks were in good condition with no signs of leakage noted. The cylinder heads were generally in good condition. The combustion faces of the valve heads were clean and seated normally in the respective inserts. The valve heads of the rear left-hand cylinder were of a lighter color compared with the valves of the other cylinders. The combustion chambers had a normal thin layer of soot and carbon deposits, but no damage was found. The rocker arms, the rocker arm shafts and the push rods were undamaged, and no abnormal wear was evident. The valve clearance adjustment screws were within the specified adjustment range. The push rods were undamaged and in good condition. The push rod conduit of the forward right-hand cylinder was partially pinched against the rod, but the absence of scuff marks on the rod indicated that the damage had occurred after the engine cut-out.

Evidence of slight seizing was found on the piston of the rear right-hand cylinder between the top ring and the crown. This is a common phenomenon in this engine type and does not affect engine operation. Piston motion about the wrist pins was normal. All piston crowns had a normal, uniform, thin layer of soot and carbon deposits. The piston rings were intact and moved freely. Some resistance to movement was found in the wrist pin of the rear right-hand cylinder. An inspection of the removed pin revealed slight blue discoloration[6] that was easily removed by polishing. The discoloration resulted from thin carbon deposits on the pin and on the piston, which had caused excessive friction and heat load. This is common in air-cooled reciprocating engines and does not affect engine operation in the early stages of build-up.

No play was observed in the connecting rod bearings, and the bearing inserts were in place. Investigators found that the engine had seized previously. However, no signs of the connecting rods hitting the crankcase or other parts of the mechanism were found. The seizure had possibly been caused by the fitting of valve push rods of incorrect length that had been replaced subsequently. Maintenance documentation indicated that shims had been installed under the valve mechanism mounts and the sufficiency of the valve mechanism adjustment range had presented challenges. However, the shims were not found during the investigation, which suggests that they had been removed during push rod replacement.

The connecting rod bearings of the forward cylinders showed signs of incipient damage. Scratching of bearing inserts and localized damage to bearing material were noted. The inserts of the connecting rod bearings of the rear cylinders were in a slightly better condition. Apart from scratches, which were consistent with the direction of rotation of the crankshaft, extensive pitting was found in insert material. This damage was likely caused by contaminants in engine oil[7]. Insert damage had had no apparent effect on engine operation. It is possible that some damage was a result of extended periods of engine inoperation and pitting corrosion.

The gear-type oil pump mounted on the front of the engine was in good condition. The oil pickup tube and strainer were undamaged. The mesh size of the strainer was approximately 0.8 mm; therefore, small particles could have passed the strainer into the oil system. A visual inspection indicated that lubricating oil was of good quality and oil quantity was correct.

The two camshaft gears were in good condition, and the camshaft rotated normally. Significant camshaft end float was noted and measured. It was found to be 0.30 mm, well above the maximum value of 0.10 mm given in the maintenance and repair instructions. The effects of this end float on the magneto drive coupling were examined to determine if the coupling had slipped when the crankshaft moved forward due to propeller pull. The coupling is essentially a plastic disk with machined recesses on both sides. Bosses on the adapter mounted on the rear end of the crankshaft and on the magneto drive gear engage these recesses. Since the bosses engage the recesses to a depth of only few millimeters, slipping was not ruled out. However, it was found that the crankshaft end float had been insufficient to cause slipping.

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6 Steel turns blue when overheated. If discoloration appears only on the surface and can be removed by polishing, its effects on the structural strength of the part are negligible.

7 Pitting occurs when particles carried by engine oil become embedded in the soft bearing metal.

Figure 12. The rear end of the crankshaft, the magneto, and the magneto drive coupling. (Photo: SIAF)

The nuts of the heavy-duty crankcase pass-through studs were found under-torqued. However, no stretching or pull-out from the threads in the other crankcase half was noted. The fit of the crankcase halves was inspected with the crank mechanism not installed. The crankshaft bearing journals were in good condition and showed only minor local polishing. An inspection of the camshaft showed that the bearing surfaces and cam contact surfaces were in good condition. Even though the valve tappets were generally in good condition, some had signs of incipient pitting corrosion. The tappet assemblies moved freely in the bores machined in the crankcase. The camshaft and crankshaft bearing inserts fitted in the crankcase halves were in adequate condition considering the running time of the engine, and no signs of insert movement was noted. The camshaft inserts displayed polishing of varying degree and uneven wear of metal. Some inserts had scratches and localized craters caused by contaminants in lubricating oil. No signs of seizing were found.

The camshaft bearings displayed surface damage and wear of varying degree. These anomalies were similar to those found in the camshaft and connecting rod bearings, including surface craters caused by contaminants, scratches, and localized flaking of bearing material. The aft bearing was by far in the worst condition. The bearing surface that was in contact with the crankshaft bearing journal was entirely covered with the above-mentioned damage, and the surfaces of the end bearings were scratched and worn. The shims fitted at the rear end of the crankshaft for end play adjustment were intact with no signs of heat-induced or mechanical damage, but wear was readily apparent.

Adhesive sealant, applied in the crankcase mating surfaces, had extruded into the oil passage within the aft bearing outer race. This had caused significant blockage and the reduction of oil flow to the bearing surfaces.

The engine oil pressure regulating valve was disassembled and inspected for sticking or blockage. The piston moved normally but showed significant scratching and other minor damage. However, it is likely that valve operation had been adequate because no clear signs of low engine oil pressure were discovered, and the most recent recorded oil pressure readings were also within limits.

Investigators learned that the engine had previously suffered temperature-related problems. Attempts had been made to rectify these issues by modifying the routing of cooling airflow and by installing an oil cooler. The oil cooler and the fitting of upgauged cylinders and pistons had apparently solved the problems, that had possibly stemmed from an oversize and excessively high-pitch[8] propeller.

Apart from wear and tear, particularly in the engine bearings, engine disassembly and inspection did not reveal the reason for the sudden cut-out.

2.2 Conditions

2.2.1 Weather

Weather at the time of the accident was sunny. Ground at the aerodrome was covered with snow. Jyväskylä weather observation facility reported[9] clear skies and over 10 km visibility. Temperature was +9.5 °C and dew point was +1 °C. Atmospheric pressure was 1,024 hPa. Data from the Finnish Meteorological Institute (FMI) indicated that relative humidity was 53 % and dew point was +0.5 °C[10]. The pilot had copied on his knee pad the following METAR information: "320, 02 kt cavok 10/00 H1024[11]."

2.2.2 Finnish Meteorological Institute Model of Weather Conditions at Traffic Circuit Height

The investigators asked the FMI to provide data of weather conditions at the traffic circuit height approximately 150 m to 250 m above aerodrome elevation.

The report was created using the MEPS[12] numerical weather prediction model that calculates proactively the state of the atmosphere. Data of the prevailing atmospheric conditions is needed to determine an initial condition. This data must be as accurate as feasible since it is the basis for prediction, and it is derived from worldwide surface observation networks, balloon soundings, maritime and aerial platforms, and satellite and weather radar observations. The theoretical horizontal resolution of MEPS is 2.5 km while vertical resolution is 65 levels from ground level to approximately 30 km. The spacing of the levels increases from the height of approximately two kilometers towards the upper atmosphere.

Modeling indicated that on the day of the accident the sun had warmed-up the ground resulting in an increase in atmospheric moisture due to melting snow. As a result, the relative humidity of the air mass at 150 m altitude had increased from the ground level value (from

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8 The theoretical distance the propeller moves forward in one rotation.
9 Meteorological aerodrome report: METAR EFJY 171620Z AUTO 32004KT CAVOK 10/01 Q1024=.
10 Finnish Meteorological Institute observation archive for Jyväskylä aerodrome.
11 Wind from 320° at the velocity of 2 kt, sky clear and no significant weather phenomena, air temperature +10 °C, dew point temperature 0 °C, air pressure 1,024 hPa.
12 Mesoscale Ensemble Prediction System.

approximately 50 % to approximately 60 %) while outside air temperature had dropped slightly (from approximately 10.5 °C to 9.5 °C), and dew point temperature had increased from approximately 0.5 °C at ground level to approximately 1.5 °C.

2.2.3 Atmospheric Conditions and Carburetor Icing

Certain atmospheric conditions are conducive to ice accumulation inside carbureted engines. Ice accretion in the carburetor or in the inlet ducting may be extremely rapid and can occur within the timespan of only minutes. Icing can cause rough running, loss of power and/or engine cut-out. Since ice melts after engine cut-out, evidence of icing may be difficult to find in post-accident investigation. In-flight icing can be prevented by preheating carburetor inlet air.

Icing is most common in carbureted engines because low pressure is created in the carburetor venturi, and the resulting pressure differential sucks fuel into the inlet duct[13]. Fuel vaporization and reduction of air pressure will cause a temperature drop in the carburetor. If temperature falls below freezing, water condenses and ice will form on the internal surfaces of the carburetor. Carburetor icing is most likely on warm days when inlet air humidity is high, but it can also occur on clear days when air temperature is above zero.

All engine types are not equally prone to icing. Increasing distance between the carburetor and the hot parts of the engine increases susceptibility to icing. Engines with most of the inlet ducting separate from the engine and with the carburetor not in contact with the oil sump are more prone to icing than engines in which the ducting is partly integral with the oil sump or other engine components. De-rated engines are particularly susceptible. The use of motor gasoline increases likelihood of icing because of its higher water content and increased volatility. Reduced power settings make engines more prone to carburetor icing.

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13 Aeronautical information publication OPS T1-18, 1984.

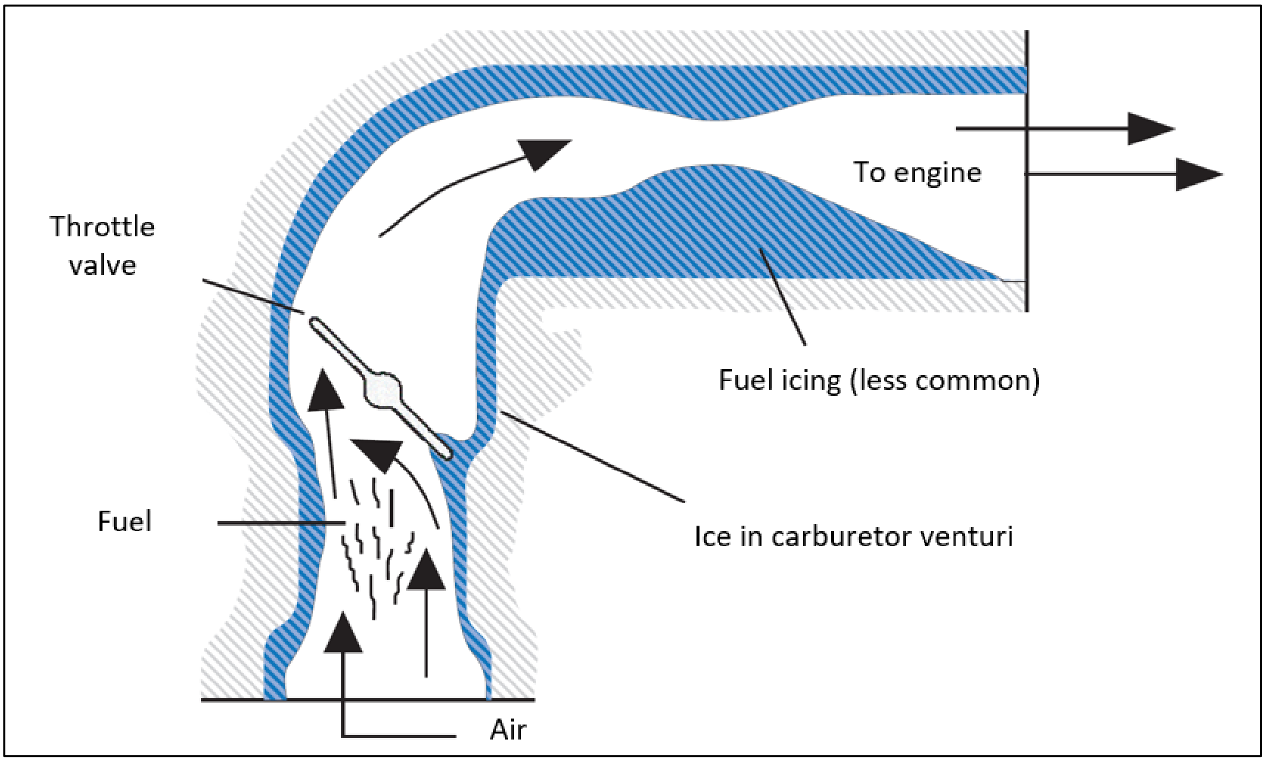

Figure 13. Ice build-up in the induction system with ice accumulation shaded in blue. (Photo: EGAST GA5, *Piston Engine Icing*, annotations: SIAF)

In carbureted engines ice forms typically in the engine air filter, induction system bends, the alternate air door, the carburetor venturi and the jet housing, and the throttle valve.

Figure 14 shows susceptibility to icing as a function of temperature, dew point and power setting. The MEPS model indicated that at the time of the accident temperature at landing circuit height was +9.5 °C and dew point was +1.5 °C. This point is shown in the figure. Susceptibility to icing was moderate at cruise power and serious at descend or idle power, or serious at any power setting.

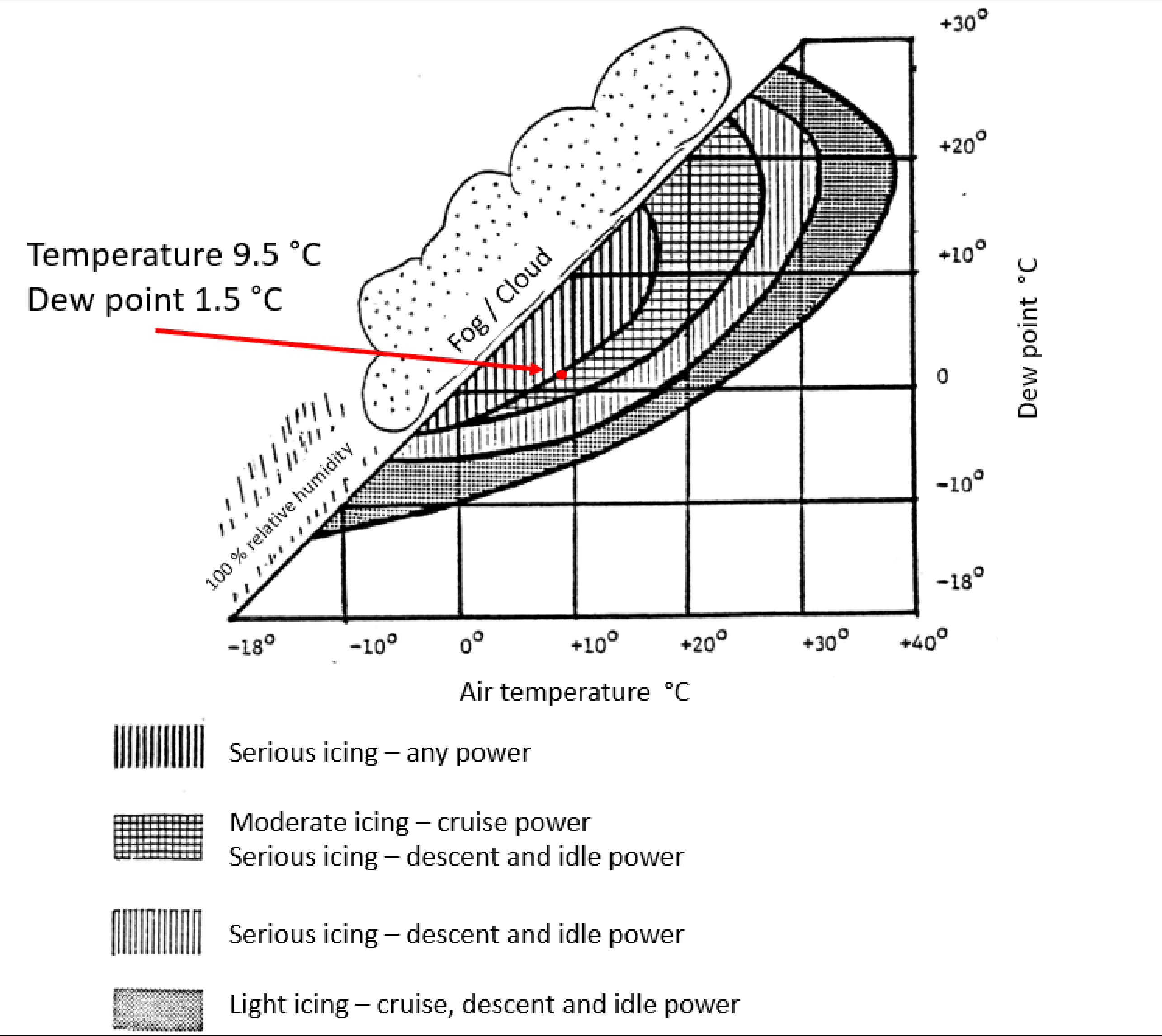

Figure 14. Susceptibility to carburetor icing as a function of temperature, dew point and power setting. The red arrow and dot indicate the prevailing conditions at landing circuit height at the time of the accident. (Photo: Aeronautical information publication OPS T1-18, October 22, 1984, canceled in 2003, annotated in red by SIAF)

2.3 Recordings

The investigators requested radar data of the accident flight from the air force and Fintraffic ANS. Recorded radio communications on the local control frequency were also requested from Fintraffic ANS. Finavia was asked to provide any aerodrome surveillance camera footage that could have captured the takeoff or other portions of flight of the accident airplane.

The pilot's traffic advisory transmissions were heard on the local control frequency, and they helped to create an accurate timeline of the flight.

Air force or Fintraffic ANS radars had not captured the track of the accident flight. Neither was the airplane captured by surveillance cameras at the aerodrome or in its vicinity. Eyewitness observations were compared against Fintraffic ANS radar data. Although the radars had not captured the accident airplane, the flight paths of other airplanes could be compared with eyewitness observations to create a more accurate timeline.

2.4 Personnel, Organizational and Management Information

The 61-year-old pilot held a valid private pilot license (PPL) and a class 2 aeromedical certificate. He had valid gyroplane pilot, glider pilot, touring motor glider (TMG) pilot and ultralight pilot licenses, a flight instructor rating and a flight examiner's certificate for ultralight and glider pilot licenses.

He had accrued approximately 320 h on powered PPL category airplanes. He had over 1,270 h on gliders, over 480 h on TMGs, slightly over 200 h on gyroplanes and just over 300 h on ultralight aircraft. He had not flown during the 90 days preceding the accident flight.

The accident had no bearing on organizations or on flight training. The accident airplane was privately owned by the pilot, and the flight was a personal solo flight.

Table 1. Pilot's flying experience.

Flying experience	During past 24 h landings/hours	During past 30 days landings/hours	During past 90 days landings/hours	Total landings/hours
All PPL airplanes	-	-	-	1,239/319
On accident airplane type	-	-	-	251/97
Ultralight airplanes	-	-	-	1,945/323
Gliders and TMGs	-	-	-	2,366/1,726
Gyroplanes	-	-	-	1,599/216

2.5 Preventive Actions of Authorities

The Finnish Transport and Communications Agency Traficom issues safety bulletins. Their purpose is to share information of current topics between general aviation and recreational pilots. The agency also issues annual winter operations bulletins that contain guidance for operations in icing conditions and for the use of inlet air preheat. The bulletin also gives tips for winter aircraft storage and preparation for flight and describes typical accidents that have occurred in winter. The bulletin explains that carburetor icing can occur in conditions conducive to visible moisture, and that carburetor icing may also occur during taxi. However, the bulletin does not describe in detail the effects of temperature and dew point on the risk of carburetor icing. This information is currently available in aeronautical information publication OPS T1-18, which has been canceled but is still accessible on a non-Traficom server.

2.6 Rescue Services and Preparedness

Finavia operates Jyväskylä aerodrome and maintains a regulatory rescue service at the aerodrome to respond to aircraft accidents and incidents within the aerodrome area.

The Aeronautical Rescue Coordination Center (ARCC) coordinates and directs search and rescue operations in Finland until the lost aircraft is located.

The Air Force Academy (AFA) maintains a competent rescue service at the aerodrome to respond primarily to events involving air force aircraft within the aerodrome area.

The Central Finland Rescue Department exercised[14] overfall command and control of rescue operations in the region of Central Finland in accordance with the Rescue Act[15]. The department was one of Finland's twenty-two regional rescue departments. When the accident aircraft is located and rescue operations can be launched, the ARCC will transfer overall operational responsibility to the incident commander. In this accident, the rescue effort involved units from Jyväskylä central fire station, Seppälä fire station, the partially full-time fire brigade of Tikkakoski and the AFA. The response also included two paramedic units, a paramedic field supervisor and an ambulance helicopter.

2.7 Regulatory Framework

2.7.1 Aviation Regulations Governing Amateur-built Aircraft

An amateur-built aircraft is defined as an aircraft of which at least 51 % is built by an amateur, or a non-profit association of amateurs, for their own purposes and without any commercial objective. Type certification is not required for an amateur-built aircraft and a certificate of airworthiness is not issued. Instead, the aircraft is awarded a permit to fly provided it meets applicable requirements. Construction, airworthiness requirements and continuing airworthiness monitoring of amateur-built aircraft are governed, respectively, by aviation regulations AIR M5-2, AIR M5-1 and AIR M16-1. These are discussed below to the extent that is applicable to this particular accident. New versions of AIR M5-1 and AIR M5-2 were issued after the accident in the summer of 2022. The following paragraphs are based on the revised versions, and major changes to the earlier versions are also described.

2.7.2 AIR M5-2 Construction of Amateur-built Aircraft

Construction must conform with the general aircraft engineering practises and the quality of the product must comply with acceptable aeronautical standards.

An amateur builder is responsible for the construction and airworthiness of his aircraft. He must also ensure that the building surveyor can exercise adequate oversight of construction work. The surveyor verifies that the aircraft is built in compliance with applicable aviation regulations and that good engineering practises are observed. He will address any defects as necessary. He will oversee construction and flight tests until the aircraft is awarded a permit to fly. However, he is not responsible for the aircraft's airworthiness. A surveyor can be a person who has completed the construction of an equivalent aircraft, or a licensed aircraft engineer with experience from aircraft of the same category.

An amateur-built aircraft must pass an airworthiness review before it can be taken into use. If it meets the criteria laid down in applicable aviation regulations it will be awarded a permit to fly for test. Upon completion of the flight test program, it must be subjected to a second airworthiness review, which is required for a permanent permit to fly. Airworthiness reviews are governed by regulation M16-1.

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14 Until December 31, 2022, when the responsibilities were transfered to counties.
15 379/2011.

Major Changes from Previous Version

An earlier version of AIR M5-2 was in effect during the construction of the accident airplane. It stipulated that the builder of an amateur-built aircraft needed to have a permit to build from the Civil Aviation Administration (CAA). The application complete with attachments was sent to Finnish Aeronautical Association (FAA), from where it was forwarded with comments to the CAA. A permit to build was issued for a period of 5 years, and it could be renewed when the builder indicated that construction was ongoing and provided a statement, signed by the surveyor, of the current stage of the project.

The current regulation does not require a permit to build and allocates increased responsibility for good workmanship and airworthiness compliance to the builder and the surveyor. The permit to build is now outweighed by a builder's log. The current version contains more detailed requirements for this document than the previous version.

An initial inspection of the aircraft is now undertaken during the final stage of construction, when an application for a temporary permit to fly for test is submitted. An airworthiness review is carried out at this stage.

2.7.3 AIR M5-1 Airworthiness Requirements for Amateur-built Aircraft and Aircraft Constructed for Research, Test or Scientific Use

Regulation AIR M5-1 stipulates that the aircraft structure is designed to protect the occupants also in minor accidents in which the airplane sustains damage due to the exceedance of design loads. Components and equipment must be attached so that they do not become displaced in minor accidents and do not cause injury to the occupants.

The windshield and windows must be of shatter-resistant material that does not obstruct vision to an extent that would jeopardize safety. The pilot must be able to reach and operate all controls from his position unhindered by the safety harness and aircraft structure.

The seats must be designed to withstand limit loads. Each seat must have a harness with a shoulder strap. Harnesses must be of the three-point type or better and of similar construction and quality as the equipment approved for aircraft or motor vehicles.

The engine or the electrical power line does not need to be type-certified provided that safe installation and operation can be achieved. If the carburetor type is susceptible to icing the engine must be fitted with an efficient inlet air preheat system.

Before the aircraft can be awarded a permanent permit to fly, an airworthiness inspector shall confirm that the technical data, operating procedures and limitations described in the flight manual conform with the aircraft and the flight test report. A copy of the manual must be submitted to Traficom. The aircraft must have maintenance program. Maintenance instructions must be amended as necessary based on operational experience and if required in aviation regulations.

Major Changes from Previous Version

The new version of AIR M5-1 specifies the requirements for seat harnesses. The aircraft must have harness with a shoulder strap for every seat in the approved seating configuration. The strap must not be attached to the lap belt by stitching, by a loop or in any like manner. When the quick-release fitting is operated, all parts of the harness must be released so that they will not impede exit from the aircraft.

The previous version stipulated that safe engine operation had to be verified by running the engine on the ground for 3 h minimum and operating it for no less than 45 h in flight before a permit to fly was issued. These requirements are also included in the new version, but it is now stipulated that the engine must operate without any anomalies and changes for no less than 45 h on test flights. The reliability of the propeller must also be verified by operating it without any anomalies and changes for no less than 45 h on test flights.

2.7.4 AIR M16-1 Continuing Airworthiness Monitoring of Amateur-built Aircraft

Regulation AIR M16-1 stipulated that the Finnish Transport Safety Agency (FTSA)[16] carries out the initial airworthiness review of non-EASA aircraft and issues an airworthiness review certificate or a temporary permit to fly before the award of the first certificate of airworthiness or a permit to fly.

After the issue of a certificate of airworthiness or a permit to fly, periodic airworthiness reviews may be made by the FTSA or by approved continuing airworthiness management organizations, airworthiness inspectors and licensed maintenance technicians who hold an airworthiness inspector’s authorization.

An airworthiness review is requested by the owner, holder or operator of the aircraft. The review confirms that the aircraft is in compliance with current continuing airworthiness requirements. It consists of an inspection of aircraft systems, equipment and documents, and a test flight if necessary.

The FTSA or the continuing airworthiness management organization produces an airworthiness review report and an airworthiness review certificate that confirms the aircraft is airworthy and includes the expiry date of the certificate. A certificate of airworthiness is valid for 36 months.

2.7.5 PEL M3-4 National Requirements for Aircraft Maintainer

Section 3 of regulation PEL M3-4 defines an aircraft mechanic.

Requirements for an aircraft mechanic's license are established by Traficom. The holder is authorized to issue a release to service for aircraft shown in the license. The license may also be awarded to person that is named in the permit to build of an amateur-built aircraft that has been completed and received a permit to fly, or to persons nominated by the association to which the permit to build is awarded, if certain conditions are met.

The requirements for an aircraft mechanic’s license include minimum training and experience in order to ensure that the holder possesses sufficient skills and knowledge of aircraft systems and their maintenance.

2.7.6 Guidelines for Flight in Icing Conditions and Carburetor Icing

Aeronautical information publication OPS T1-18 contained information of carburetor icing. This publication was, however, removed from the series of aviation regulations in 2003, and no information is currently available in Finnish on the websites of Traficom or recreational pilot associations. However, the Traficom website has a link to the canceled publication.

Same information can be found in English in the safety information leaflet GA5 *Piston Engine Icing*, issued by EGAST[17]. This leaflet is also accessible via a link on the EASA[18] website. The

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16 AIR M16-1 was issued in 2012, when the competent authority was known as the Finnish Transport Safety Agency, the predecessor of the current Finnish Transport and Communications Agency Traficom.

17 European General Aviation Safety Team.

18 European Union Aviation Safety Agency.

leaflet discusses types of icing, engine factors, atmospheric conditions conducive to icing, ice recognition and practises and procedures after icing is observed.

In 2021, Traficom published FMI's guidebook titled "Aviation Meteorology for Recreational Pilots." The booklet explains weather phenomena that pilots should be aware of when flying in Finnish airspace. The possibility of carburetor icing is mentioned, and the booklet also cautions that conditions conducive to carburetor icing are not included in aeronautical weather information. The text explains that carburetor icing is common on warm and humid days when the moisture content of the inlet air is high. Furthermore, it is noted that icing can also occur on a clear day in above-zero temperatures. However, the guidebook does not describe in detail the effects of temperature and dew point on the risk of carburetor icing.

Traficom's annual winter operations bulletins for general and recreational pilots recommend that in winter pilots should make a habit of applying inlet air preheat for 30 s to 35 s at intervals of 15 min to 20 min to prevent ice build-up in the carburetor. Pilots should also monitor engine speed and apply inlet air preheat any time it drops below 2,000 r/min, regardless of conditions. It is further recommended that inlet air preheat should be used on throughout the traffic circuit. If the aircraft does not have inlet air preheat, it is recommended that the pilot avoids conditions of visible moisture.

2.8 Tests and Research

2.8.1 Fuel Analysis

A plastic fuel can was found in the accident airplane's parking spot. Its contents did not match the fuel sample taken from the airplane fuel system. A sample taken from the can was compared with the fuel system sample to determine whether more than one fuel type had been used in the airplane.

The samples were sent to Neste Oil Engine Laboratory for analysis. The results showed that the system sample was grade 98E gasoline while the can contained small engine fuel. No trace of small engine fuel was found in the system sample, which contained impurities and ingredients that defied analysis but did not significantly affect the characteristics of the fuel. The water content of the sample was on a high side, but no clear water was found. Investigators were unable to determine the origin or quantity of the fuel in the airplane.

However, the pilot had written on his knee pad that he had serviced the airplane with 37 l of fuel, and a sales receipt of grade 98E fuel was found in his car.

2.8.2 Fuel System Capacity downstream of Shut-off Valve

Fuel system capacity downstream of the shut-off valve was calculated using the following default values: The length of the 6 mm inside diameter hose was approximately 1 m, so the capacity of the hose was approximately 0.28 dl. The capacity of the water separator cup and carburetor float chamber was approximately 1.5 dl and 0.25 dl, respectively. Therefore, the estimated fuel system capacity downstream of the valve was approximately 2.03 dl, which was sufficient for a flying time of slightly over one minute at cruise power. It was therefore unlikely that the valve was closed during takeoff.

2.8.3 Test Runs with Similar Engine

Investigators carried out test runs with an engine and fuel system similar to those fitted in the accident airplane in order to determine engine running time when takeoff is conducted with the fuel shut-off valve closed. Another objective was to examine engine behavior when the choke is closed at different power settings.

At 1,250 r/min idle speed, the engine ran for 38 s in the first test and 47 s in the second. When power was increased to the cruise setting of 2,500 r/min, the engine ran for 8 s in both tests.

In one test, the choke was closed at the cruise power setting; the engine sputtered and cut off after approximately 5 s.

The test runs indicate that an engine fitted with a similar fuel system will cut off in less than one minute with the shut-off valve closed. Takeoff with the valve closed was considered a remote possibility, even though system capacity downstream of the valve would have permitted flight at cruise power for slightly over one minute.

2.8.4 Tachometer Examination

The tachometer was examined and functionally tested at Insta ILS. A microscope inspection was performed for signs of anomalies such as electrical breakdowns, short circuits, thermal and fire damage, bad solder joints, insulation damage and loose items.

During the functional tests the tachometer signal did not ground to the instrument case or any other line, and no signs of previous electrical breakdown or grounding to the case or other electrical components were found. The mechanism and case are completely insulated from other electrical parts and from ground. Measurements revealed no leaks from the case or the mechanism to other parts. The only anomaly were changes made in the instrument dial. Examination and testing showed no fault that could have caused magneto grounding and resulting engine cut-out.

2.8.5 C 22/1998 L: Ultralight Airplane Accident near Kymi Aerodrome on September 26, 1998

The SIAF investigated in 1998 an accident that occurred to a Monnett Sonerai I. The builder-pilot took off from Kymi aerodrome. During initial climb at approximately 100 m above ground level, he switched off the electric fuel pump for fear of flooding the right-hand carburetor. Seconds later, the engine cut off without warning. The pilot assessed the situation, considered return to the airfield impossible, and decided to attempt forced landing in a felling field. The gliding performance of the airplane was, however, inadequate, so the pilot elected to put the airplane down in tree tops. The airplane's forward motion stopped upon contact with the trees, and it fell to ground from approximately 12 m height in a nose-down attitude, sustaining substantial damage. The pilot was uninjured.

The engine was disassembled and examined, but the investigation revealed no technical fault that could have caused engine cut-out. The engine had a single ignition system consisting of one magneto fitted with an impulse coupling. The magneto was in good condition, but the material of the magneto switch cable was unsuitable for aircraft use. The oversize terminal lug of the cable could make contact with the capacitor housing and thereby cause magneto grounding. This was suggested by the fact that the magneto did not produce spark until the lug was disconnected and then reconnected. The surveyor and the inspector had both overlooked the incorrect cable type.

It was determined that pilot's actions were essential for his survival. After he realized that impact was unavoidable, he steered the airplane into the trees in a controlled manner without attempting turns or making last-ditch corrections.

The SIAF issued two safety recommendations:

1. *Constructors of amateur-built aircraft should look for information and guidance by examining type-certified aircraft. Components that are critical to engine operation could be sourced, for example, from type-certified aircraft that have been withdrawn from use to ensure that the components are of "aeronautical quality". These components include magneto switches, main electrical power switches, and wires, among others.*
2. *Surveyors of amateur-built aircraft projects should monitor the progress of the project carefully and give a critical appraisal of structural solutions that are not in conformance with the drawings, and of materials that are not normally used in aircraft construction.*

   Inspectors should also pay attention to the above-mentioned matters during inspections.

These recommendations are of general nature and inconsistencies have been observed in their implementation.

2.8.6 C 17/1999 L: Aircraft Accident at Viitasaari Aerodrome on August 4, 1999

The SIAF investigated in 1998 an accident that occurred at Viitasaari aerodrome to a Rans S-6 Coyote II mod ultralight airplane. The engine lost power during a go-around, and the pilot force-landed in trees on the extended runway centerline.

The investigation found no single reason for the power loss, but the most probable cause was traced to the length and sharp bends of the inlet ducting, which combined to cause a major flow reduction. Airflow cools down long inlet ducts and fuel condenses on their interior walls. After the engine has run at idle for some time, as could happen during descent, and the throttle is then opened, the velocity of the fuel-air mixture increases, and condensed fuel separates from the walls. This enrichens the mixture received by the engine to such an extent that rough running and in the worst case cut-out may occur.

The SIAF issued one safety recommendation concerning the installation of four-point seat harnesses in ultralight airplanes. The current regulations state that seats must be fitted with a three- or four-point harness.

2.8.7 C 11/2002 L: Ultralight Aircraft Accident at Viitasaari Aerodrome on November 16, 2002

The SIAF investigated in 2002 an accident that occurred at Viitasaari aerodrome to a Rans S-7L Courier ultralight airplane. When the aircraft was nearly over the end of the runway on takeoff the engine cut off abruptly. The aircraft decelerated rapidly, entered a left spiraling motion and impacted ground. The pilot sustained serious injuries and the aircraft was substantially damaged.

The engine had been modified from automobile use. To prevent vapor lock the fuel pump had been fitted with a return pipe between the pump and the fuel tank. Investigation found that the pipe had been installed incorrectly. This likely led to the development of vapor lock and resulting engine cut-out. A contributing factor to the incorrect installation of the pipe was a complete failure of the supervision of the engine modification.

The SIAF issued four safety recommendations, of which the following two are related to the OH-XMA accident investigation:

> *Aviation regulations neither give competency requirements for the surveyor nor define the scope of supervision. Clearly defined competency requirements would assist in the allocation of appropriate persons as surveyors. The description of the scope of supervision would assist surveyors to understand their role and responsibilities during*

construction. The surveyor should be actively involved in the construction from the beginning to the completion in order to be able to properly function in his guiding role. Based on this, he could then submit an inspection report to the inspector and to the competent authority for further action.

1. *The investigation team proposes that the Aviation Safety Section of the Civil Aviation Administration augments it guidance dealing with the supervision of construction of amateur-built aircraft.*

This recommendation can be regarded as partially implemented because the revised regulation AIR M5-2 assigns more supervisory responsibility to builders. In fact, this means that the builder's responsibility is emphasized and the role of supervision somewhat reduced.

The importance of surveyor support will be significant if the first safety recommendation is implemented. Both the builder and the surveyor should attend the initial inspection. If the inspection reveals several or safety-critical deficiencies, these should be reinspected after corrective actions have been carried out.

2. *The investigation team proposes that the Aviation Safety Section of the Civil Aviation Administration improves the real airworthiness monitoring capacity of the first inspections of amateur-built aircraft and their equipment.*

The recommendation for reinspection after the airworthiness review has found serious or several deficiencies and the recommendation for surveyor attendance have not been implemented. Therefore, the latter recommendation remains unimplemented.

2.8.8 L2014-02: Aircraft Accident Resulting in Death of Eight Skydivers at Jämijärvi on April 20, 2014

The SIAF investigated in 2014 an accident that occurred at Jämijärvi to a Comp Air 8 airplane. The airplane impacted ground after an in-flight wing failure, and 8 skydivers on board sustained fatal injuries.

A winglet structure comprising a wing extension at the plane of the wing and a winglet had been installed on both wings. The permit to build did not mention these, nor had their effects on the structural strength and flight characteristics been established before commencing the construction. The modifications increased the aerodynamic loads on the aircraft. The safety factor for the wing’s actual stress resistance, given in the permit to build, did not materialize at -1.8 g load factor at the maximum aircraft weight.

The probable cause of the accident was that the stress resistance of the right wing strut was exceeded as a result of the force which was generated by a negative g-force. The buckling of the strut was followed by the right wing folding against the fuselage and the jump door, thus effectively preventing exit through the door.

The SIAF issued five safety recommendations. Of them, the following is related to the OH-XMA accident investigation:

The application for a permit to build did not articulate that self-designed winglets would be installed on the aircraft. The builders did not apply for a change to the permit. The surveyor and the inspectors overlooked the structural modifications. The modifications increased the stress on the aircraft’s structures.

The Safety Investigation Authority of Finland recommends that the Finnish Transport Safety Agency ensure that the experience and training of persons that supervise and inspect experimental aircraft meet the requirements of construction and modification control. [2015-S10]

According to the current regulations, a surveyor can be a person who has built an equivalent aircraft, a licensed aircraft technician or an aeronautical engineer. After the accident it was decided that the initial inspection must be carried by Traficom. The recommendation can, therefore, be regarded as partially implemented.

2.8.9 Accident to Monnett Sonerai II L in Kajaani

A Monnett Sonerai II L airplane was involved in an accident in Kajaani in 2019. Sole occupant was fatally injured. The Sonerai II L is a two-seat derivative of the Sonerai I. The aircraft experienced an engine failure and the pilot attempted forced landing on a tall corn field. The aircraft nosed over and the canopy was destroyed. The deformation of the upper fuselage structure behind the cockpit and of the vertical stabilizer trapped the pilot between the airplane and the ground.

The SIAF did not open an investigation into the accident, but available information suggested that the aircraft's structure failed to protect the pilot in a low-speed nose-over.

3 ANALYSIS

A SIAF-developed format of the AcciMap approach[19] was used to support the analysis of the occurrence. The following text is arranged in accordance with an AcciMap diagram created during the investigation and shown below. The occurrence is depicted as a chain of events along the bottom of the diagram. Contributing factors at various levels can be examined by moving up and down the diagram.

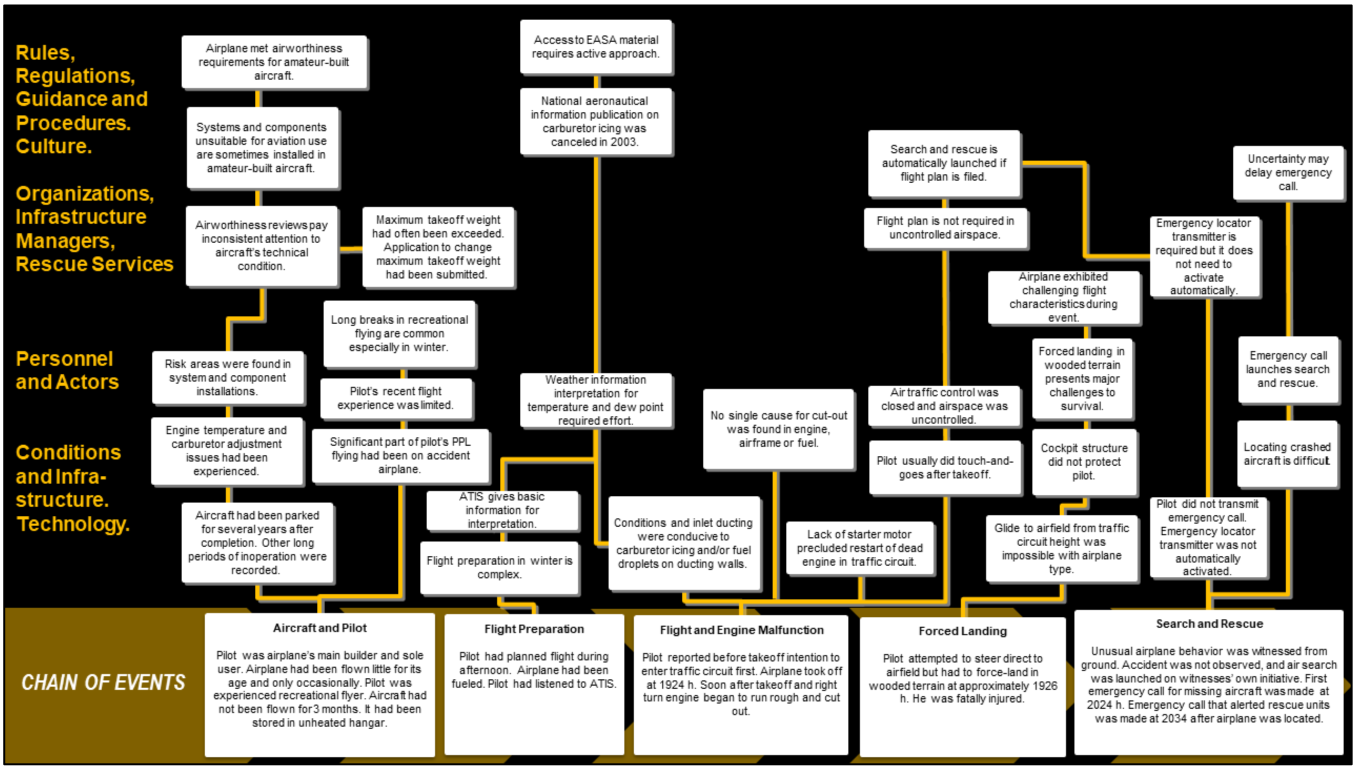

Figure 15. AcciMap diagram, investigation L2022-02. (Photo: SIAF)

3.1 Aircraft and Pilot

Engine Issues

High engine oil and cylinder head temperatures had been evident during the history of the airplane, and early test flights had even been aborted due to excessive temperatures. High temperatures had caused general wear and tear in the very low-hour engine, particularly in the crank mechanism bearings. High temperatures had probably resulted from stresses imposed on the engine by the excessively large-diameter propeller. Extended periods of engine inoperation were also a probable factor behind bearing wear.

Fuel condensation on the interior walls of the long inlet ducting could, at least in part, explain the need for repeated carburetor adjustment, and engine overstressing had possibly caused problems in determining the correct mixture setting. However, these issues were not considered probable causes of engine cut-out.

The propeller shaft support bearing could not be inspected without disassembling the structure. Maintenance records and instructions contained no information of the inspection or

[19] Rasmussen, J. & Svedung, I. (2000) *Proactive Risk Management in a Dynamic Society*. Karlstad, Sweden: Swedish Rescue Services Agency.

maintenance of the bearing. Wear due to excessive crankshaft end float had caused a significant play between the bearing and the shaft. Additional wear could have led to the breakdown of the propeller shaft support. A procedure for the propeller shaft bearing and for the connection between the propeller shaft and the crankshaft should preferably be included in the maintenance program.

Risk Areas and Aviation-incompliant Installations

The engine had a single ignition system with no backup. This type of system is common in automobile engines modified for aircraft use. The tachometer was connected to the same magneto terminal with the magneto switch. This increases the risk of sudden engine cut-out because a tachometer or wiring fault may ground the magneto and cause a cut-out. Because even a single faulty component or circuit board can cause grounding, the tachometer was examined for signs of faults or electrical breakdowns. Examination and tests showed that it had operated normally.

The inlet air temperature gage was supplied with a signal from a sensor mounted well away from the carburetor, at the Y-junction of the inlet ducting, and therefore the indicated temperature was probably higher than the temperature in the carburetor venturi. This was a possible factor in the delayed application of inlet air preheat.

Electrical wiring and connections were a mixture of miscellaneous materials, including automotive wires and building and construction cables. Some crimp connectors were unshielded, deficiencies were found in wiring attachment, and wires were routed in a way that exposed them to chafing against the airplane structure. Although the above-mentioned risk factors were unlikely to have contributed to the accident direct, they could also have caused the abrupt engine cut-out.

Aircraft electrical, avionics and component installations should be designed considering the environmental and operational effects on the components, wire routings and attachments. The quality of wires should be verified. Electrical installations are often concealed behind structures and interior trim, which hampers the continuous monitoring of their condition. The correct attachment of wires and cables, hoses and tubing ensures their continued integrity. Especially in areas where electrical wires are routed in near hoses and tubing that contain flammable fluids, non-standard wires, connectors and attachments are a fire risk. Wires approved for aviation use are PTFE[20]-insulated and therefore have better thermal and bending resistance than PVC[21]-insulated wires intended for automotive and construction use. Attachments should be made considering wire heating and any routing-induced signal disturbances. Wire quality is closely linked with continuity, durability and weight. Aircraft wires are designed to meet the requirements of aviation environment, and compared with automotive wires they possess better continuity per diameter, which translates into weight savings. The insulation on many of these wires is less flexible and more chafe-resistant.

Equipment Installations, Technical Condition and Continuing Airworthiness Monitoring of Amateur-built Aircraft

The operating environment should be taken into consideration in the design, construction and maintenance of aircraft and components. Factors affecting system operation include, among others, temperature variations, humidity and moisture, acceleration forces, and vibration. Attempts are also being made to make structures and systems as small and lightweight as

[20] Polytetrafluoroethylene, commonly known by its trade name, Teflon.
[21] Polyvinyl chloride.

feasible. The systems must be reliable because even minor anomalies may jeopardize flight safety. It is therefore important that aircraft materials, components and systems are designed for reliable operation in the applicable environment and flight regime.

Components and systems of type-certified aircraft are thoroughly inspected and tested before use. They are subject to rigorous quality standards that must be met before they are approved for aviation use. Systems are tested at specified intervals, and the component life is under continuous monitoring. This also applies to all materials used in aviation.

The regulations and requirements for non type-certified amateur-built aircraft are less restrictive. Functional requirements have been established for components and systems, but specific quality requirements do not exist. Components do not need to be designed for aircraft use, and materials do not need to meet quality requirements that have been established for type-certified aircraft. Consequently, components and materials are more readily available and less costly, which in part makes amateur-building possible.

Most amateur-built aircraft are constructed from assembly kits or detailed plans using specified materials and components, for load-bearing structures in particular. However, the responsibility of the builder and the maintainer is accentuated with regard to component selection and the standard of the final assembly, and they should understand what materials, components and assembly methods are suitable for the intended operating environment.

Lack of instructions and knowledge during construction or maintenance may lead to a situation where unsuitable components or materials end up in the aircraft. Incorrect or inappropriate assembly methods may also be used. Unsuitable materials or system installations may be difficult to detect in the completed aircraft, especially in areas where they are concealed behind aircraft structure.

Competency requirements have been established for the surveyor, whose task is to verify that the aircraft is constructed in compliance with aviation regulations, and good engineering practises are observed. As an example, a person can be nominated as a surveyor if he has completed the construction of a similar aircraft. However, he is not responsible for the aircraft’s airworthiness. Although technical education or experience is not required for the construction of an amateur-build aircraft, the builder is responsible for the construction and airworthiness of his aircraft and should therefore have sufficient basic skills and knowledge of quality matters and other criteria in aviation. Extensive basic knowledge of aviation technology would also help the builder in the operation, maintenance and airworthiness management of the aircraft. The end result could be improved amateur-built aircraft safety and reduced possibility of any technical errors during construction and maintenance.

The purpose of Traficom’s airworthiness review is to ensure that the aircraft is constructed and maintained correctly and is safe to operate. Challenges in the airworthiness review of an amateur-built aircraft may arise from the rarity of the aircraft type, requirements that are less restrictive than for type-certified aircraft, and the achievable accuracy of the inspection. In these cases, the role of the inspector’s knowledge of aircraft structures and systems is accentuated.

Pilot’s Recency

The experienced recreational pilot had accumulated only a small number of flight hours during the period preceding the accident. On the other hand, the characteristics of the airplane would not have enabled him to reach the airfield from the altitude where the problem occurred, and no indications of the loss or airplane control were found.

3.2 Flight Preparation

Aeronautical Weather Information and its Interpretation

The pilot had planned the accident flight earlier in the afternoon. He had listened to aeronautical weather information broadcast and made notes on his knee pad. The high-hour pilot must have had knowledge and first-hand experience of conditions conducive to carburetor icing. However, weather information broadcasts do not caution pilots about these conditions, which must therefore be recognized by the pilot. The matter is complicated because carburetor icing can occur under a wide range of conditions. The weather information the pilot received combined with the graph showing the effects of temperature and dew point should have enabled him to assess the possibility of icing. Yet the risk of icing is not necessarily appreciated on a sunny day with air temperatures above zero and generally good weather conditions.

Even though ample information of aircraft and airfoil icing is available in Finnish, no information of conditions that could cause carburetor icing is currently available in Finland's series of aviation regulations or on the websites of recreational pilot associations. Information that is accessible on EGAST and EASA websites is in English and does not meet the needs of Finnish recreational pilots. Information contained in the canceled aeronautical information publication OPS T1-18 should be reissued since carbureted engines are still used extensively in general and recreational aviation. The publication contained, among other information, a graph showing the effects of temperature and dew point on the risk of carburetor icing. The graph is particularly easy to interpret and would help the user to figure out the risk of icing during flight planning. The location of the document on a non-Traficom server may affect accessibility, however.

3.3 Flight and Engine Malfunction

Weather conditions were conducive to carburetor icing

Inlet air preheat is usually deselected for takeoff, but carburetor icing may occur abruptly and take the pilot by surprise, especially when power is reduced to the cruise setting. The pilot's intention was to conduct a touch-and-go from the traffic circuit height. Ice started to form in the carburetor when he reduced power, if not earlier, and caused sudden engine cut-out.

Approach and traffic circuit entry procedures include performing checklists. One item in the accident airplane's checklists was the selection of inlet air preheat. The cut-out occurred at the halfway point of the downwind leg when the pilot may not have completed the checklist.

Soot in the exhaust system and spark plugs combined with carbon deposits on the cowling were consistent with an excessively rich air-fuel mixture, which could have caused the cut-out. Possible causes of mixture enrichment included carburetor icing or separation of fuel and moisture from the inlet ducting walls, or both.

Inlet ducting characteristics and carburetor location increased likelihood of icing

Carburetor location at the end of long, separate inlet ducts well clear of the hot engine parts increased the risk of carburetor icing significantly. The long ducting, which was susceptible to temperature drop, was prone to the formation of fuel droplets and occasional rapid mixture derichment and sudden enrichment. These factors may also have caused rough running.

Inlet air temperature sensor location in the ducting away from the carburetor may have led to an incorrect interpretation of carburetor temperature, and therefore the pilot could not accurately anticipate the possibility of icing. An ideal sensor location would have been in the carburetor venturi where inlet air temperature is lowest.

The inlet air preheat system could be selected on to divert hot air from a heat exchanger installed on an exhaust duct to the inlet air housing. The system was operated by a lever from the cockpit. This lever was found in the forward (deselected) position, but its position at the time of the accident could not be positively determined due to impact damage.

Other aircraft operating from the aerodrome on the day of the accident did not report indications of icing. Aircraft are fitted with a variety of carburetor, inlet air duct and inlet air preheat installations. Some of them are less susceptible to icing, and even those that are prone to icing can operate without any issues under favorable conditions.

Engine Condition and Cut-out

The investigators could not pinpoint any cause of the sudden cut-out in the engine itself or in the ignition and fuel systems. Apart from moderate wear and tear, no mechanical defect that could have led to the cut-out was found.

Fuel Quantity and Fuel Cock Setting

The amount of fuel on board was sufficient; the fuel was of the correct grade, and no signs of leakage were found. Test runs showed that an engine fitted with a similar combination of the carburetor, fuel tank and fuel system would have run at cruise power for less than 10 s with the fuel shut-off valve closed. The likelihood of a takeoff with the valve closed was considered unlikely since this would have caused engine stoppage during taxiing-out, if not earlier.

Restart Option at Traffic Circuit Height

Restarting of an engine that is not fitted with a starter motor will be possible as long as the propeller is windmilling, provided that the cause of the cut-out has cleared – which would be the case if carburetor ice melts, for instance. The engine-out glide airspeed given in OH-XMA's emergency checklist coincides with the airspeed at which propeller rotation stops. It is possible that the pilot reduced the speed from the normal traffic circuit speed to this glide airspeed. This could have resulted in propeller stoppage, after which a successful restart would have required a significant airspeed increase, and this would have been impossible due to low height.

Delayed Emergency Response Center Call

The pilot had the habit of conducting touch-and-goes before proceeding on a cross-country flight. Therefore, eyewitnesses who knew him were initially not concerned although they did not see the accident airplane after it had joined the traffic circuit. They had no direct view towards the airfield area. The emergency response center was notified of a missing aircraft only after the pilot had failed to return to the vicinity of the aerodrome within the anticipated timeframe. Search and rescue was initiated approximately one hour after the accident, but this delay was not a factor because the pilot had sustained fatal injuries on impact.

The local control facility was closed, and the airspace was uncontrolled. A flight plan is not required for flight in uncontrolled airspace. However, if a flight plan is filed and contact with the aircraft cannot be established, search and rescue is initiated.

3.4 Forced Landing in Wooded Terrain

The cut-out occurred at 150 m height on the downwind leg at a point where power-off glide to the airfield was beyond the capabilities of the airplane. After the cut-out, the pilot had little time to choose the direction of glide, and since good options were not available, he apparently elected to head for an apron on the south side of the runway. But the pedestrian gliding characteristics of the airplane precluded extended power-off flight. When the pilot found that gliding performance would not allow reaching the apron, and no optional forced landing sites were available, he concluded that landing in a wooded terrain was unavoidable.

The choice of a landing site is crucial to a successful forced landing. The possibility of serious injury and material damage is higher during a landing in wooded terrain or on trees compared with landing on unobstructed terrain. Landing in wooded terrain has inherent dangers. If no better option is available, several instructions recommend bringing the airplane down in tree tops, in controlled flight and at the lowest possible airspeed. Since the stalling speed of the accident airplane type is between 70 km/h and 80 km/h, it is likely that tree impact occurred at this or higher airspeed.

Cockpit Structure

Although the cockpit structure remained essentially intact, the initial impact with the trunk of a tree and the subsequent impact of the cockpit section with another tree caused fatal injuries to the pilot. The cockpit structure did not offer sufficient protection to the pilot.

The requirements in place for amateur-built aircraft do not include a safety cockpit or the use of a helmet. They stipulate that the structure of an amateur-built aircraft should protect the occupants during minor accidents, but this requirement is not elaborated.

In the accident that occurred to a Sonerai II in Kajaani in 2019, the structural weaknesses of the canopy and the airframe in the cockpit area contributed to fatal injuries to the pilot when the aircraft nosed over at a low speed during a forced landing.

3.5 Search and Rescue

Emergency Locator Transmitter and Emergency Call

Authorities usually initiate search and rescue after the activation of an emergency locator transmitter (ELT), after the receipt of an emergency transmission, on an emergency call, or automatically when contact with an aircraft that has filed a flight plan cannot be established. In this accident, the ELT did not activate, no flight plan was filed, and an emergency call was made when a recreational pilot had taken off search the accident airplane. For these reasons, search and rescue was launched approximately one hour after the accident.

Aviation regulation GEN 1.5 states that an aircraft must be fitted with an ELT. The device does not need to activate automatically, in which case the pilot will need to activate the ELT manually. The accident pilot did not transmit and emergency call, nor did he activate the ELT.

The location of a manually activated ELT may play a major role in an accident. If the device is within the pilot's reach, he or she can activate it even when trapped in the seat. When the pilot has a parachute, the device can be mounted on the parachute, in which case it will guide responders to the pilot, not to the aircraft.

Challenges to Locating Accident Aircraft

Eyewitnesses may find the threshold of calling an emergency response center high when they are not certain that an aircraft accident has occurred and want to avoid unnecessary calls. Air search of an accident aircraft may take time. If the planned route of the aircraft is unknown, search and rescue must be extended over a large area, which is a time-consuming effort.

A good rule of thumb is to make an emergency call whenever an aircraft accident is suspected.

4 CONCLUSIONS

Conclusions encompass the causes of an accident or a serious incident. Cause means the different factors leading to an occurrence as well as relevant direct and indirect circumstances.

1. It is possible that the engine cut out due to the accumulation of ice or condensed fuel in the carburetor or in the inlet ducting. Carburetor location and inlet ducting configuration made them prone to icing and to formation of fuel droplets, which is a typical feature of the engine type. Weather conditions and the phase of the flight were conducive to carburetor icing. The airplane had an inlet air preheat system, but its effectiveness or application during the flight were not positively determined.

    Conclusion: *Conditions conducive to carburetor icing may surprise the pilot. Combined with structural configurations that are susceptible to icing, they could lead to a sudden engine cut-out that leaves little time to respond.*

2. Carburetor icing may occur over a wide range of temperature and humidity variations and in all seasons. Conditions conducive to airframe icing are easier to recognize.

    Conclusion: *The aviation weather service and icing condition advisories do not include information of possible carburetor icing; they only caution pilots of airframe icing.*

3. The accident airplane met the requirements for amateur-built aircraft and had passed an airworthiness review. Although no cause for the abrupt engine cut-out was found in the airplane, faults in certain component installations and structural solutions could have led to the engine failure.

    Conclusion: *Airworthiness requirements for amateur-built aircraft do not guarantee that only materials, components and installations suitable for aeronautical applications are used in aircraft. Responsibility for the safety of the completed product rests with the builder, the surveyor and the airworthiness inspector, with a great deal of leeway.*

4. Previous training or experience of aeronautical engineering are not required from the builder of amateur-built aircraft.

    Conclusion: *Incorrect or inappropriate knowledge or skills may lead to dangerous structural solutions or incorrect component installations. In the construction phase, primary responsibility for the quality of workmanship and safety rests in practice with the surveyor and the airworthiness inspector. Efficient and coordinated training could improve recreational stakeholders' knowledge of safe aeronautical practises and ensure that correct knowledge and skills are passed on to the surveyors.*

5. Aeronautical information publication OPS T1-18, which contained information of carburetor icing, was removed from Finland's series of aviation regulations in 2003. The publication included, among other information, a graph showing the effects of temperature and dew point on the risk of carburetor icing. Traficom's winter operations bulletins have a link to the canceled document on a non-Traficom server. The same information can be found in English in safety information leaflet GA5 *Piston Engine Icing,* issued by EGAST, but this cannot be accessed via the website of Finland's competent aviation authority.

Conclusion: *The lack of essential Finnish language flight safety information from the website of Finland's competent aviation authority hampers the dissemination of relevant know-how in recreational aviation.*

6. The pilot sustained fatal injuries on tree impact. The cockpit structure did not protect the occupant although the airplane met the structural criteria for amateur-built aircraft.

    Conclusion: *The requirements for the structures of amateur-built aircraft are less restrictive than for type-certified aircraft and do not address occupant safety matters to the same extent. The occupants of amateur-built aircraft should be aware of the resultant risk.*

7. The launch of the search and rescue effort was delayed because the accident was not observed, the pilot had not filed a flight plan, and his intentions were unknown. Moreover, his emergency locator transmitter was not of an automatically activated type. The resulting uncertainty delayed the emergency call.

    Conclusion: *Filing a flight plan would reduce the delay in the launch of a search and rescue effort. A manually activated emergency locator transmitter is of little use if the occupant is unable to activate the device. However, these were not factors in this particular accident.*

8. Reaching the airfield area after the engine cut-out from the lower-than-normal traffic circuit height was beyond the capabilities of the accident airplane.

    Conclusion: *It is important to select a traffic circuit height that allows for reaching the airfield in the event of an engine failure, considering the characteristics of the aircraft type and the prescribed VAC[22] procedures.*

9. Restarting of an engine that is not fitted with a starter motor will be possible as long as the propeller is windmilling. If propeller rotation had already stopped, a successful restart would have required a considerably higher airspeed than used in the traffic circuit, or alternatively, sufficient altitude that could have converted into airspeed.

    Conclusion: *Restarting a dead engine at low airspeed and low height would have been practically impossible.*

22 Visual approach chart.

5 SAFETY RECOMMENDATIONS

5.1 Ensuring Availability of Information Contained in Aeronautical Information Publication OPS T1-18

Carburetor and inlet ducting icing may come as a surprise because icing can occur over a wide temperature range. The effect of temperature and dew point on the risk of carburetor icing is not apparent from aeronautical weather information, but it was discussed in aeronautical information publication OPS T1-18, which was canceled and removed from Finland's series of aviation regulations in 2003. It is currently available on a non-Traficom server only.

The Safety Investigation Authority Finland recommends that

> *The Finnish Transport and Communications Agency Traficom ensures that information of carburetor icing (OPS T1-18 "Kaasuttimen jäätyminen" and EGAST GA5 Piston Engine Icing or equivalent information) is made available in Finnish. [2023-S19]*

5.2 Skills Development of Builders of Amateur-built Aircraft

Training and experience requirements for builders of amateur-built aircraft are not defined, and incorrect or inappropriate knowledge or skills may lead to dangerous structural solutions or incorrect component installations. Efficient and coordinated training could improve recreational stakeholders' knowledge of safe aeronautical practises. Aircraft building is also a learning experience in which cooperation between the builder and the surveyor is essential.

The Safety Investigation Authority Finland recommends that

> *The Finnish Transport and Communications Agency Traficom and recreational pilot associations jointly ensure that up-to-date instructional material and training are available to the builders of amateur-built aircraft, and that cooperation between the builder and the surveyor during the building project is emphasized. [2023-S20]*

5.3 Airworthiness Review of Amateur-built Aircraft

Current aviation regulation AIR M5-2 no longer requires a permit to build for an amateur-built aircraft. Increased responsibility for good workmanship and airworthiness compliance is allocated to the builder and the surveyor.

The first inspection conducted by the authority is undertaken during the final stage of construction, when an application for a permit to fly for test is submitted. Even if the inspection reveals serious deficiencies, reinspection will not necessarily be required.

The Safety Investigation Authority Finland recommends that

> *The Finnish Transport and Communications Agency Traficom establishes a practise in which the surveyor should be available for the initial airworthiness review of an amateur-built aircraft. If the inspection reveals serious deficiencies, the aircraft should always be reinspected. [2023-S21]*

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Rasmussen, J. & Svedung, I. (2000) Proactive Risk Management in a Dynamic Society. Karlstad, Sweden. Swedish Rescue Services Agency.

Investigation Material

1) Photographs, diagrams, and other material produced during on-site investigation
2) Police photographs from the accident site and investigation reports
3) Weather data
4) Finnish Meteorological Institute model of weather conditions at traffic circuit height
5) Interviews
6) Secondary surveillance radar data
7) Forensic pathology report
8) Insta ILS report on examination of tachometer
9) OH-XMA flight manual
10) OH-XMA technical log
11) OH-XMA documents
12) Pilot's logbook
13) Pilot's licenses
14) Pilot's aeromedical certificate
15) Emergency Response Center Authority alert log and incident report
16) Emergency Response Center recordings

17) Results of Neste Oil Engine Laboratory fuel analysis
18) Radio communication recording from Jyväskylä aerodrome (EFJY TWR) on frequency 118.000.

SUMMARY OF COMMENTS TO DRAFT FINAL REPORT

The draft final report was submitted for comments to the Central Finland Rescue Department, the Finnish Transport and Communications Agency Traficom, the National Police Board, Air Force Command Finland, Finavia, Fintraffic ANS, the National Transportation Safety Board of the United States, and the interested parties. Pursuant to the Safety Investigation Act, no comments given by private individuals are published.

The Central Finland Rescue Department stated that generally speaking they have nothing to add to the draft report. They suggested minor amendments to the description of the paramedics' actions and the alerted units and gave clarifying information regarding the responsibilities in the search of a lost aircraft.

The Finnish Transport and Communications Agency Traficom regards the report as a commendable piece of work that brings to the fore various facets of amateur-built aircraft construction and highlights recent regulatory changes and therefore serves as a source of abundant and useful information to support amateur aircraft builders. On a granular level, Traficom's comments were related to safety recommendations directed to the agency.

Traficom explained that material on carburetor icing is widely available to users in the annual winter operations bulletins and via associated website links. The agency noted that safety recommendation 5.1 was based on a conclusion drawn from incorrect statements and recommends that the information available on its website should be published. Furthermore, the agency is aware of the possibility of having an aeronautical information publication that has been removed from the series of aviation regulations on a non-agency server may increase the risk of the information contained therein becoming inaccessible. Traficom will initiate actions to address this matter.

Traficom also stated that the training requirements for the builders of amateur-built aircraft as described in the original text of safety recommendation 5.2 cannot be met under the Aviation Act. In any amateur-built aircraft project, competency requirements are prescribed for the surveyor, and any major changes would need to be approved by the competent authority. Instead of tightening regulations, Traficom would as the primary option increase know-how among amateur builders as a voluntary effort of recreational pilot associations or by other convenient means. The agency also maintains that instead of defining training requirements, emphasis should be put on closer cooperation between the builder and the surveyor during the project.

The requirement for the presence of the surveyor during the airworthiness review of amateur-built aircraft, as proposed in the original text of safety recommendation 5.3, would bring no added value in Traficom's view. However, the agency explained that the surveyor should be available during a review. In Traficom's opinion, a review can be discontinued, if necessary, in cases where particularly serious deficiencies are found, and then started again from the beginning, but the agency continued that these deficiencies would not automatically require reinspection.

In addition to the foregoing, Traficom proposed amendments to those parts of the text that discuss airworthiness inspector's authorization and electrical wires used on aircraft. Finally, the agency suggested that conclusion no. 9 be clarified. The amended text should mention that restarting an engine that is not fitted with a starter motor would be possible without airspeed increase provided that the propeller is still windmilling.

The National Police Board, **Air Force Command Finland**, **Finavia**, **Fintraffic ANS** and the **National Transportation Safety Board of the United States** had no comments on the draft report.