Amateur-built Aircraft Accident at Hyvinkää Aerodrome on September 27, 2021

L2021-03

FOREWORD

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 involved an amateur-built airplane and occurred at Hyvinkää aerodrome on September 27, 2021.

Air transport pilot Mika Kosonen was appointed the investigation team leader. The appointed team members were air transport pilot, flight instructor Kimmo Lius, special investigator Juho Posio and aeromedical examiner, adjunct professor Alpo Vuorio. The investigator-in-charge was Chief Air Safety Investigator Janne Kotiranta.

The European Aviation Safety Agency (EASA) accredited a technical advisor to the investigation.

Insta ILS submitted a report on examinations carried out on the airplane's airspeed indicator and altimeter. The Forensic Laboratory of the National Bureau of Investigation assisted in the examination of an iPad device recovered from the wreckage.

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. Information collected by the safety investigation authority, which is of a particularly sensitive and personal nature, including information concerning the health of individuals, shall not be made available or used for purposes other than safety investigation. Information concerning the health of individuals shall be included in a report only when relevant to the analysis of the accident or serious incident. Information or parts of the information not relevant to the analysis shall not be disclosed.

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, its summary, and appendices were published on the SIAF's internet page at www.turvallisuustutkinta.fi on September 26, 2022.

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Cover photo: SIAF

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1 EVENTS

1.1 Sequence of Events

On Monday September 27, 2021, a pilot receiving instruction and a flight instructor were departing on a refresher flight from Hyvinkää aerodrome. The purpose of the flight was to extend the validity of the LAPL[1] held by the pilot receiving instruction. The intention was to conduct cross-country work and return to Hyvinkää for three simulated forced landings[2] on runway 22.

The pilots elected to use a tandem-seat Van's RV-8 amateur-built airplane for the flight. In this particular airplane, the instructor occupying the rear seat had a control stick and a throttle lever, but neither flight instruments nor rudder pedals were installed. In addition to being long-time acquaintances, the pilots were part-owners and therefore familiar with the airplane, which was a factor in its selection for the flight. The pilot receiving instruction had been involved in the building of the airplane, in which he had logged 450 h, while the instructor had accumulated less than 30 h on the RV-8.

The flight took off at 1145 h[3]. The pilot receiving instruction was the pilot flying during the flight. At 1238 h, the airplane joined right downwind of the traffic circuit[4] for runway 22, at approximately 800 to 900 ft[5] AMSL[6], or approximately 400 to 500 ft above aerodrome elevation[7]. On reaching the end of the downwind leg, the pilot receiving instruction advised on the aerodrome frequency that he would commence a simulated forced landing on runway 22.

The simulated forced landing was commenced approximately 300 to 400 ft above aerodrome elevation, at approximately 100 kt[8]. The distance between the airplane and the runway centerline on downwind was approximately 400 m. The pilot reduced power to idle and initiated a steep right-hand turn towards the threshold[9] of runway 22. During the turn, speed fell rapidly to a value close to stalling speed[10]. Control was lost, and the airplane impacted ground to the left of runway 22 final approach track approximately 130 m before the threshold. The pilot receiving instruction was fatally injured while the instructor sustained serious injuries. The aircraft was damaged beyond repair.

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1 Light aircraft pilot license. An LAPL allows the holder to act as a pilot-in-command on single-engine aircraft with a maximum takeoff mass of 2,000 kg or less. For additional information on LAPL, see para. 2.7.1.

2 In a simulated forced landing the pilot reduces engine power to idle in order to practise approach and landing without power.

3 All times are Finnish daylight savings time (UTC + 3 h).

4 A traffic circuit is a specific pattern describing the flight path that an aircraft must follow in the vicinity of an aerodrome. It consists of a downwind leg that is reciprocal to the landing direction and runs parallel with and to one side of the runway, a base leg perpendicular to the runway, and a final approach leg that ends on the landing runway.

5 Altitudes are given in feet in aviation. One foot equals 0.3048 m.

6 Altitude is measured in aviation by comparing ambient air pressure at the flight altitude with air pressure at mean sea level.

7 Aerodrome elevation is the altitude above mean sea level (AMSL) of the highest point of the landing area. Hyvinkää aerodrome elevation is 430 ft.

8 Speeds are given in knots in aviation. One knot equals 1.852 km/h.

9 The threshold marks the portion of the runway that is available for landing.

10 Stall occurs when the angle between relative wind and the wing chord, i.e., angle of attack, exceeds the critical value for that particular wing cross section. When this occurs, lift reduces abruptly and drag increases accordingly.

Figure 1. The accident scene as seen from final to runway 22 with the accident site circled in red. (Photo: Eastern Uusimaa Police Department, edited by SIAF)

1.2 Post-accident Events

Several persons arrived at the accident site immediately after the occurrence. The first was a passer-by who had observed the accident sequence. This person called the emergency response center (ERC) at 1239 h. Other witnesses included the crew of another airplane that was holding for runway 22 approximately 200 m from the accident site. The crew reported the accident on the aerodrome frequency, called air traffic control, and proceeded to the accident site to help the airplane´s occupants.

Attempts were made to open the rearward-sliding canopy, but these were initially unsuccessful due to the distortion of the fuselage. The ERC was advised that the canopy could not be opened. However, the canopy was forced open before the arrival of the first paramedic unit. One of the crew members of the other airplane then reached into the cockpit and turned the master switch to “off” to prevent possible fire. The batteries remained connected.

1.3 Alerting and Rescue Operations

1.3.1 Alerting

The call made at 1239 h was relayed to the ERC in Vaasa. The ERC initiated a prescribed procedure and alerted rescue units to respond to a serious aircraft accident. Two paramedic units, an emergency medical services (EMS) helicopter, a paramedic field supervisor, seven rescue units, an on-duty fire officer and several police patrols were dispatched to the accident site. Other accident-related calls were almost simultaneously received at the ERC in Kerava, which also initiated an appropriate procedure. Redundant alerts were, however, canceled.

Table 1. Alerted paramedic units.

Call sign	Role	Station	Alerted at	At accident site
EKU 7280	Paramedic unit	Hyvinkää	1241	1250
EKU 7251	Paramedic unit	Kerava	1241	Canceled
EKU 71	Paramedic field supervisor	Jokela	1241	1256
EKU 7252	Paramedic unit	Jokela	1242	1310
EFH 10	Emergency physician	Vantaa	1246	1306

Table 2. Alerted rescue units.

Call sign	Role	Station	Alerted at	At accident site
RKU 34	On-duty fire officer	Järvenpää	1241	1302
RKU 505	Heavy rescue unit	Kerava	1241	Canceled
RKU 801	Rescue unit	Hyvinkää	1241	Approx. 1252
RKU 843	Rescue unit (VFD)	Hyvinkää	1241	1257
RKH 601	Rescue unit	Riihimäki	1241	1302

1.3.2 Rescue Operation and Survival Aspects

The first emergency services entity at the accident site was a paramedic unit, which arrived approximately nine minutes from the alert and was directed to take the paramedic incident commander's role. On arrival, the unit reported initial observations on the condition of the airplane and its occupants over a multi-agency talkgroup, indicating that the pilot receiving instruction was unresponsive and the instructor needed urgent hospital care. The former was removed to the immediate vicinity of the wreckage, and trauma resuscitation was commenced at 1251 h. At 1303 h, the emergency physician determined that resuscitation was unsuccessful and was to be terminated. The EMS helicopter arrived at the accident site, and its crew focused on administering care to the instructor.

The first rescue unit arrived approximately one minute after the first paramedic unit. Its firefighters assisted in moving of the aircraft occupants and sprayed the vicinity of the wreckage with fire-retardant foam. The persons who had first responded to the accident explained that the airplane had been rendered electrically safe and the master switch was in "off" position. One firefighter was told to monitor the condition of the instructor until he could be handed over to the next paramedic unit to arrive at the accident site. The leader of the unit assumed the role of the incident commander.

The paramedic field supervisor arrived at 1256 h, when the airplane occupants were already receiving medical care. The instructor was at this point handed over to another paramedic unit for transport to a hospital.

The situation had stabilized by the time the on-duty fire officer arrived and assumed operational control. His subsequent tasks included, primarily, managing inter-authority communication and deciding on further actions such as handing over the accident site to the police.

The police were alerted at 1246 h, and the police field director was tasked with operational control of police operations at the accident site.

1.4 Consequences

The instructor sustained serious injuries. The pilot receiving instruction was pronounced dead at the accident site. The airplane was damaged beyond repair by impact forces. Fuel from the breached tanks contaminated the soil at the accident site. The rescue department treated the affected area with absorbent after the wreckage was removed to another location.

2 BACKGROUND INFORMATION

2.1 Environment, Equipment, and Systems

2.1.1 Aerodrome

Hyvinkää aerodrome is located three kilometers to the north of the center of the town of Hyvinkää. The uncontrolled aerodrome[11] is operated by Hyvinkää Aviation Club. It has two asphalt runways, designated 04/22[12] and 12/30. Runway 04/22 is 1,260 m long and 18 m wide. The cross runway 12/30 is 790 m long and 8 m wide. Aerodrome elevation is 430 ft (131 m). The aerodrome is in active use by flying clubs.

Figure 2. Hyvinkää aerodrome. The white arrows and numbers indicate runway designations. The red dot indicates the accident site. (Aerial view: Orthoimage ©National Land Survey of Finland 11/2021, edited by SIAF)

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11 No air traffic control services are available at an uncontrolled aerodrome.

12 Runways are designated by their magnetic heading. The designation 04/22 refers to a runway that is oriented on the heading of 40° as seen from one end, and on the heading of 220° as seen from the opposite end.

2.1.2 Aircraft

The accident aircraft was a Van's RV-8 single-engine experimental[13] category airplane. The RV-8 is a tandem two-seat, highly maneuverable high-performance airplane stressed for aerobatics. It has a tailwheel-type landing gear. Its wingspan is 6.97 m, length 6.34 m and height 1.7 m.

The airplane, registration OH-XRV, was built in 2008, and its flight manual had been approved on July 14, 2010, by an airworthiness representative designated by the competent authority.

Figure 3. The airplane before the accident. (Photo: aircraft owner)

The airplane was powered by a Superior IOF-360 engine fitted with FADEC[14]. Engine power output was approximately 180 hp. The aircraft's empty mass and maximum takeoff mass were 504 kg and 816 kg, respectively. The limit load factors were +6 G and -4 G at the takeoff mass of no more than 703 kg. The maximum demonstrated crosswind component was 8 kt from the right and 12 kt from the left. Stalling speed at the maximum takeoff mass was 55 kt with the flaps retracted and 50 kt with the flaps fully extended.

The rear cockpit was fitted with a throttle lever and control stick, but flight instruments were not installed. The airplane had no stall warning system.

2.1.3 Damage to Aircraft

A structural examination[15] was carried out on the airplane in order to determine damage and the sequence of events. Oil and fuel samples were taken.

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13 An experimental category aircraft is a homebuilt kit aircraft or a test aircraft that is built by an aircraft manufacturer but does not have a type certificate.

14 Full authority digital engine control. FADEC is an electronic engine control system that adjusts engine parameters automatically for the most efficient engine operation for all flight regimes.

15 Damage sustained by structures and components is recorded during a structural examination. The positions of aircraft and engine controls at the time of the accident or immediately thereafter are also documented.

Fuselage

The wings remained attached to the fuselage. The right wing had canted aft by approximately 20° at the wing-to-fuselage joint creating an approximately 15 cm long gap at the leading edge, and bent up by approximately 15° at mid-span. The leading edge had minor abrasions forward of the main spar, and a palm-sized hole was evident at a distance of 30 cm from the fuselage. The left wing leading edge showed abrasions, and dents were noted in the lower surface, but the wing structure was intact. Damage to the wings is shown in figure 4.

The horizontal stabilizers and elevators remained attached to the fuselage and showed no significant external damage. The elevators were deflected fully up, which was consistent with the position of the controls sticks. The elevator trim tab[16] was deflected approximately 2° up, indicating a nose-down trim setting. The linkage between the control stick and the elevators was undamaged and securely attached, and the elevators could be moved by manipulating the control stick. The linkage and cables between the rudder and the pedals were undamaged, but the pedals were jammed due to fuselage deformation. However, the rudder could be moved by applying pull on the cables.

Figure 4. The airplane after the ground impact. The right wing is canted aft, and its leading edge has separated from the fuselage. (Photo: Police)

The fuselage exhibited compression damage. The nose section had partially separated forward of the cockpit and twisted about the airplane's longitudinal axis. A deep depression with no signs of impact damage was noted on the right-hand side in line with the mid-point of the airplane's registration. The right-hand landing gear was torn off the mounting bracket.

16 An elevator trim tab is a surface that is adjusted to neutralize control forces. When the airplane is trimmed to level flight, the pilot will not need to apply forward or aft stick pressure in order to maintain altitude. When the airplane is trimmed nose-heavy, it tends to descend, while a tail-heavy trim setting causes a climbing tendency.

The left-hand landing gear remained attached to the mounting bracket but had folded beneath the fuselage. The tailwheel mount was bent to the right when viewed from the direction of travel. Damage to the fuselage is shown in figure 5.

Figure 5. Fuselage damage and the partial separation and twisting of the nose section are apparent. (Photo: SIAF)

Propeller

The airplane had a two-bladed propeller. The outer portion of one blade had broken off at a point 50 cm from the hub, and the fibers at the fracture point showed rearward bending. The other blade had bent aft approximately 15˚ at the root and exhibited leading edge chafing. Damage to the underside of the spinner between the blades was observed. The propeller mounting flange remained attached and was undamaged.

Engine

The forward right-hand side of the engine compartment was compressed inward. The alternator had torn off the mounting bracket. The engine remained attached to the engine mount, which had been forced inward at its bottom right-hand side at a point 10 cm from the firewall. The throttle control linkage was attached to the fuel injector servo, and its position indicated engine operation at idle or near idle. No significant contamination was found inside the throttle valve. The propeller governor was in the mid-range position, and continuity was established between the governor and the propeller control lever.

No other damage was noted in the engine compartment, and no signs of oil leaks were found. The oil noted on the ground after the impact had exited via a breach in the oil sump. The fuel injector lines contained fuel. The most extensive damage to the engine was apparent in the lower right-hand portion when viewed to the direction of travel.

Windshield and Canopy

The windshield and the canopy remained attached. Higher-than-normal force was needed to move the canopy due to the distortion of the side rails. An approximately 40 x 40 cm hole was found in the rear of the canopy behind the seatback. Figure 6 shows damage to the canopy.

Figure 6. The side rails were distorted. An approximately 40 cm diameter hole is evident in the rear of the canopy. (Photo: SIAF)

Cockpit

The instrument panel was bent but otherwise undamaged. The right-hand side of the glareshield exhibited deformation. The forward portion of the cockpit section was displaced to the left when viewed to the direction of travel. The footwell structure of the forward cockpit had partially disintegrated with tear-type damage apparent on the right-hand side, while the left-hand sidewall had been forced inward. Downward bending was noted near the right-hand seat attachments. The seatback was canted to the right at its upper attachments, but the seat belts remained attached to the fuselage and were undamaged. The rudder pedals remained attached to the shaft, and the control cables remained connected to the pedals. The control stick remained attached, and functional connection between the stick and the ailerons was established. Damage to the instrument panel is shown in figure 7.

Figure 7. The instrument panel was bent at mid-point. Deformation of the glareshield is also shown. (Photo: SIAF)

The rear cockpit appeared to have no significant damage. The seat and the seatbelts remained attached to the fuselage and were undamaged. The rudder pedals had been removed before the flight, but the ends of the rudder control pushrod between the front and rear cockpit were hanging from their attachments. Control stick operation was normal, connection between the stick and the control surfaces was established, and the control surfaces could be moved by manipulating the stick. The throttle lever was undamaged and remained connected to the front cockpit throttle lever.

The pitot-static system[17] components remained attached and were undamaged. The propeller control lever was in the full forward position. The throttle lever was in the approximate mid-position and was bent. The pushrod showed damage due to contact with a fuselage frame on impact. Throttle valve position was not consistent with throttle lever position as a result of forces generated on impact.

2.1.4 Conclusions from Aircraft Damage

Condition of Aircraft during Flight

No signs of inflight damage, malfunction or component failure were found in the airplane. Examination of the engine revealed no signs of an inflight engine failure. Engine rotation was tested by rotating the propeller, and no anomalies were evident. However, a complete power loss or rough running could not be entirely ruled out. The examination of the elevators, rudder, ailerons and flight control linkages suggested that these control surfaces had operated normally until the impact. The airplane had been structurally intact until the impact.

[17] A pitot-static system senses the static pressure of outside air and dynamic pressure generated by the forward movement of the aircraft to determine airspeed and altitude.

Power Setting during Final Stages of Flight

The forward right-hand side of the engine received the initial impact. The separated section of the failed propeller blade showed slight forward bending at the tip. The other blade remained complete. The position of the blades suggested low-pitch propeller operation.

The bending of the front cockpit throttle lever suggested that the pilot undergoing instruction had held his hand on the lever on impact. This observation is supported by the injuries found in his left hand and by the fact that no parts or components that could have caused the bending were identified in the vicinity of the lever. Damage to the pushrod that extends aft from the lever suggested that the engine was running at idle or near idle.

Damage to the surface finish of the pushrod matched the position of the throttle valve. The propeller control lever was fully forward, i.e., in high-rpm, low-pitch position. However, propeller governor setting did not correspond to control lever position. The throttle control and propeller control cables were under extremely high tension and stretching caused by fuselage deformation was noted. The stretching of the cable during impact had resulted in a change of governor setting.

Damage to and the position of the fuel injection servo and the propeller and throttle control linkages suggested that the engine was running at idle or near idle on impact. This assumption is supported by a witness report of a change in engine sound. The propeller was rotating at a low speed on impact. Engine rotation stopped when the propeller struck ground. The impact of the engine with the ground initiated the crushing sequence of the forward fuselage.

Flap and Elevator Trim Settings during Final Phase of Flight

The position of the elevators and the elevator trim suggested that the control stick was in the full aft position on impact. Even though trim position suggested a nose-down trim setting, the amount of deflection was small enough to have no significant effect on the controllability of the airplane. The mechanical operation of all flight controls had been normal until the impact.

Since the flap control switch was spring-loaded to the center, flap setting could not be determined from switch position. The flap actuator[18] exhibited no damage and its position was consistent with the flaps-up configuration. Minor damage to the flaps, actuator position, the partial penetration of the right-hand flap into the fuselage due to the rearward cant of the wing and the failure of the left-hand flap control rod under tension all indicate that the flaps were retracted on impact.

Ground Impact

Damage sustained by the airplane indicates that it struck ground at low groundspeed, with a high rate of descent, and in right bank. The initial contact was by the right wing, which was canted aft and bent up. The impact imparted torsional force to the fuselage forward of the cockpit. As a result, the right-hand side of the front cockpit was split open, and the left-hand side was forced inward into the occupied space. When the fuselage struck ground, in near-level attitude, the floor structure on the right-hand side of the forward seat was deformed. When the tailwheel contacted ground, the lateral movement of the fuselage subjected the tailwheel mount to bending stress and caused the deformation of the center fuselage.

The leading edge of the right wing showed minor abrasions forward of the main spar, and a palm-sized hole was created at a point 30 cm from the fuselage. The shape of the hole and the

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[18] An actuator is a device that generates a desired motion on receiving an external signal. The flap switch sends a signal to the actuator, which moves the flaps to the desired position.

mechanism of puncture suggested an impact from the outside, possibly produced by the separated landing gear, which had also created a dent on the wing under surface at the first letter of the airplane's registration.

Although the pilots had their seat belt fastened, the shoulder harness were loose, which allowed abrupt upper body movement on impact and head contact with the aircraft structure.

2.2 Conditions

2.2.1 Weather

Weather on the day of the accident was clear and sunny. The weather observation facility at Helsinki-Vantaa airport[19] located 37 km from Hyvinkää aerodrome reported winds from 110° variable between 080° and 170° at 3 m/s. Temperature was 12 °C and dew point was 8 °C. Atmospheric pressure was 1,031 hPa. Visibility was over 10 km with few clouds at approximately 550 m. Hyvinkää aerodrome has no automatic weather observation facility. Aerodrome surveillance video recording of the windsock at the time of the accident was examined. Imagery shows that wind was from 120° to 130° at 2 to 3 m/s, and the motion of the windsock suggested neither gusting nor variations in wind direction.

Figure 8. The windsock at the time of the accident, circled in red. (Photo: Hyvinkää aerodrome surveillance video recording, edited by SIAF)

2.3 Recordings

SSR[20] data from Fintraffic ANS was available for the investigation. The data shows the airplane's groundspeed, altitude (AMSL) and track during all phases of the flight. In addition, the airplane's route could be verified from GPS[21] data from a SkyDemon mobile application recovered from the wreckage. Aerodrome surveillance video recording shows the airplane in

19 Meteorological aerodrome report: METAR EFHK 270920Z 11005KT 080V170 9999 FEW018 12/08 Q1031 NOSIG=.

20 Secondary surveillance radar. SSR is used primarily in civil aviation to locate and identify aircraft. SSR position data invariably contains errors. Additional inaccuracies are caused by the relatively low data update rate. Different SSR systems are in use, and variations exist in their accuracy. Additional factors, such as range and update rate, affect SSR date accuracy. Recorded speeds are groundspeed. Altitudes are given with an accuracy of 100 ft.

21 Global Positioning System. GPS is a worldwide satellite-based locating system. Its lateral accuracy is a few meters. Vertical accuracy is slightly lower.

the traffic circuit and entering the final turn. Radio communications on the aerodrome frequency were embedded in the recording.

2.3.1 Secondary Surveillance Radar Data

SSR data shows the accident flight from the takeoff up to and including the landing. Recorded data indicated that the initial and cross-country phases of the flight were normal.

The airplane joined the traffic circuit at the beginning of right downwind at 1238 h, at 1,000 ft AMSL and at approximately 100 kt[22] groundspeed. Groundspeed reduced on the downwind leg to approximately 90 kt and altitude began to decrease. The airplane initiated the turn towards the threshold at 600 m AMSL at approximately 80 kt groundspeed. Recorded data did not permit the detailed examination of the flight on the base leg. During the turn, the airplane descended to approximately 500 ft AMSL, and recorded data suggested a possible further speed reduction during the turn.

The airplane's trajectory on the unofficial Hyvinkää aerodrome landing chart[23] is shown in figure 9. The red dots indicate the airplane's ground track in the traffic circuit.

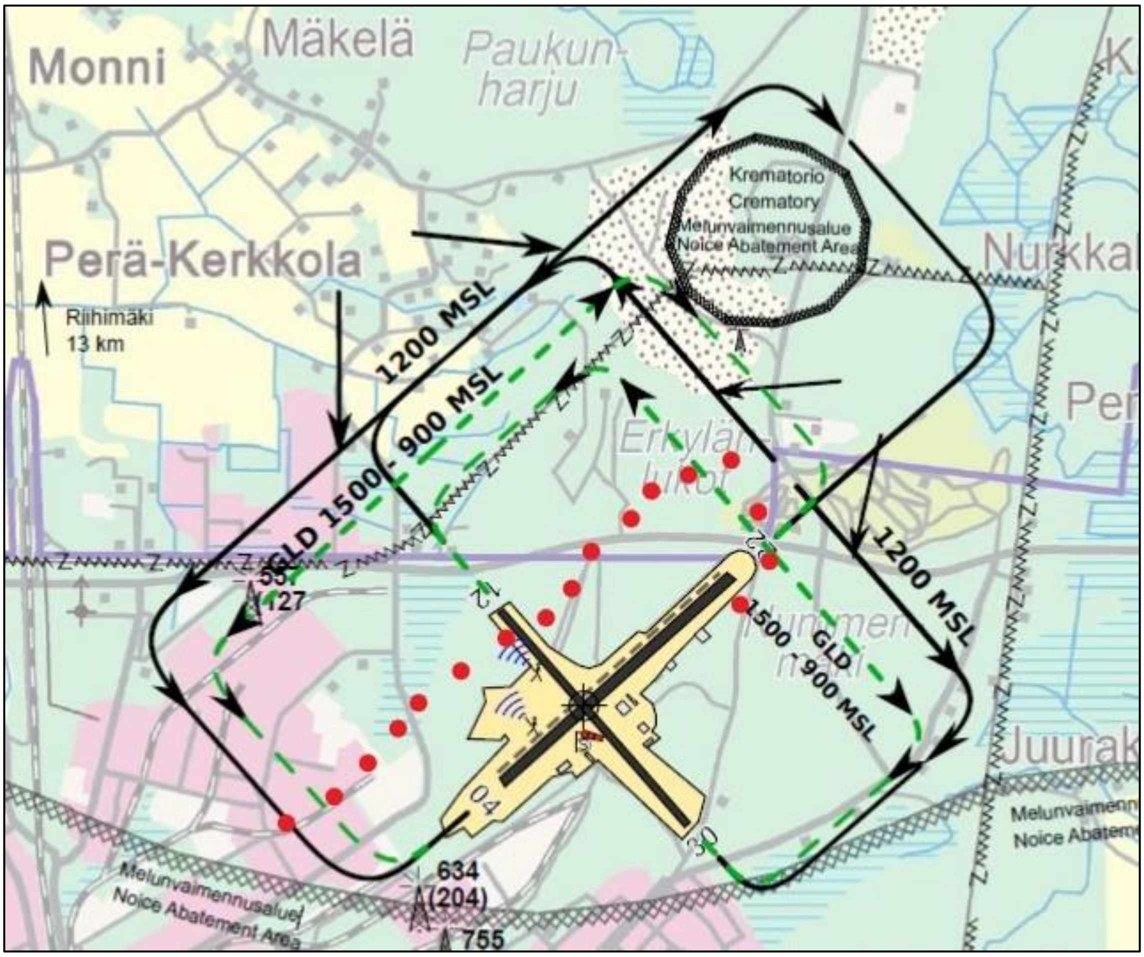

Figure 9. The airplane's track on the unofficial landing chart. The black lines represent the traffic circuits. The red dots are SSR targets. (Photo: Tom Arppe, edited by SIAF)

22 Recorded speed data contains inaccuracies, especially where the airplane executed rapid speed or heading changes; therefore, any flight regime analyses based exclusively on recorded data are estimates.

23 An unofficial landing chart of Hyvinkää aerodrome shows the approximate traffic circuits for the runways and contains essential information for operations to and from the aerodrome.

2.3.2 Video Recording and Radio Communications

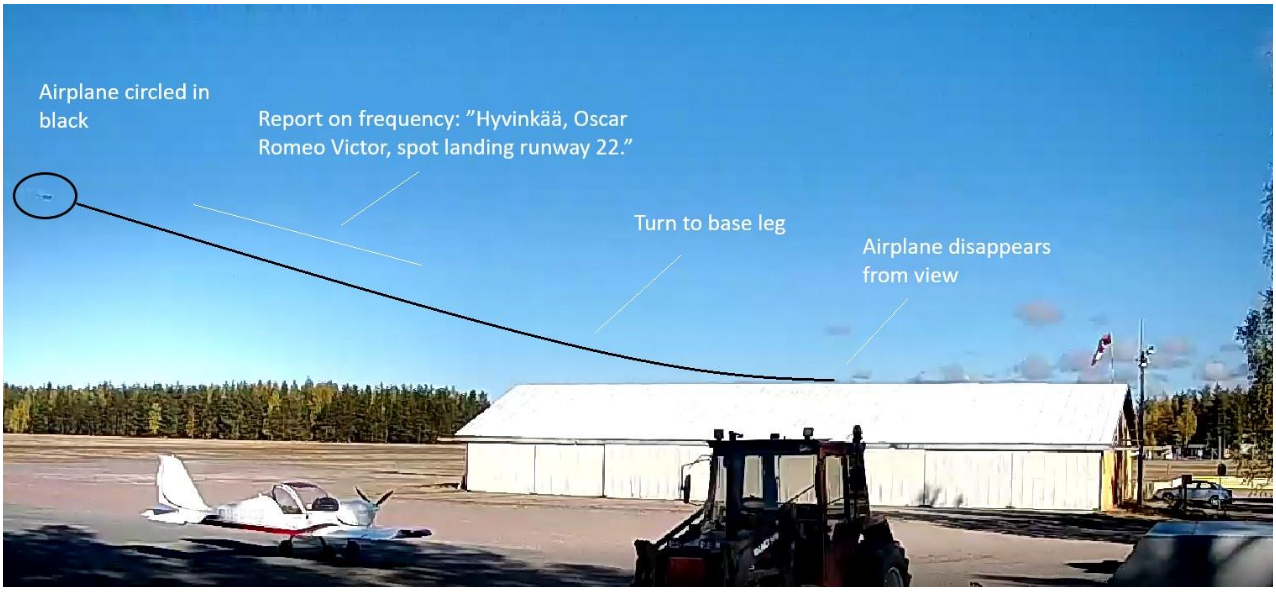

Figure 10. The airplane's flight path derived from video recording. (Photo: Hyvinkää aerodrome surveillance video recording, edited by SIAF)

The aerodrome surveillance video captured the airplane at the end of right downwind for runway 22 and during the base turn. Radio communications on the aerodrome frequency were captured on the recording. At 1235 h, the pilot receiving instruction reported that OH-XRV was approaching the aerodrome and estimated joining the traffic circuit in 2 minutes. At 1237 h, he reported an intention to carry out a simulated forced landing with power[24] on runway 22. At 1238, he reported downwind for runway 22 and advised that he would commence the simulated forced landing. At 1239 h, the pilot of the holding airplane reported the accident on the frequency. Video footage shows the accident airplane in rapid descent.

2.3.3 Conclusions from Recordings

The traffic circuit was flown very close to runway 04/22 centerline. Before the entry into the final turn, the airplane was approximately 400 m from the centerline and descended rapidly at the end of the downwind leg.

The recordings indicate that the turn towards the threshold, and the initial phase of it in particular, was flown in steep bank, and airspeed reduced during the turn. However, the exact speed during the turn cannot be determined from SSR data. The video recording and SSR data both show that the turn was flown at a low altitude above ground level.

2.4 Personnel, Organizations and Safety Management

2.4.1 Pilot Receiving Instruction

The pilot receiving instruction was a 78-year-old recreational pilot. He held an LAPL with sailplane tow and night ratings. His previous proficiency check with an examiner had been on April 24, 2018, and he had subsequently been granted a Covid-19 extension on April 22,

[24] A simulated forced landing is usually carried out with the engine at idle.

2020[25]. His SEP(A) rating was thereafter valid until August 23, 2020. He did not comply with the LAPL recency requirements at the time of the accident because he had not completed refresher training in the last 24 months and was therefore qualified to act as a student during the flight. He held an LAPL medical certificate that was valid until March 18, 2022.

He had approximately 1,200 flight hours in total, 450 h thereof on the accident airplane.

Table 3. Flying experience of the pilot receiving instruction.

Flight experience	During last 24 hours	Last 30 days	Last 90 days	Total approximately
On all aircraft types	1 landing / 1 h 15 min	10 landings / 11 h 15 min	24 landings / 22 h 25 min	1,200 h
On RV-8	1 landing / 1 h 15 min	10 landings / 11 h 15 min	24 landings / 22 h 25 min	450 h

2.4.2 Medical History of Pilot Receiving Instruction

The pilot receiving instruction had held a valid aeromedical certificate almost without interruption over the last few years. His medical history[26] from 2014 onward is described below.

Aeromedical Examination in February 2014

The records of this examination contain a mention of a faulty aortic valve and ascending aorta aneurysm. Both were under monitoring by a hospital. The pilot had also been placed on blood pressure medication. He had smoked for 50 years. He was granted a class 2 medical certificate. The licensing authority required that the pilot produce a cardiologist’s evaluation report and the results of an ultrasound scan in the next examination[27]. The authority based this requirement on a statement that it had requested from a cardiologist who had experience in aviation medicine.

Aeromedical Examination in January 2015

The follow-up cardiovascular examination showed that the pilot's general condition had remained essentially unchanged, except for progression of the aortic aneurysm. It was therefore decided that magnetic resonance imaging (MRI) of the great vessels should be carried out after 6 months. It was assessed, using the ICAO[28] Manual of Civil Aviation Medicine[29] as a guideline, that the aortic aneurysm was acceptable and under proper monitoring by a hospital. The validity of the class 2 medical certificate was limited[30] to 6 months. The licensing authority also required that the pilot produce a cardiologist’s

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[25] A Finnish Transport and Communications Agency decision (TRAFICOM/122157/05.00.28.00/2020) permitted the extension of the validity of class ratings, type ratings and instrument ratings by no more than four months between March 27 and November 27, 2020, for a period not exceeding the end of the exemption.

[26] Article 16 paragraph 5 of Regulation (996/2010) on the investigation and prevention of accidents and incidents in civil aviation states that information concerning the health of individuals shall be included in a report only when relevant to the analysis of the accident or serious incident.

[27] Specific regular medical examination (SIC).

[28] International Civil Aviation Organization.

[29] ICAO Doc 8984 Manual of Civil Aviation Medicine.

[30] Limited period of validity of the medical certificate (TML).

evaluation together with the results of an ultrasound scan of the heart and of the MRI of the great vessels in the next examination. The authority based this requirement on a statement that it had requested from a cardiologist who had experience in aviation medicine.

Aeromedical Examination in July 2015

The results of the MRI of aorta from April 2015 were available in this examination. They indicated no progress in the disease of the aortic artery wall compared with the MRI performed in 2013. Aortic valve regurgitation had also remained essentially unchanged. The pilot was placed on cholesterol-lowering medication. The validity of the class 2 medical certificate was limited to 6 months. The licensing authority also required that a cardiologist's evaluation be conducted.

Aeromedical Examination in April 2016

The results of a hospital examination conducted in October 2015, which indicated no essential progress in aortic valve regurgitation or in aortic aneurysm, were available in this examination. During the hospital visit, the pilot was advised to avoid extreme stress, while the follow-up period was extended to 12 months. He was granted a class 2 medical certificate for 12 months. The licensing authority required that the pilot produce a cardiologist's evaluation report in the next examination.

Hospitalization and Surgery in January–March 2017

While the certificate granted in April 2016 was still valid, the pilot showed progressive symptoms of a serious previously undiagnosed coronary artery disease. The disease was diagnosed in January 2017 and required surgery, that was carried out in March. It involved triple bypass surgery and the replacement of the aortic valve with a tissue valve. In addition, the aortic aneurysm was grafted. During the operation, the pilot experienced a major neurological complication which resulted in hospitalization for more than one month and in a prolonged functional disorder. The operation also caused aortic dissection. During hospitalization, the pilot experienced arrhythmia, which was a probable factor in the subsequent neurological complication. While being treated for this complication, the pilot was placed on anticoagulants, and he started a physiotherapy exercise program. A computer tomography scan of the aorta, performed in November 2017, indicated that the surgery had produced the desired result.

Aeromedical Examination in April 2018

The next aeromedical examination was not made until April 2018. It was made for LAPL requirements instead of class 2 requirements. The pilot reported in the application form the heart and aortic diseases but left the neurological disorder unreported. A cardiologist's evaluation was arranged for the pilot in conjunction with the examination. On the basis of the evaluation, cholesterol medication was increased, and arrhythmia, which had been a likely cause of the neurological complication, was examined, among other tests and examinations. A stress ergometry test verified that the surgery had been successful. Due to the neurological complication that had occurred during the surgery, the pilot was examined by a neurologist and a neuropsychologist. He was granted a certificate for 12 months. The licensing authority required that the pilot produce the report of a cardiologist's evaluation including the results of an ultrasound scan of the heart and arrhythmia examination in the next aeromedical examination. The pilot was granted an LAPL aeromedical certificate valid until February 2019.

Aeromedical Examination in July 2019

This examination was preceded by a cardiologist's evaluation in April 2019. The evaluation indicated a need for increased cholesterol and blood pressure medication, while an arrhythmia examination revealed susceptibility to arrhythmia. The cardiologist also proposed a more thorough examination to diagnose the symptoms of claudication that the pilot displayed. Since a stress ergometry test could not be carried out in a technically reliable manner, the cardiologist proposed that a similar special examination be conducted in a hospital. This examination was carried out in June 2019. The pilot was granted an LAPL aeromedical certificate valid for 12 months beginning on July 3, 2019. The licensing authority required that the pilot produce the report of a cardiologist's evaluation in the next examination.

Aeromedical Examination in March 2021

This examination commenced in March 2021, by which time the pilot's medical certificate had been lapsed for approximately 10 months. A cardiologist's evaluation had begun in January 2021. During the evaluation, the anticoagulant was changed to a type that did not require regular laboratory monitoring. This change necessitated a waiting period of three months and a new stress ergometry test. It became necessary to conduct the test in a hospital because the heart rate could not be raised sufficiently. No indication of significant oxygen deprivation in the heart muscle was found in the hospital examination, and the stress ergometry test produced findings that were identical with those obtained in 2019. On July 30, 2021, the pilot was granted an LAPL aeromedical certificate valid until March 18, 2022. The validity of the certificate was limited to 12 months from the commencement of the examination, and the pilot was required to produce a report of a cardiologist's evaluation in the next examination. On August 19, 2021, the licensing authority specified that the pilot should also produce the results of a stress ergometry test and of an ultrasound of the heart in the next examination.

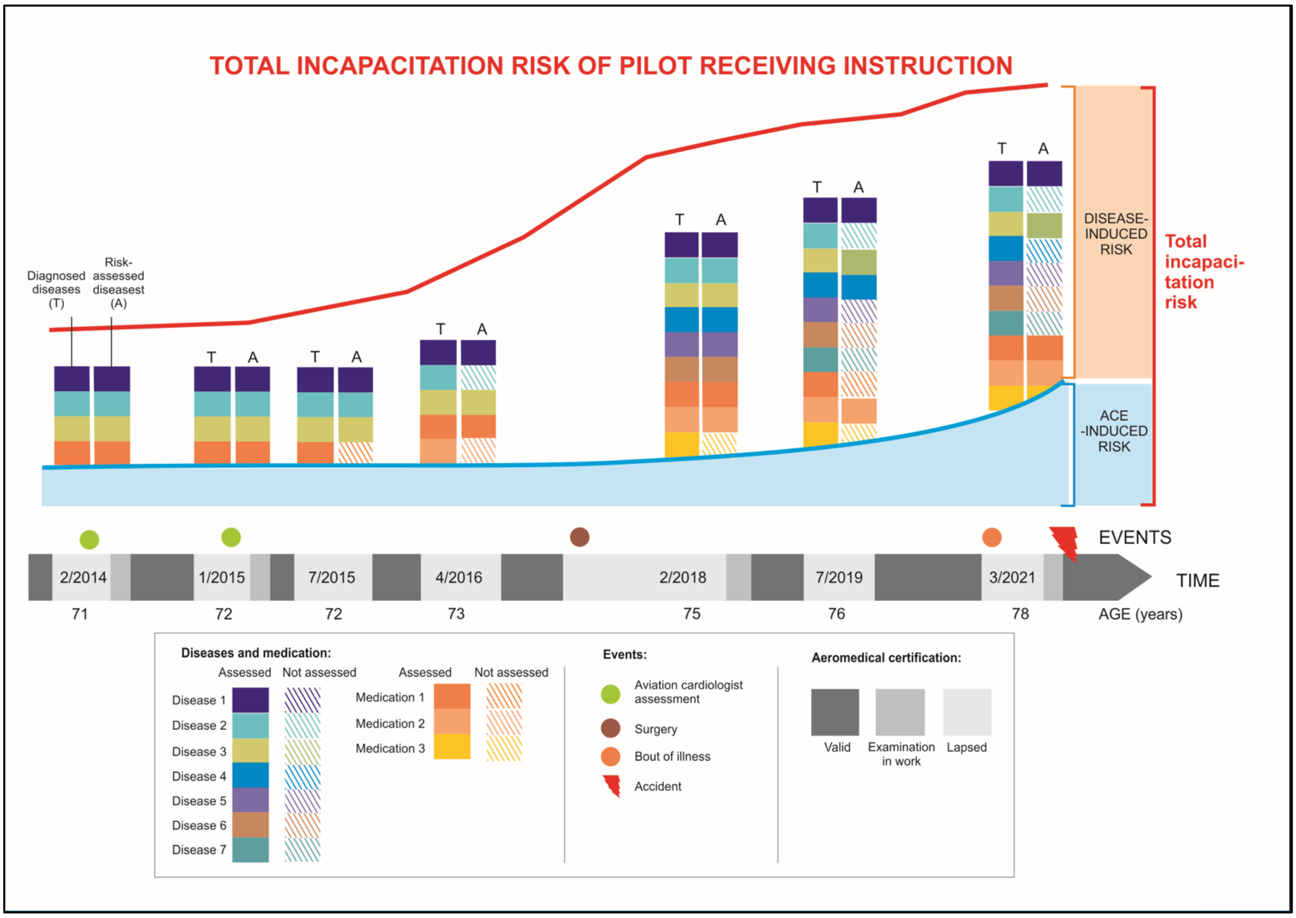

Figure 11. Timeline showing diseases, medications and development of incapacitation[31] risk, based on the results of aeromedical examinations. (Photo: SIAF)

Pre-accident Medical Condition

The pilot receiving instruction did not have a standing patient care relationship with a health center. Paramedic care records show that he had collapsed after a bout of illness on April 29, 2021, and had reported chest discomfort. A paramedic unit had checked his condition but had not transported him to hospital. The paramedics had advised him to make an appointment with a health center for further examination if necessary.

No other information of the pilot's pre-accident medical condition was available because he did not have a personal physician in ambulatory health care[32]. However, it is known that his functional ability showed not only a long-term change but also daily variations.

Day of Accident

The pilot receiving instructional had felt normal on the day of the accident and showed no pre-accident changes in his state of health during the flight. Approximately one minute before the accident, he was functional and spoke on the radio. However, soon afterwards he suffered

31 Incapacitation means the inability of a pilot to carry out his or her duties. Incapacitation may occur due to a bout of illness, among other reasons.

32 Ambulatory health care is commonly understood to include outpatient care in health clinics and pre-emptive care provided by parental clinics and other similar facilities.

a bout of illness, which resulted in sudden incapacitation. He showed no signs of life when the first paramedic unit arrived at the accident site.

Forensic Examination

A forensic autopsy determined that death was caused by the rupture of the thoracic aorta and aortic dissection down to diaphragm level. Evidence of a previously undiagnosed heart attack was discovered. Forensic chemistry examination tested negative for alcohol or medical substances affecting the central nervous system. Traces of medication used to treat cardiovascular diseases were discovered in the samples.

2.4.3 Flight Instructor

The 54-year-old flight instructor held a valid PPL(A) license granted in 2016. His license included, in addition to an SEP(A) class rating, flight instructor, night training, aerobatic training, display training and class rating instructor endorsements. The flight instructor endorsement was limited to providing instruction to LAPL license holders. He held a valid class 2 aeromedical certificate. He had approximately 1,000 flight hours in total, 865 h thereof as pilot-in-command. He had 434 h of experience as flight instructor.

Table 4. Flight experience of the instructor.

Flight experience	Last 24 h	Last 30 days	Last 90 days	Total approximately
On all aircraft types	-	11 landings / 5 h 50 min	86 landings / 31 h 35 min	2,585 landings / 1,000 h
On RV-8	-	4 landings / 2 h 38 min	4 landings / 2 h 38 min	80 landings / 29 h
Flight instructor, all types	-	2 landings / 2 h 15 min	13 landings / 8 h 25 min	1,500 landings / 434 h
Flight instructor, RV-8	-	1 landing / 1 h	1 landing / 1 h	71 landings / 12 h 45 min

2.4.4 Medical Certificate of Flight Instructor

The instructor held a class 2 aeromedical certificate valid until January 15, 2022. His aeromedical examinations had not revealed any significant medical disorders.

Consequences of Accident

The flight instructor sustained serious injuries[33], receiving facial injury that required medical care. He remained hospitalized for slightly over 10 days. A blood sample tested negative for alcohol or medical substances affecting the central nervous system.

[33] According to Regulation (EU) 996/2010 of the European Parliament and of the Council, a serious injury means an injury which is sustained by a person in an accident, and which involves, among others, hospitalization for more than 48 h and a fracture of any bone (except simple fractures of fingers, toe, or nose).

2.5 Preventive Actions of Authorities

In 2016, the SIAF investigated an accident in which the pilot of a general aviation airplane suffered a heart attack on a local flight and succumbed soon after landing. He had suffered from multi-vessel coronary heart disease and sleep apnoea. Within five years before the accident, he had had three heart attacks, which had been treated with balloon angioplasty.

The investigation determined that the pilot's higher overall risk of a recurring heart attack, as regards flight safety, had not been recognized, and that the European aeromedical guidance material only partly provides for decision-making associated with overall risk assessment.

The pilot had been unaware of the privileges of a medical certification and the validities of his license. While the public health care system had been aware of the pilot's flying hobby, it was found that national legislation did not lay down any duty of notification associated with medical certification to doctors treating license holders.

The SIAF issued four safety recommendations stemming from the investigation:

1. The International Civil Aviation Organization (ICAO) review the existing guidance material contained in the Manual of Civil Aviation Medicine to include a risk assessment model to facilitate aeromedical decision-making in the evaluation of pilots at risk from recurrent heart attacks. [2017-S34]
2. The European Aviation Safety Agency (EASA) improve aeromedical examiners' risk assessment competency through promotion, competency-based recurrent training and specific training on the national procedures for referral and consultation as well as for the use of limitations. [2017-S35]
3. The Finnish Ministry of Transport and Communications standardize the duty of notification between aviation and road transport, associated with a person's state of health, as part of advancing the safety of flight. [2017-S36]
4. The Finnish Transport Safety Agency see to it that the practitioners of general and sport aviation receive clarifying information pertaining to the privileges associated with the pilot's license and the significance of the requirement to report medical issues. [2017-S37]

Recommendation 2017-S34 is on ICAO worklist and still in work.

As for recommendation 2017-S35, EASA has embarked on a development project for improving the decision-making of aeromedical examiners. This is in addition to previously issued directives and previous actions.

Recommendation 2017-S36 has been implemented in a legal amendment that harmonizes the practices for medical notification in rail and air traffic and in navigation.

Recommendation 2017-S37 has been implemented. Aeromedical examiner training now calls attention to the fact that an examiner has during every examination a duty to both advise every applicant of the significance of the duty of notification and provide appropriate guidance. This requirement is also printed in the aeromedical certificate. In general aviation, information is disseminated actively in bulletins, during various events, in social media and by giving personal consultation. The Finnish Transport and Communications Agency Traficom strives to further develop policies and the use of various avenues to extend and facilitate the reach of information.

2.6 Rescue Services and Preparedness

2.6.1 Central Uusimaa Rescue Department

The member municipalities of Central Uusimaa Rescue Department are Hyvinkää, Järvenpää, Kerava, Mäntsälä, Nurmijärvi, Pornainen, Tuusula and Vantaa. The department's area of responsibility is divided into four risk categories, of which Category 1 is the highest. The department's operational readiness conforms to the rescue service standard decision for 2021–2024. The area of responsibility is divided geographically into the Southern and Northern sectors. Each sector has a designated on-duty fire chief (P33 and P34) who assumes general operational control in cases where other agencies and operators are involved. Eight high-readiness fire stations and two standby fire stations are located in the area of responsibility. They serve as bases for rescue units equipped for immediate and appropriate response and are supported by a network of voluntary fire departments with a total capacity of 34 rescue units.

The department arranges every year inter-agency air accident response exercises and other training events and maintains close cooperation with the neighbouring rescue departments.

2.6.2 Hospital District of Helsinki and Uusimaa

The Hospital District of Helsinki and Uusimaa is made up of five hospital areas, including the Hyvinkää hospital area with its appointed chief medical officer and chief paramedic officer. The area has a paramedic supervisor, three advanced level paramedic units and six basic and advanced level units to provide full and immediate paramedic services on a daily basis.

The units are based in the rescue department's stations and in the facilities of the voluntary fire departments. The hospital area cooperates with the rescue department on almost a daily basis.

2.7 Rules, Regulations, Guidance and Procedures

2.7.1 Light Aircraft Pilot License

An LAPL is an aviation license permitting the operation of light aircraft. Essential principles and requirements for aircrew are laid down in Commission Regulation (EU) 1178/2011 Annex I on flight crew licensing (Part-FCL). The privileges and conditions of the holder of an LAPL for airplanes ((LAPL(A)) are prescribed in FCL.105.A LAPL(A), where paragraph (a) states that the privileges of the license holder are to act as pilot-in-command on single-engine piston airplanes-land or TMGs[34] with a maximum certified takeoff mass of 2,000 kg or less, carrying a maximum of 3 passengers, such that there are never more than 4 persons on board the aircraft. Paragraph (b) states that the license holder shall only carry passengers after he or she has completed, after the issuance of the license, 10 h of flight time as a pilot-in-command on airplanes or on TMGs. The license holder may not engage in commercial operations.

Extension of Validity of Light Aircraft Pilot License

Recency requirements are laid down in FCL.140.A LAPL(A), where paragraph (a) states that license holders shall only exercise the privileges of their license when they have completed, in the last 24 months, as pilots of airplanes or TMGs, at least 12 h of flight time as pilot-in-command, including 12 takeoffs and landings; and refresher training of at least 1 h of total flight time with an instructor. License holders who do not comply with the requirements in

[34] Touring motor glider.

paragraph (a) shall undertake a proficiency check with an examiner before they resume the exercise of the privileges of the license; or perform the additional flight time or takeoffs and landings, flying dual or solo under the supervision of an instructor, in order to fulfil the requirements in paragraph (a). The recency requirement is established using the last 24 months preceding a flight as pilot-in-command, and recency endorsements are not entered in the license or in the pilot's logbook.

2.7.2 Use of Amateur-built and Experimental Aircraft on Dual Training Flights

A specific approval from a competent authority will be required for the use of amateur-built aircraft for Part-FCL training, refresher training, skill tests and proficiency checks. Aircraft or TMGs used for dual instructional flights shall be approved under Annex VII (Part-ORA) ORA.ATO.135 or Annex VIII (Part-ATO) DTO.GEN.240.

2.7.3 Refresher Training Flight

The contents of a refresher flight are regulated by AMC1 to FCL.140A. The acceptable means of compliance shall be adhered to unless relevant alternative AMCs are approved.

When planning a flight schedule, the instructor shall consider the experience level of the pilot receiving instruction. Preflight preparation should form an integral part of the flight. During preflight preparation, the instructor and the pilot receiving instruction discuss the conduct of the upcoming flight, prepare a flight plan and carry out normal preflight preparations.

A simulated forced landing without power shall be included in a skill test[35] and a refresher flight[36]. A forced landing[37] on a refresher flight may be simulated by conducting an approach to landing, beginning from no higher than 2,000 ft altitude above the runway with the engine power set to idle.

2.7.4 Medical Certification

Medical certificates are subject to the requirements laid down in Part-FCL Annex IV (Part-MED), where paragraph MED.A.030 b states that when exercising the privileges of an LAPL, the license holder shall have at least a valid LAPL medical certificate.

A class 2 medical certificate is valid for 60 months, until the license holder reaches the age of 40. Thereafter, the validity period is 24 months, until the license holder reaches the age of 50, and for license holders aged above 50, the validity period is 12 months. An LAPL medical certificate is valid for 60 months, until the license holder reaches the age of 40. Thereafter, the validity period is 24 months.

If the applicant does not meet all of the requirements for the medical certification of the relevant class, an aeromedical examiner (AME) must assess whether it is possible to grant a certificate with limitations. The AME may also limit the validity period of the certificate. A limitation or limitations will be entered in the certificate.

For example, the holder of a certificate with an OSL (operational safety pilot limitation) shall only operate an aircraft with another pilot on board. There are few OSL-limited pilots in Finland. The holder of a certificate with an OPL (operational passenger limitation) shall only operate an aircraft without passengers on board. The holder of a certificate with an ORL

[35] LU3224 – 1/2019 Part 5, item b: Simulated forced landing.
[36] LU3270 – 1/2019 Item 4.3: Simulated forced landing without power.
[37] LU3270 – 1/2019 Item 3.5.

(operational pilot restriction limitation) shall only operate an aircraft if one of the two following conditions have been met:

A) another pilot fully qualified to act as pilot-in-command on the relevant class and type of aircraft is on board, the aircraft is fitted with dual controls and the other pilot occupies a seat at the controls;
B) there are no passengers on board.

The most common causes for the foregoing limitations in Finland are anticoagulant treatment and post-heart attack condition.

License holders may not use[38] the privileges of the medical certificate if they know that their state of health is impaired. Moreover, they must contact an AME or an aeromedical center (AMC) without undue delay if they have undergone a surgical or another invasive procedure.

2.7.5 Aeromedical Examination

The AME assesses the pilot's fitness for flying by using Part-MED requirements as a guideline. Decisions are made based on the future risk of illness-induced incapacitation and on evidence-based medical examination. However, specialists' statements will be needed in cases where an aging pilot has multiple diseases. Even significant variations may exist between recommendations given by individual specialists, but as a rule it is recommended that the specialist who gives a statement is conversant with the specific features of aviation environment.

The pilot fills in a detailed application form during the examination. The AME and the pilot review the form and confirm the information with their signatures. The AME then performs the examination which includes, among other things, vision and hearing tests and an assessment of the impact of possible illnesses on medical certification. The AME may issue or renew a certificate or extend its validity only if the applicant has produced all pertinent personal health information including medical examination reports and test results.

The pilot receives a signed medical assessment on completion of the examination. The present practice became effective in the spring of 2013. The assessment constitutes the AME's decision on advising whether the applicant is fit or unfit or referred to the licensing authority, AMC or AME. The AME can ask for any specialists' statements that are required. According to the present practice, as a rule, the AME decides whether to grant a certificate or not.

2.8 Other Investigations

2.8.1 Incapacitation

A study conducted in 2017[39] analyzed 114 fatal general aviation accidents involving pilots aged 70 or more. The accidents had occurred in the United States between 2003 and 2012. The results showed that 19 % of the accident pilots had significant diseases that very likely contributed to the accident. Compared against a control group of pilots aged 60 to 63, the subject group included a higher proportion of polypharmatic cases with a statistically more significant number of users of three or more drugs. Because polypharmacy can be considered to be linked with comorbidity, the study advised that the aeromedical assessment of an elderly pilot should include a statement from the attending general practitioner.

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[38] Aviation Act (864/2014) Section 49.

[39] Vuorio A., Asmayawati S., Budowle B. et al (2017). General Aviation Pilots Over 70 Years Old. Aerospace Medicine and Human Performance, Vol. 88(2), p. 142–145.

Another study[40] analyzed fatal accidents to pilots aged 80 years or higher. The author raised a concern for an increase in mishaps among this population. The study revealed that the number of pilots in this age group was growing, and this was accompanied by a relative high accident rate among pilots aged 80 or higher. Landing accidents figured highly in the findings, which the author says may reflect a decline in the speed of cognitive function and coordination. He proposes new means for enhancing flight safety, suggesting, for example, that elderly pilots should consider more carefully the impact of ambient conditions that affect flying and partake on a regular basis in tests predictive of pilot flight performance.

Systematic compilation and analysis of statistics on incapacitation events are one way towards improved flight safety. An example[41] is a registry[42] maintained by the FAA[43], which combines pilots' medical information with operational information. An FAA study[44] from 2018 examined findings reported in the autopsies of 602 pilots who had died in aircraft accidents. Cardiovascular abnormalities were discovered in approximately 85 % of the cases and they were the most common finding. A study carried out by the Australian Transport Safety Bureau[45] looked at differences between commercial and general aviation from the incapacitation point of view. Commercial pilots have learned and drilled control handover to the non-impaired crew member in the event of incapacitation. On the other hand, general aviation flights are often single-pilot operations, and an incapacitation event on board a two-pilot aircraft may become as a complete surprise since actions for this kind of an emergency are seldom practised.

2.8.2 Aeromedical Guidelines of European Aviation Safety Agency, Federal Aviation Administration of United States and International Civil Aviation Organization for Elderly Pilots

EASA guidelines[46] do not specifically mention elderly pilots or factors affecting their state of health. The same applies broadly to the guidance issued by the FAA[47].

The ICAO manual[48] mentions elderly pilots in a few contexts. AMEs are reminded that the increased occurrence rate of cardiovascular diseases among elderly western pilots will potentially be reflected in an increased incapacitation rate. On the other hand, the manual points out that older, more experienced pilots have fewer accidents, which may bring down the number of accidents. The manual also explains the effects on aging on the prediction of several diseases and suggests that assessments of neurological diseases should be supported by additional performance tests. It also reminds that the prescribed intervals between medical examinations should be observed and shortened for elderly pilots if necessary.

Aeromedical Evaluation Processes

Decision-making processes and related documentation are key safety management elements. Aeromedical decision-making processes are based on EASA's guidance. Additional decision-making tools include the results of evidence-based medical examinations and treatment

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40 Douglas D. B. (2018) General Aviation Accidents involving Octogenarian Airmen: Implications for Medical Evaluation. Aerospace Medicine and Human Performance, Vol. 89(8), p. 687–692.

41 Venesco J. L., DeJohn D. O. (2021). Federal Aviation Administration, Washington DC, DOT/FAA/AM-21/28.

42 Incapacitation Data Registry.

43 Federal Aviation Administration of the United States.

44 Ricaurte, E. M. Federal Aviation Administration (2018), Washington DC, DOT/FAA/AM-18/8.

45 Australian Government (2015), AR-2015-096, Australian Transport Safety Bureau.

46 EASA, Easy Access Rules for Medical Requirements, EU, 2020.

47 FAA, Guide for Aviation Medical Examiners, 2022.

48 ICAO Manual of Civil Aviation Medicine, 2012, Third Edition, Montreal, Canada.

recommendations. Their application in aeromedical decision-making may prove somewhat challenging due to the fact that general health-care instructions will need to be tailored for the requirements of aviation environment. Aeromedical decision-making combines decision-making processes based on both evidence-based medicine and risk assessment. The success of this combination is difficult to determine, even though evaluation can be performed during audits and aviation accident investigations[49]. Procedures used in safety management systems[50] or their elements are also applicable to the management of aeromedical decision-making processes.

Aeromedical assessments of working-age pilots often focus on a specific disease (figure 12), in which case the procedure is routine and can be based on aeromedical guidelines and evidence-based medicine. The AME may also consult a specialist of the relevant medical specialty who has experience of aviation medicine.

If a working-age pilot suffers from multiple diseases, the procedure becomes more challenging, and aeromedical guidelines and evidence-based medicine offer much less support for risk assessment. An additional challenge will be the need to use several specialists knowledgeable of aviation medicine, and forming a comprehensive picture from their assessments will be difficult.

The procedure will prove extremely challenging, or even impossible to execute, when an elderly pilot has multiple diseases. Aeromedical guidelines and studies carried out about evidence-based medicine do not commonly address elderly pilots; therefore, risk assessment may become extremely difficult because a big picture of age-related additional risks cannot be obtained. Moreover, when a comorbid elderly pilot is treated with several drugs, the results of the treatment will be difficult to verify. Also, the medical specialist may often be less conversant with issues related to elderly pilots compared with his knowledge of working-life pilots since the former cases are less frequent.

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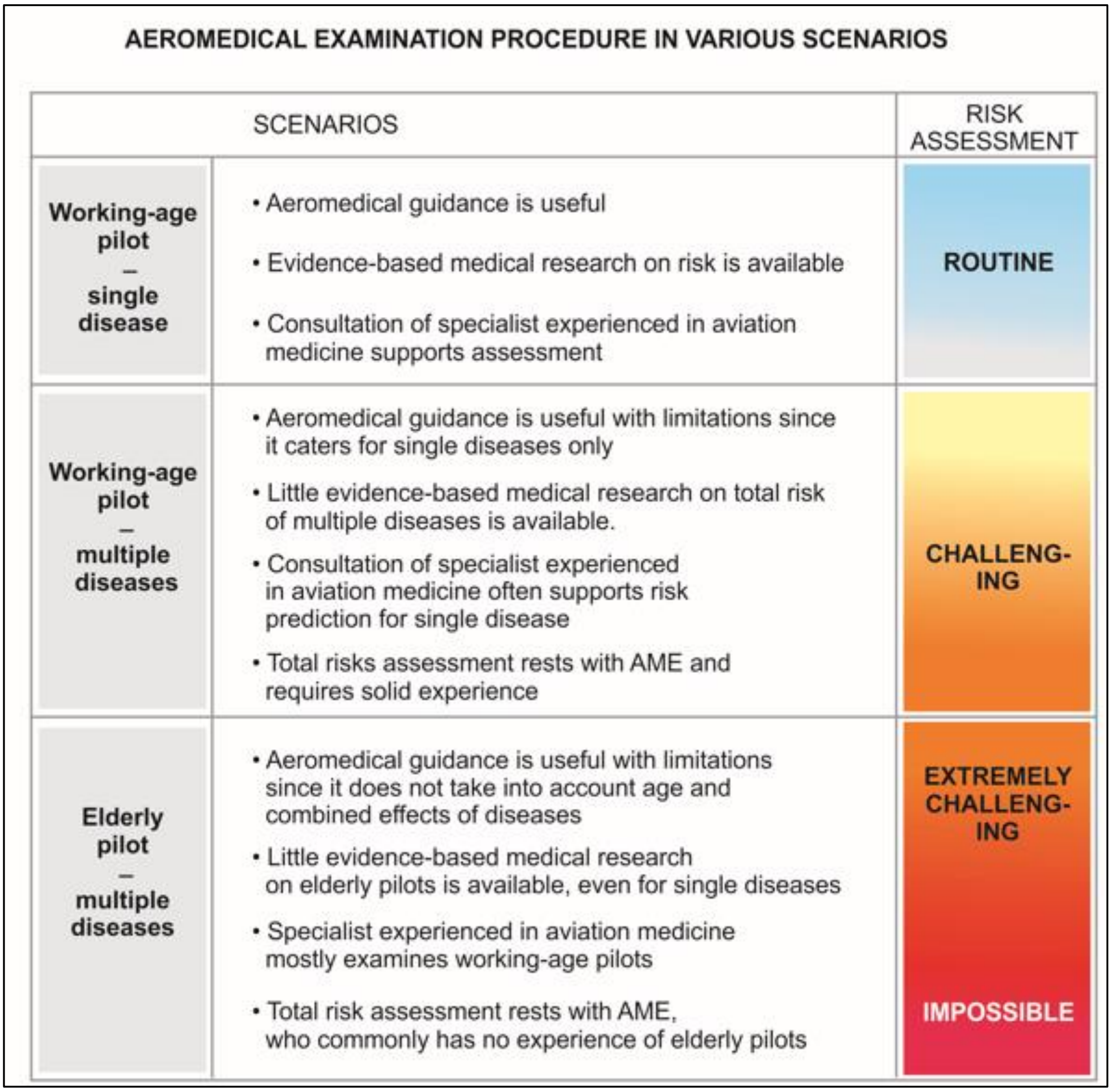
49 Watson, D. B. (2005) Aeromedical decision making and evidence-based medicine risk management paradigm. Aviation, Space and Environmental Medicine. Vol. 76, p. 58-62.

50 ICAO. (2012). Manual of Civil Aviation Medicine. Annex 1. Chapter 6–6.3.2.5.1. Doc 8984 3rd edition. ISBN 978-92-9231-959-5.



AEROMEDICAL EXAMINATION PROCEDURE IN VARIOUS SCENARIOS

SCENARIOS		RISK ASSESSMENT
Working-age pilot – single disease	• Aeromedical guidance is useful • Evidence-based medical research on risk is available • Consultation of specialist experienced in aviation medicine supports assessment	ROUTINE
Working-age pilot – multiple diseases	• Aeromedical guidance is useful with limitations since it caters for single diseases only • Little evidence-based medical research on total risk of multiple diseases is available. • Consultation of specialist experienced in aviation medicine often supports risk prediction for single disease • Total risks assessment rests with AME and requires solid experience	CHALLENG-ING
Elderly pilot – multiple diseases	• Aeromedical guidance is useful with limitations since it does not take into account age and combined effects of diseases • Little evidence-based medical research on elderly pilots is available, even for single diseases • Specialist experienced in aviation medicine mostly examines working-age pilots • Total risk assessment rests with AME, who commonly has no experience of elderly pilots	EXTREMELY CHALLENG-ING IMPOSSIBLE

Figure 12. Aeromedical assessment and challenges in various scenarios. (Photo: SIAF)

Aortic Diseases and Aeromedical Decision-making

The ICAO manual discusses aortic diseases in more detail than the EASA guidance material. The manual explains that in one-sixth of the cases where the pilot has been diagnosed with aortic aneurysm this involves dilation of the aorta in more than one segment. The manual also calls attention to the fact that aortic aneurysm is more common in men aged over 55 than in women in the same age group. Age, coronary artery disease and high blood pressure impair prediction significantly. EASA stresses that diseases in the descending aorta shall always be evaluated by a cardiologist and the licensing authority before granting a class 2 certificate.

A theme issue on aviation medicine in an international publication series on cardiology came out recently. One of the articles[51] discusses aeromedical assessment after aortic cardiovascular surgery. The author emphasizes the importance of close liaison between the

[51] Guettler N., Nicol E. D., d'Arcy J. et al. Non-coronary cardiac surgery and percutaneous cardiology procedure in aircrew Heart 2019:105, p. 70–73.

cardiothoracic surgeon[52], cardiologist and AME during follow-up post-surgery assessments. They also maintain that aortic dissection is incompatible with aircrew duties and should preclude aeromedical certification, and remind that pilots should not be subjected to elevated acceleration forces. The recommendation of having a cardiothoracic surgeon participate in assessment is formulated as follows by an internationally renowned specialist in his review on aortic aneurysms[53]: “Although formally trained in ‘cardiovascular medicine,’ most cardiologists devote their attention to the heart and its coronary arteries.”

2.8.3 Examination of Airspeed Indicator and Altimeter

The airspeed indicator and altimeter were examined at Insta ILS, a maintenance, repair and overhaul provider specialized in aviation systems and special electronics. The purpose of the examination was to determine the serviceability of the instruments during the accident flight and their indications on impact.

Examination of Airspeed Indicator

A visual external inspection showed no signs of removal of the case attachment screws. It is probable that the case had not been removed before, or the case and the screws had been repainted after removal and subsequent reinstallation. The instrument exhibited no significant external damage sustained before or during the accident.

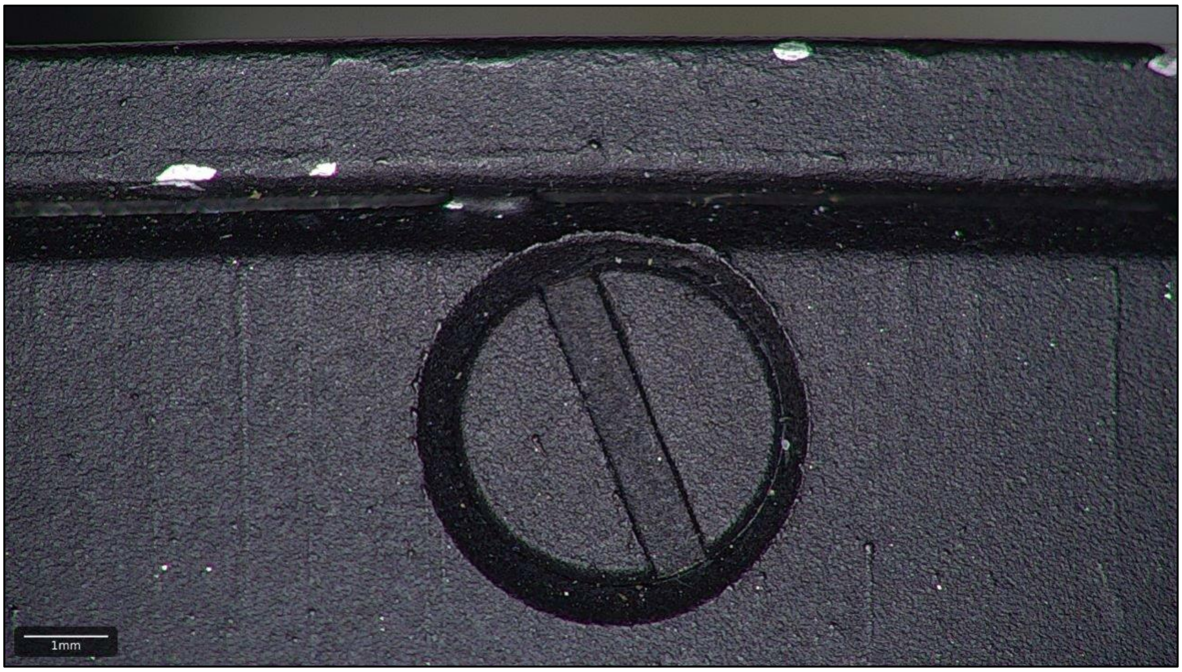


Figure 13. An airspeed indicator case attachment screw and surface finish. (Photo: Insta ILS, usage rights: SIAF)

The instrument was functionally tested before case removal. The test showed that its operation was reasonably normal. The maximum difference between the indicated and actual speed was 5 kt.

No damage incurred by impact forces was found in the internal mechanism. Microscope examination of the instrument face revealed two possible signs of pointer impact and one

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52 A specialist in surgical operations performed in the chest cavity.
53 Isselbacher E. M., Thoracic and abdominal aortic aneurysms. Circulation 2005:111. p. 816–828.

scratch. The impact marks were at 37 and 68 kt, and the scratch at 42 kt position. These imprints are shown in figures 14 and 15.

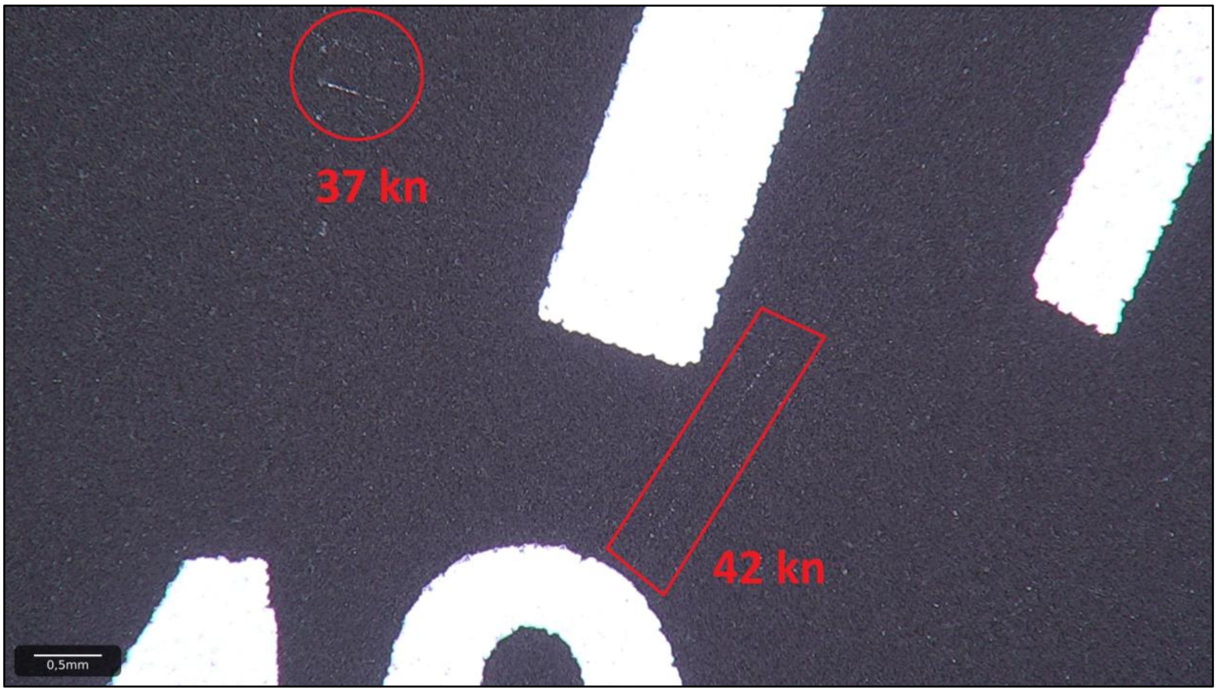

Figure 14. Impact mark and scratch on the airspeed indicator face. (Photo: Insta ILS, usage rights: SIAF)

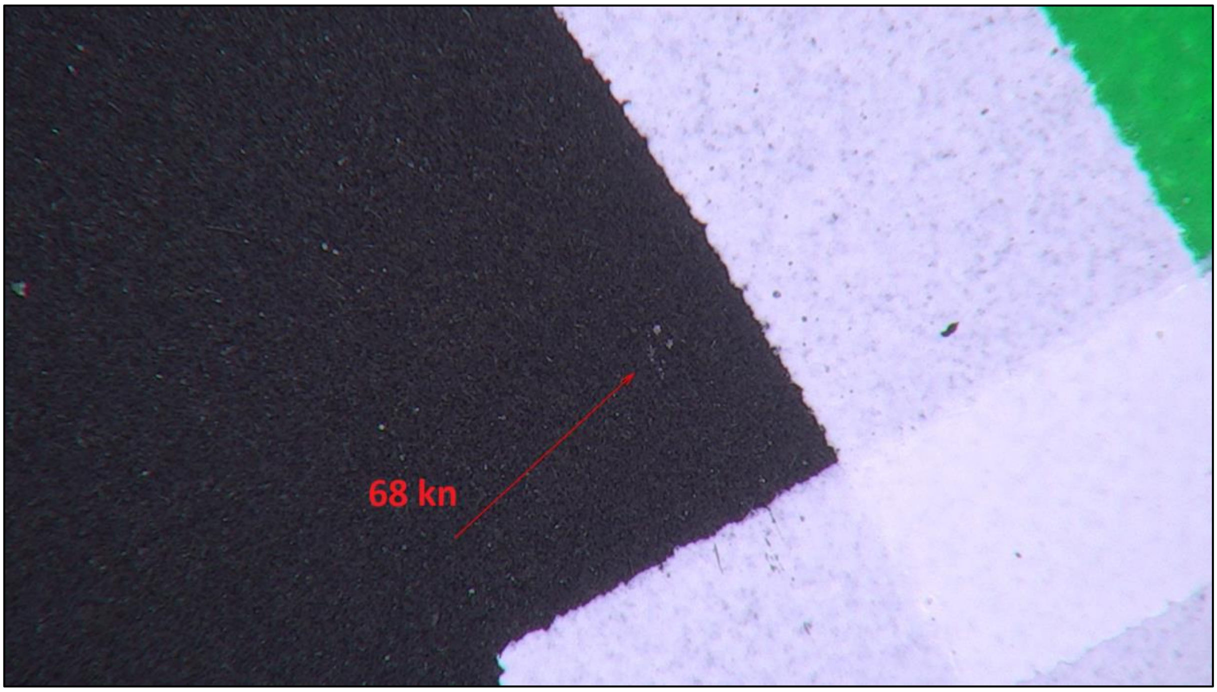

Figure 15. Impact mark on the airspeed indicator face. (Photo: Insta ILS, usage rights: SIAF)

Examination showed that the surface finish of the instrument face is prone to damage, and it is easily damaged by pointer contact. When an impact occurs, the pointer bends toward the face and its tip makes an initial contact. Therefore, the imprints at the pointer tip location were possibly impact-related, while the scratch had probably been produced earlier. The examination indicated that airspeed on impact had in all probability been 37 or 68 kt. It is also possible that the two imprints were created when parts of the airplane struck the ground during the impact sequence.

Examination of Altimeter

Hard sealing paint on the heads of the altimeter case lockscrews was intact. A visual inspection indicated that no maintenance had been carried out on the instrument while installed, or if any maintenance action had been performed, the screw heads had been repainted. Immediately after the impact, the altimeter indicated -2,820 ft at the pressure setting of 1,028 hPa, which indicated damage to the instrument.

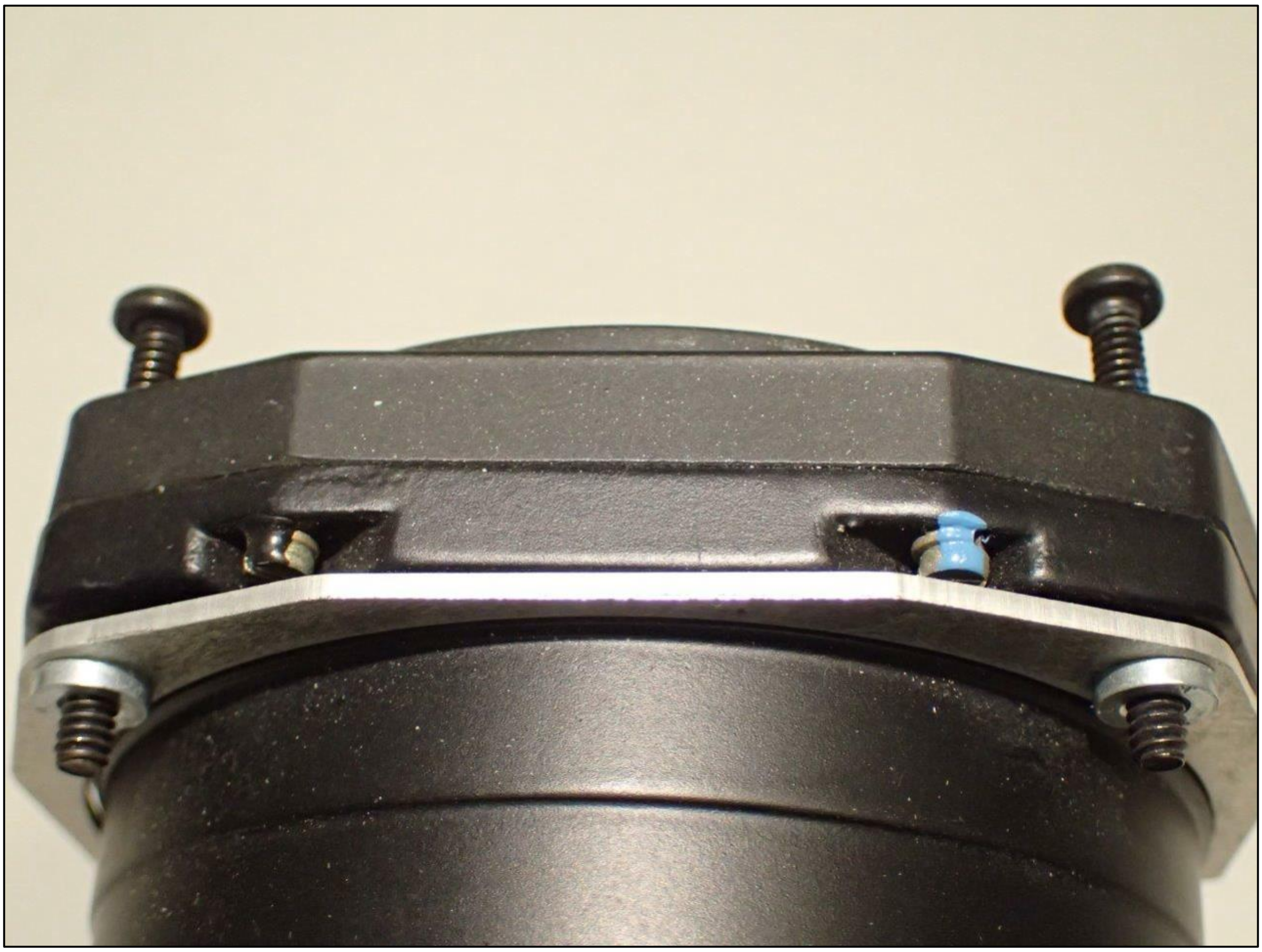

Figure 16. Altimeter case lockscrews. The left-hand and right-hand screws are sealed with black and blue paint, respectively. (Photo: Insta ILS, usage rights: SIAF)

Operation was examined in an altimeter test chamber by lowering the ambient pressure from the prevailing atmospheric pressure to pressure corresponding to 3,500 ft altitude. The instrument responded to pressure changes normally, and pointer movement was free and sensitive.

The instrument face was subjected to microscope examination using the same technique as for the airspeed indicator, and no impact marks were found. When the barometric setting was adjusted to the prevailing pressure, the instrument indicated -3,255 ft.

Figure 17. Altimeter indication after barometric pressure reset. (Photo: Insta ILS, usage rights: SIAF)

Examination revealed damage to the sector gear. The damage supports an assumption that the gear had slipped several teeth of the handstaff pinion, which had resulted in the incorrect indication. When the mechanism was rotated by hand to a position where the damaged section of the gear engaged the pinion, the pointers moved to indicate a value approximately 2,500 ft higher.

The results of the examination and damage to the mechanism suggest that the indicated altitude on impact had been near zero. The instrument had been serviceable before the accident.

3 ANALYSIS

A SIAF-developed format of the AcciMap approach[54] 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.

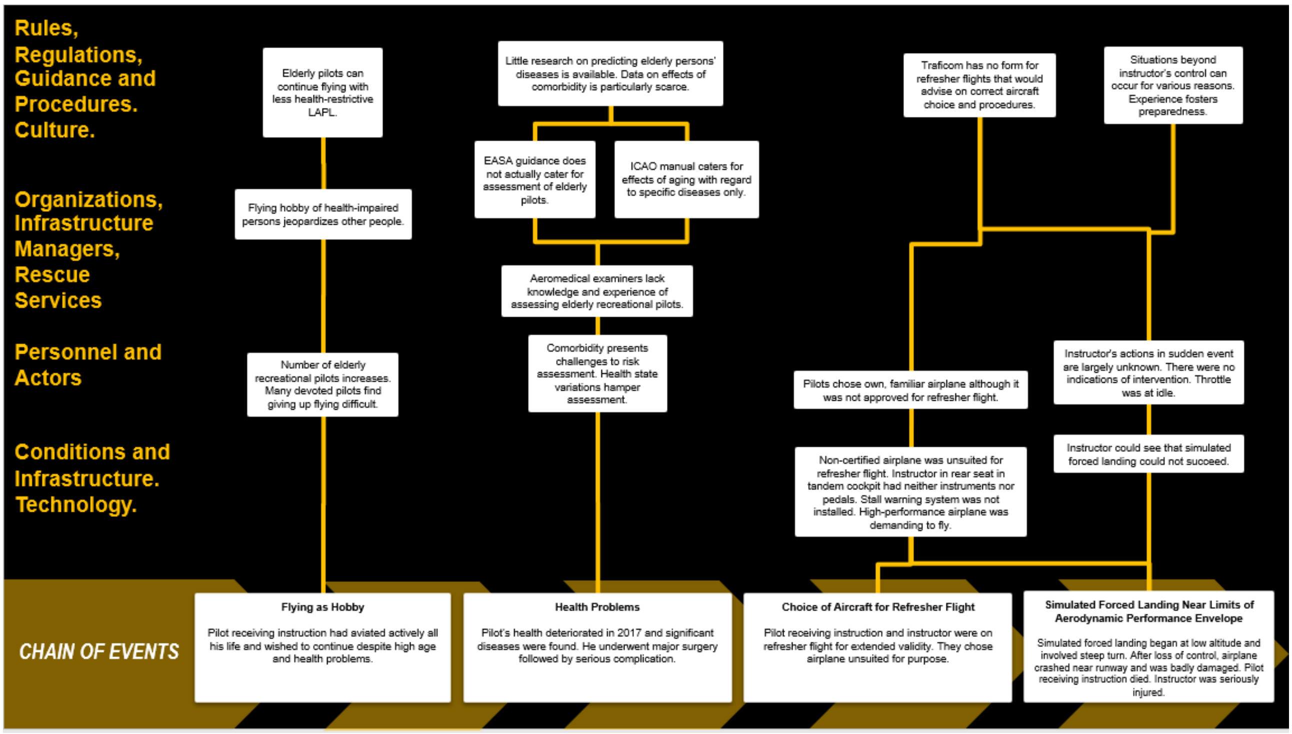

Figure 18. AcciMap diagram, investigation L2021-03. (Photo: SIAF)

3.1 Recreational Flying as Hobby

The pilot receiving instruction had been involved in aviation all his life and was willing to continue recreational flying, even at the age of 78 and despite health issues. Recreational flying is a time-intensive hobby and can turn into an indispensable part of an individual´s life, and therefore many devoted aviators will find it difficult to give up flying. Also, many individuals begin recreational flying during later years of their life, which translates into an increasing number of elderly pilots and more health-related risks.

When persons with an impaired state of health continue flying, they jeopardize the safety of not only themselves but also of outsiders. In cases where a pilot's health has degraded to such an extent that it does not meet the requirements for a class 2 medical certificate, he or she has an option to continue pursuing the hobby under the privileges of a medically less restrictive LAPL and act as pilot-in-command on high-powered single-engine piston airplanes with a maximum certified takeoff mass of 2,000 kg or less.

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

3.2 Health Problems

3.2.1 Health Problems in 2017

In 2017, the pilot receiving instruction underwent major surgery for the treatment of three cardiovascular diseases, one of which was related to the great vessels. After the surgery he was hospitalized for an extended period due to a serious neurological complication, which was probably caused by susceptibility to a heart condition discovered during the operation.

3.2.2 Health Monitoring and Assessment of Incapacitation Risk among Comorbid Elderly Pilots

AMEs and aviation medicine specialist possess markedly less experience of elderly pilots compared to working-age pilots. EASA's guidance material does not take into account the effects of aging on the prediction of diseases. In addition, few evidence-based studies of the prediction of diseases in elderly persons are available. It is particularly difficult to obtain information on the effects of comorbid elderly persons' diseases on prediction, which makes predicting a pilot's functional ability difficult. Recent studies suggest that landing accidents are typical among elderly pilots.

3.2.3 Comorbidity of Pilot Receiving Instruction

Before the surgery, the pilot had significantly fewer diseases that required monitoring, risk assessment and medication than after the surgery, and therefore monitoring and risk assessment had been easier to arrange. The amount of medication and the number of diseases to be monitored increased after the operation. Some of the diseases and medications could be monitored in ambulatory health care, but a significant number necessitated hospital monitoring and regular hospital examinations. The pilot did not have a personal doctor in ambulatory health care, which was one factor in the failure to carry out comprehensive assessments of his health and performance in a documented manner.

3.2.4 Effects of Limited Experience on Incapacitation Risk Assessment of Comorbid Elderly Pilots

AMEs often need to assess incapacitation risks of working-age pilots diagnosed with only one or two diseases, in which case assessment is a relatively straightforward process. A limited number of examinations will be needed, and they can often be done in ambulatory health care facilities. In addition, working-age pilots are commonly under monitoring by aviation occupational health care providers, and a fairly comprehensive picture of their state of health is therefore available.

The pilot receiving instruction was under an elevated comorbidity-induced risk, and an additional incapacitation risk caused by his high age was not fully assessed. This assessment was hampered by the fact that the pilot did not have a personal doctor in ambulatory health system, and some examinations had to be done in specialized health care facilities. Moreover, the AME and the licensing authority had limited experience of assessing the state of health of comorbid pilots. All this led to an annually growing incapacitation risk created by the combination of aging and comorbidity. This went unrecognized, and the validity of the pilot's medical certificate was extended.

3.2.5 Aeromedical Guidance and Aging Comorbid Pilot

Aeromedical guidance is traditionally based on the requirements of military aviation and the professional pilot community. Incapacitation risk is therefore assessed, as a rule, by looking at a single significant disease diagnosed in a working-age pilot. From this premise it can be understood why guidance material has been written to cater essentially for this scenario. EASA's guidance does not really address age-related specific factors in medical assessment. The ICAO manual discusses aging-related issues that may affect the prediction of specific diseases. Aeromedical assessment can also be supported by an evaluation carried out by a specialist who has experience from aviation medicine, even in cases where the pilot under examination has previously been evaluated by a physician in the same medical specialty. In case of the pilot receiving instruction, this was done on two occasions before the surgery of 2017, but not after the surgery.

3.2.6 Research into Comorbidity among Elderly People and Disease Prediction

As a general observation, studies on the prediction and treatment of diseases among elderly people have only become available during the past few years. However, the amount of data is very limited, and information of the prediction concerning elderly comorbid people is particularly hard to come by. There are few aeromedical studies looking at increased age-related incapacitation risk among elderly pilots - and among elderly comorbid pilots in particular. With very limited information available, the assessment of incapacitation risk will be extremely difficult or even impossible.

3.3 Choice of Aircraft for Refresher Flight

The accident airplane was part-owned by the pilot receiving instruction and the instructor and was therefore familiar to both. However, its use for the purpose would have required an advance approval from the competent authority.

The pilot receiving instruction and the instructor were seated in tandem, and the instructor did not have the controls and instruments available for an emergency situation. Therefore, he had only limited possibilities to intervene with the control inputs of the pilot receiving instruction.

Traficom has not issued a report form for LAPL refresher flights. As a result, LAPL refresher flight instructors will need to apply the contents of the existing report forms issued for skill tests and refresher flights for other license types. The refresher flight report forms do not call attention to the need to obtain an approval for the use of amateur-built and experimental aircraft in training.

3.4 Simulated Forced Landing Near Limits of Aerodynamic Performance Envelope

The pilot receiving instruction was at the controls when the airplane was in the traffic circuit, and the instructor monitored his actions from the rear cockpit. The airplane joined the traffic circuit at approximately 1,000 ft AMSL. Because Hyvinkää aerodrome elevation is 430 ft, altitude above the ground level was low. When the airplane initiated the turn toward the threshold, altitude had reduced to 600 m AMSL, and the turn was therefore flown at a very low height. Moreover, when the turn was initiated, the distance between the airplane and the runway centerline was no more than approximately 400 m, which necessitated a steep turn to align the airplane with the runway. Airspeed fell to near stalling speed during the turn. The turn was flown at the limits of the airplane's aerodynamic performance envelope, and due to lack of instruments and a stall warning system the instructor had limited opportunity to notice the development of a serious situation.

The pilot receiving instruction was capable of performing his functions one minute before the impact. He suffered a bout of illness either very close to the ground or upon impact. The event caused sudden incapacitation. If incapacitation had occurred in flight, the instructor would have been faced with a highly demanding situation with extremely limited time for appropriate response and corrective actions.

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. The pilot receiving instruction was 78 years of age. Despite his age, he wanted to continue flying. Over the years he had been diagnosed with a growing number of diseases and his medication had been increased.

   Conclusion: *Assessing the aeromedical fitness of an elderly comorbid person is extremely challenging. The current guidelines do not particularly support an assessment process.*

2. The pilot receiving instruction and the instructor departed on a refresher flight in an airplane that was not fitted with instruments and rudder pedals in the rear cockpit. The airplane was not suitable for the flight.

   Conclusion: *An aircraft that is in training use shall be fitted with controls and indicators appropriate to the training given and operable from both the student's and the instructor's position for normal and emergency procedures. In addition, a specific approval from a competent authority will be required for the use of amateur-built and experimental aircraft in training.*

3. The airplane commenced a simulated forced landing close to the runway centerline at an unusually low altitude, and a steep turn to align the airplane with the runway was necessary. While airspeed dropped, stalling speed increased.

   Conclusion: *A simulated forced landing from a low altitude will easily lead to a situation where the airplane nears the limits of its aerodynamic performance.*

4. The pilot receiving instruction suffered a bout of illness either very close to the ground or upon impact. The event caused sudden incapacitation.

   Conclusion: *Sudden incapacitation of a pilot receiving instruction may result in a situation where the instructor has insufficient time to respond.*

5. Recent studies suggest that landing accidents are typical among elderly pilots.

   Conclusion: *Flight instructors should take into consideration the possible slowing down of the cognitive functions of elderly pilots.*

5 SAFETY RECOMMENDATIONS

5.1 Specific Approval of Amateur-built and Experimental Aircraft

Amateur-built and experimental aircraft used for refresher training shall be fitted with controls and indicators appropriate to the training given. A specific approval from a competent authority will also be required for these aircraft. However, the refresher flight report forms do not call attention to the fact that a specific approval is required for of amateur-built and experimental aircraft.

The Safety Investigation Authority of Finland recommends that

> *The Finnish Transport and Communications Agency Traficom improves the knowledge of general aviation pilots of the requirement for obtaining a specific approval for the training use of amateur-built and experimental aircraft. [2022-S25]*

The refresher flight report form should be updated to indicate, among others, the requirement for obtaining a specific approval for aircraft.

5.2 Training of Aeromedical Examiners in Assessment of Elderly Pilots

The number of elderly recreational pilots has increased. Aging increases incapacitation risks, and accident rates among elderly pilots are rising. Assessing the aeromedical fitness of elderly comorbid pilots is extremely challenging, but aeromedical examiners' experience of assessing these applicants is limited.

The Safety Investigation Authority of Finland recommends that

> *The European Aviation Safety Agency improves aeromedical examiners' knowledge and skills in the assessment of the state of health of elderly comorbid pilots. [2022-S26]*

Means to this end could include setting up a theme workshop and introducing improved training material.

5.3 Updates to Aviation Medicine Guidelines

The current edition of the International Civil Aviation Organization's Manual of Civil Aviation Medicine brings up the impacts of aging only in a few contexts. Research into health-related accidents to elderly pilots is also limited. The assessment of incapacitation risk is therefore particularly challenging.

The Safety Investigation Authority of Finland recommends that

> *The International Civil Aviation Organization updates its Manual of Civil Aviation Medicine to better address age-related factors behind various diseases from an aeromedical point of view. [2022-S27]*

The chapter on risk assessment should call attention to the special features of the risk assessment of elderly comorbid pilots.

5.4 Implemented Measures

After the accident, on February 8, 2022, Traficom issued on its internet pages a bulletin on the training use of amateur-built aircraft. The bulletin reminds that a specific approval will be required for these aircraft. The bulletin also explains the phases of the specific approval process and lists those aircraft that have been granted a specific approval for training use in Finland. Traficom has also added, post-accident, to the refresher training report form[55] an LAPL refresher training option[56]. In addition, a cross-reference to the specific approval requirement will also be added to the form as Annex I.

55 https://www.traficom.fi/fi/liikenne/ilmailu/ilmailun-tarkastuslentajat-ja-kielitaitotarkastajat?toggle=Luokka-%20ja%20tyyppikelpuutusten%20lentokoe-%20%20ja%20tarkastuslentolausunnot

56 https://asiointi.traficom.fi/omatrafi-formservlet-web/lomake/LU3270

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Investigation Material

1) Photographs, diagrams and other material produced during on-site investigation
2) Police photographs and investigation reports
3) Weather information
4) Interviews
5) Secondary surveillance radar data
6) Surveillance video recording from Hyvinkää aerodrome
7) Radio communication recording from Hyvinkää aerodrome
8) Route data from SkyDemon mobile application
9) On-duty fire officer's vehicle camera recording
10) Forensic pathology report
11) Pilots' accident-related medical data
12) Insta ILS report on examination of airspeed indicator and altimeter
13) RV-8 airplane flight manual

SUMMARY OF COMMENTS TO DRAFT FINAL REPORT

The Safety Investigation Authority of Finland requested comments to the draft final report from the Finnish Transport and Communications Agency Traficom, the European Aviation Safety Agency (EASA), the International Civil Aviation Organization (ICAO), the Central Uusimaa Rescue Department and the actors involved. Pursuant to the Safety Investigation Act, no comments given by private individuals are published.

Transport and Communications Agency Traficom gave its backing to the safety recommendation regarding a specific approval for amateur-built and experimental aircraft. The agency proposed amendments and corrections with regard to the regulations and directives mentioned in paragraph 2.7 and revision of terminology related to non-certificated amateur-built aircraft.