Airliner Veering Off the Runway During Landing Roll at Savonlinna Airport on 7 January 2019

L2019-01

SYNOPSIS

Pursuant to section 2 of the Safety Investigation Act (525/2011), the Safety Investigation Authority decided to investigate a runway veer-off of an airliner during the landing roll at Savonlinna airport on 7 January 2019. The purpose of 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.

Special Investigator Timo Naskali was appointed as team leader for the investigation group, accompanied by Airline Pilot Juha-Pekka Keidasto, Airline Pilot Hannu Halonen, Air Safety Investigator Tii-Maria Siitonen (until 3 Dec 2019) and Special Investigator Hannu Hänninen. Jari Kotimäki, Master of Laws, and Tuomas Tuisku, Master of Science (Technology), were appointed as expert members to the investigation. Chief Air Safety Investigator Ismo Aaltonen acted as investigator-in-charge. During his leave of absence, from 1.1.–31.3.2019, Chief Air Safety Investigator Kalle Brusi acted as investigator-in-charge. As of 19 August 2019, Chief Air Safety Investigator Janne Kotiranta was the investigator-in-charge.

The Latvian Transport Accident and Incident Investigation Bureau (TAAIB), the UK Air Accidents Investigation Branch (AAIB) and the Swedish Accident Investigation Authority (SHK) designated their accredited representatives to the investigation. The European Union Aviation Safety Agency (EASA) designated a technical adviser to the investigation. The flight recorders were downloaded at the laboratory of the UK Air Accidents Investigation Branch (AAIB).

Safety investigation examines the course of events, the causes and consequences, the search and rescue actions as well as the 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 also examines possible shortcomings in the authorities' provisions and orders regarding safety.

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

Prior to the completion of the investigation report, 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. A summary of the comments is included in the investigation report. However, under the Safety Investigation Act, no comments given by private individuals may be included in the investigation report.

The investigation report was translated into English by R&J Language Service.

The investigation report, including its summary, is published on the internet page of the Safety Investigation Authority at www.sia.fi.

Investigation: L2019-01
Investigation report 14/2019
ISBN: 978-951-836-560-3 (PDF)
Helsinki, 10 Dec 2019

Cover photo: Police of Finland

TABLE OF CONTENTS

1 EVENTS

1.1 Sequence of events

The positioning flight MTL650P with a Saab 340B aircraft departed Riga for Savonlinna on Monday morning, 7 January 2019 at 03:45[1]. Latvian A/S RAF-AVIA was the air operator. The estimated duration of the flight was 1 h 43 min. The flight crew comprised the captain (Pilot Flying, PF) and the co-pilot (Pilot Not Flying, PNF). Also, a ground engineer was on board. The purpose was to ferry the aircraft to Savonlinna as the airline had not flown scheduled flights between Savonlinna and Helsinki-Vantaa during the Christmas and New Year holidays. Flight MTL650 from Savonlinna to Helsinki was scheduled to depart at 06:00.

The maintenance shift at Savonlinna airport began at 03:00. At the beginning of their shift they cleared snow from the front of the airport and the apron. Runway clearance with two runway maintenance vehicles began at 03:50. According to the maintenance personnel's observations the runway was free of ice but there was packed snow at the edges. New snow kept falling throughout the runway clearance process. Once the clearance was completed, a friction measuring vehicle entered the runway at 05:02. Right from the beginning of the friction measuring the driver determined that, according to the measured values, the runway needed to be cleared some more.

According to the captain's account the flight progressed faster than anticipated, owing to favourable wind conditions. He decided to reduce speed so as to arrive when the airport opened. As per the NOTAM[2] bulletin, Savonlinna airport was scheduled to open at 05:40. The AFIS officer informed the Area Traffic Control Centre (ATCC) that the AFIS would open earlier because the flight was estimated to arrive in Savonlinna at 05:36.

The airport maintenance supervisor decided to clear the runway again and the maintenance vehicles entered the runway at 05:05. Soon after this the AFIS officer announced to air traffic that the AFIS was open. The flight crew of the positioning flight contacted Savonlinna AFIS for the first time at 05:07. The AFIS officer told them that there was no other traffic in the vicinity of the airport and reported the runway in use as well as the prevailing weather conditions. He also told them that runway clearance was ongoing and that he would inform them once the work was completed. At 05:31 the AFIS officer reported that the positioning flight should enter the holding pattern VALGU for a least one pattern before they could expect any further information.

The runway maintenance vehicles exited the runway at 05:34 and the runway friction measuring vehicle entered the runway. The friction measuring device displayed the average friction for the different sections[3] of the runway: A:0.29 B:0.22 and C:0.23, in which A corresponds to "medium to poor" and B and C to "poor" estimated runway friction.[4] The driver reported the results to the AFIS officer at 05:42. According to the inspection, the cleared width of the runway was 37 metres, the estimated runway friction for each third of the runway was poor[5], and there was a 4 mm layer of dry snow covering the entire cleared area. The critical snowbanks were 40 cm high and were four metres inside of the runway edge lights. Friction

---

1 All times in the investigation report are in Finnish Daylight Saving Time (UTC+2h).

2 NOTAM, Notice to Airmen.

3 Section A refers to the first third viewed from the threshold of the lower-numbered runway.

4 On the friction measuring device the last measurement was saved in the same file as the previous measurement, which began at 05:04 but had been discontinued. This being the case, the earlier measured section could reduce the calculated average of the section that had been measured before.

5 The person inspecting the runway may, using his judgement, determine the estimated runway friction to be one level worse than the measured values.

was also poor on the taxiway and the apron. The AFIS officer reported the runway conditions to the pilots of the positioning flight.

At 05:43 the captain of the positioning flight reported being established on the ILS localiser. The AFIS officer said that wind was 220 degrees at five knots and that runway 12 was free. The pilots used 20 degrees flap during the approach. According to the flight data recorder the approach was stable until the threshold. During the final approach the pilots saw the approach and runway lights well. Owing to the icing conditions they intended to use an airspeed which was 10 knots higher than the Aircraft Operations Manual's prescribed minimum approach speed. At the threshold their speed was 126 knots, while the approach's target speed was 120 knots.

However, the airspeed at the touchdown zone markings was 123 knots. Contrasting from normal, the aircraft floated close to the surface for 6–7 seconds before touching down. The flight crew did not consider aborting the landing, i.e. going around. Following the level flight the captain steered the aircraft toward the ground at a fairly high vertical speed. A person working at the airport saw that the aircraft was still airborne when passing taxiway A and that it very rapidly lost altitude after it. The aircraft touched down at 05:50, approximately 307 metres after the optimal touchdown point, on the left side of the runway. At touchdown the airspeed was 109 knots, which corresponds to the 110 knot target speed.

Judging by the marks on the snow the left main landing gear hit the left snowbank on the uncleared area. The nose gear touched the runway, following which the left main gear became airborne for a moment and the right main gear touched the ground. The left main gear touched down again. After having travelled approximately 100 metres from the first touchdown point the aircraft's nose gear and the right main landing gear moved outside the cleared runway area. The aircraft was tracking towards the left, away from the direction of the runway. The pilots tried to turn the aircraft back towards the runway centreline. According to the markings the aircraft began to turn and started to skid sideways outside the cleared area of the runway. When the left main gear hit a high snowbank outside the runway, the aircraft began to turn more sharply to the left. The left engine stalled when snow entered its air intake. The pilots did not deploy reverse thrust. The right main gear knocked one runway edge light over. The aircraft stopped in half-metre deep snow outside the runway, at a 110 degree angle in relation to runway 12.

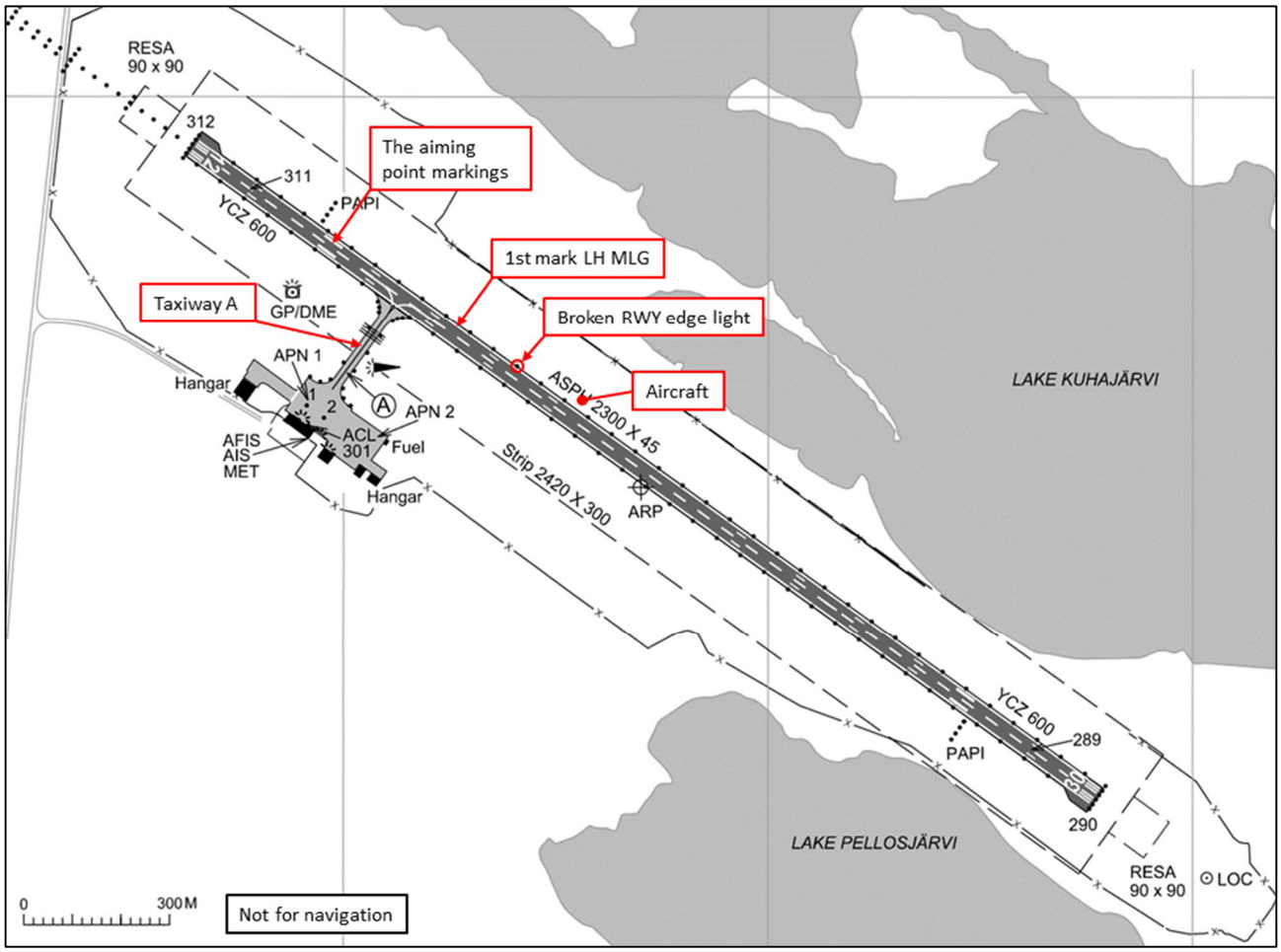

Figure 1. Stages of the landing on the runway. (Base map: ©ANS Finland Oy; markings and positioning: SIAF)

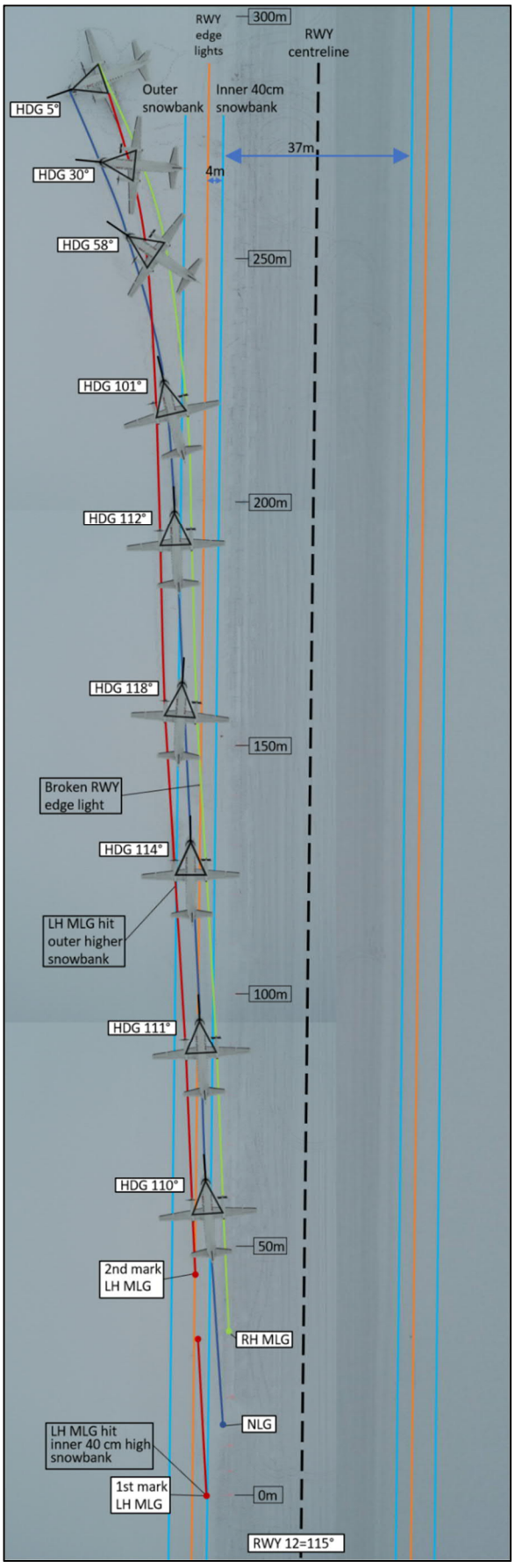

Figure 2. The heading of the aircraft during the landing roll according to the markings left by the tyres. (Base images: Police of Finland; drawings and markings: SIAF)

1.2 Alerts and rescue operations

The maintenance supervisor, who was watching the landing, saw a thick plume of snow coming from the left side of the runway. Hence, he asked the AFIS officer about the situation.

At 05:50 the captain of the positioning flight reported on the radio to the Savonlinna AFIS officer that they were outside the runway. The AFIS officer acknowledged this and reported an aircraft accident on the radio to the airport rescue service[6]. The rescue service replied that they were on their way to the site. The AFIS officer asked for more details from the captains, and the captain replied that they required assistance to exit the snowbank. The AFIS officer replied that he would organise it.

At 05:52 the AFIS officer told the rescue personnel on the radio that he would make the normal emergency alerts and that the fire department was not required at this stage. He called the Emergency Response Centre (ERC) and at the same time permitted an airport rescue vehicle to enter the runway. During the emergency call the AFIS officer reported the accident and said that there were no passengers on board. He said that the captain had told him that the aircraft had veered off the runway a little and that the fire department was not needed. The ERC operator double-checked that no additional assistance was required. The AFIS officer promised to let the ERC know if he received any more information. The ERC operator did not deploy any rescue service units, nor did she report the occurrence to the Savonlinna region divisional (fire) officer on duty.

At 05:53 the AFIS officer permitted another airport rescue vehicle to enter the runway. He also reported the occurrence to the Aeronautical Rescue Co-ordination Centre (ARCC). The ARCC asked whether the aircraft could exit the snowbank on its own. The AFIS officer replied that it would require assistance. He also said that the occurrence did not cause any other damage and that the rescue units were already on their way to the site. The ARCC then stated that they would log this in their journal.

The rescue personnel that arrived at the aircraft provided more information to the AFIS officer. They said that the aircraft was deep in the snow, upright on its landing gear approximately 10–15 metres outside the edge of the runway, and that the cabin door was open. At 05:54 the AFIS officer reported the occurrence to the airport manager. Following this, the AFIS officer contacted Lento P3[7], who said that everything at the occurrence site was OK and that the flight crew only requested towing.

At 05:58 the AFIS officer called the ARCC again and reported that the accident did not result in any injuries to persons and that the aircraft only required towing assistance. The AFIS officer and the ARCC officer on duty agreed on the manner of reporting the occurrence to Safety Investigation Authority Finland. The AFIS officer said that he had already reported the occurrence to the ERC and that there was no need for the regional rescue department to come to the site. Moreover, the AFIS officer said that he would close the runway.

The ensuing communication stated that the aircraft was deep in the snow and that the situation would probably last several hours. At 06:13 the AFIS officer stated that the situation was over, but the runway would remain closed. From then on the radiocommunication centred on follow-on arrangements. A police patrol was called to assist in investigating the site.

---

6 In this case rescue service refers to the airport maintenance service personnel on duty.

7 During an alert the maintenance supervisor assumes the role of airport rescue coordinator Lento P3.

Following the investigation of the site, snow removal and repairing the nose wheel damage the aircraft was ready to be towed. At approximately 20:00 it was moved to the hangar used by the airline.

1.3 Consequences

The accident did not result in any injuries to persons.

1.3.1 Damage to aircraft

The accident caused considerable damage to the aircraft. Both of the aircraft's propellers were damaged: among other things, the damage included fractures, delamination, and some broken-off propeller tips. The nose wheel's right tyre came off its rim. The nose wheel's landing light wiring and control wiring sheared off. The landing light casings situated on both wing roots were broken and the landing lights were damaged from ingesting the snow. There was a 60 cm x 45 cm x 2.5 cm dent on the right front fuselage skin panel. Additionally, dents, cracks and paint damage were found around the fuselage, on skin panels and parts. Much of the damage was caused when the aircraft ran into the packed snowbank, which the propellers also hit. The propellers flung snow and ice clumps onto the fuselage. The right main landing gear's left tyre tread was damaged when it hit the runway edge light. Snow was packed inside the left engine intake and stalled the engine. The cabin was undamaged.

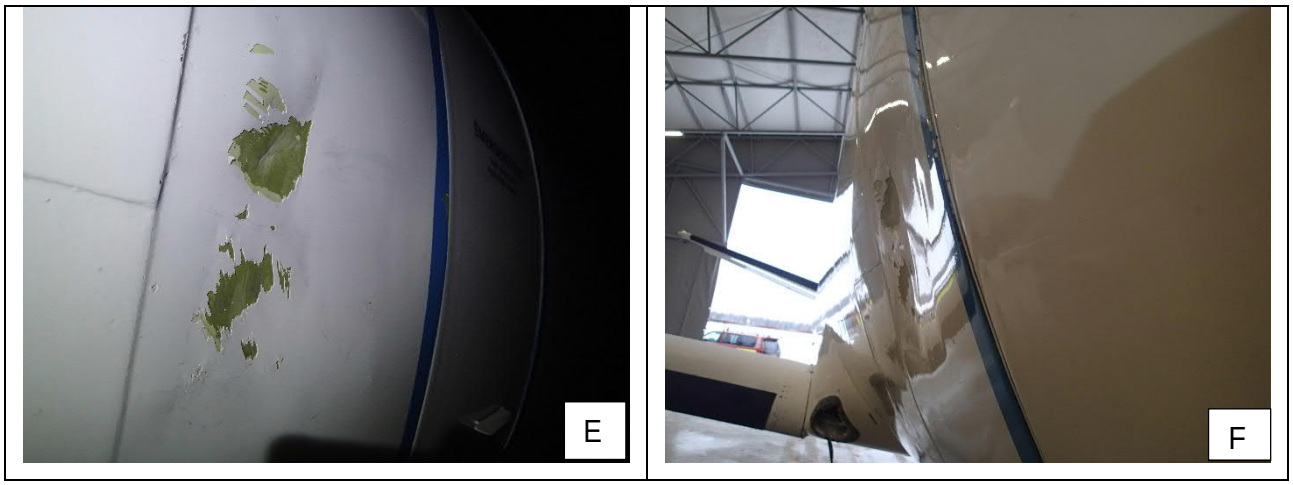

Figure 3. A Nose landing gear, B Damage to the landing lights at the wing root, C-D Damage to propeller blades, and E-F Damage to the right side of the aircraft. (Photos: SIAF)

1.3.2 Damage to airport and indirect consequences

The right main landing gear broke one runway edge light on the left side of the runway. Airport maintenance replaced the light fixture.

Figure 4. The broken runway edge light. (Photos: SIAF)

Savonlinna runway remained closed until 21:44 in the evening of the accident day. The aircraft was originally scheduled to fly from Savonlinna to Helsinki, departing at 06:00. When the flight was cancelled the carrier arranged taxi transportation for the passengers. Also, the following three days' flights were cancelled and the carrier arranged alternative modes of transport for the passengers. Following the accident the carrier temporarily continued operations by using Budapest Aircraft Service, their other subcontractor. RAF-AVIA resumed operations as a subcontractor on the route in the beginning of March 2019 with an ATR airliner.

2 BACKGROUND INFORMATION

2.1 Environment, equipment and systems

2.1.1 Savonlinna airport EFSA

Savonlinna airport is situated[8] 15 km to the north of the city centre. In 2018, the airport handled approximately 11 000 passengers and 463 landings. No cargo flights are flown from Savonlinna. The operational hours of the airport and the times when the AFIS officer is present are published through NOTAM bulletin.

The magnetic bearings of runways 12/30 are 115 degrees and 295 degrees, respectively. The runway is 2 300 m long and 45 m wide. ILS[9], LOC[10] and RNAV[11] (GNSS[12]) instrument approach systems are published for runway 12, the occurrence runway. ANS Finland conducted a calibration flight for the ISL system on 15 November 2018. Runway 30 only has a RNAV (GNSS) approach system. Runway 12 has PAPI[13] lights and an approach lighting system as well as runway edge lights, but no runway centreline lights.

Figure 5. Savonlinna airport EFSA (Photo: Orthophoto©National Land Survey of Finland 1/2019)

8 The Aerodrome Reference Point (ARP) coordinates are 615634N 0285642E. Aerodrome elevation is 312 m.
9 Instrument Landing System.
10 Localizer.
11 Area navigation.
12 Global Navigation Satellite System.
13 Precision Approach Path Indicator.

2.1.2 Aircraft information

The occurrence aircraft is a Saab 340B airliner, intended for short and medium-distance routes. It has two GE CT7-9B turboprop engines. Its registration is YL-RAF, serial number 340B-228 and the year of manufacture is 1991.

The aircraft has a 2+1 person crew and it can carry 33–36 passengers, depending on cabin configuration. The airline uses this aircraft type for cargo and passenger flights. The length of the aircraft is 19.73 m, wingspan 21.44 m, main landing gear track width is 6.71 m and the maximum take-off weight is 13 155 kg. On the occurrence day's flight the take-off speeds were calculated to correspond to the weight of 11 107 kg.

Figure 6. Saab 340B (YL-RAF) at the accident site. (Photo: Police of Finland)

2.2 Conditions

2.2.1 Meteorological information

The prevailing weather at the time of the occurrence matched the weather forecast. The meteorological conditions were good enough for an ILS approach and landing.

According to the Finnish Meteorological Institute's weather data, a snow front passed Savonlinna from the west to the east during the morning of the occurrence day. Snow, which started at approximately 04:00, was weak but it intensified prior to the landing. At the time of the occurrence wind was at 210–220 degrees, 4–5 knots (2–2.5 m/s) gusting to 8–10 knots (4–5 m/s). Visibility varied between 1 900 and 2 400 metres. Cloud base was at 500–600 feet (150–180 metres). Cloud cover was 5–7/8.

Savonlinna METAR[14], half an hour before the occurrence (03.20 UTC) and at the time of the occurrence (03.50 UTC):

EFSA 070320Z 21004KT 180V260 3000 -SN BKN006 OVC017 M02/M02 Q1011
EFSA 070350Z 22005KT 170V260 2500 SN BKN005 OVC015 M02/M02 Q1010

According to the general area forecast (GAFOR), in addition to the snow, there would be freezing rain or drizzle in the area during the morning and before noon. The Terminal Area Forecast (TAF) published at 04:25: From 05:00–14:00 wind 250 degrees at 9 knots (4–5 m/s), visibility 5 000 metres with light snow, and cloud base at 500 feet (150 metres). At times from 05:00–11:00 visibility 1 500 metres with light freezing drizzle and cloud base at 300 feet

[14] Observational weather data

(100 metres). The weather was forecasted to improve from 11:00–13:00 so that visibility would be over 10 kilometres and cloud base at 1 500 feet (500 metres).

EFSA 070225Z 0703/0712 25009KT 5000 SN OVC005 TEMPO 0703/0709 1500 FZDZ BKN003 BECMG 0709/0711 9999 BKN015=

2.2.2 Conditions at landing

Following the Christmas break at the end of the previous week, airport maintenance had cleared, among other things, the runway edge lighting area and ploughed the outer snowbank farther from the runway. On Monday, the morning of the occurrence day, maintenance personnel started runway clearance at approximately 03:50. It was snowing during the runway clearance.

According to the maintenance personnel's observations the runway was free of ice. However, there was packed snow at the edges. The runway was cleared twice to achieve better runway friction. During the final clearance flight MTL650P arrived at the terminal area and joined the holding pattern in accordance with the AFIS officer's communication. When runway friction measuring ended at 05:42, the cleared width of the runway was 37 metres, the estimated runway friction for each third of the runway was poor, and there was a 4 mm layer of dry snow covering the entire cleared area. The critical snowbanks were 40 cm high and four metres inside of the runway edge lights. The snowbanks did not block out the runway edge lights. The AFIS officer communicated this runway information to the pilots of MTL650P. Normal winter conditions prevailed at the airport.

Runway friction was measured again at 07:52, after the occurrence. This was done in accordance with instructions without any additional runway maintenance action. At the time of the occurrence, and following it, it had been snowing. At the time of measuring the snow layer on the runway was estimated to be 8 mm. This is why the estimated runway friction had probably degraded from the time when the aircraft landed. The measured friction data averaged at A:0.31 B:0.31 ja C:0.30. The estimated runway friction was medium to poor for each third of the runway.

The minimum required cleared width of the runway for a Saab 340 aircraft is 30 m[15]. While poor estimated runway friction is permitted, the commander of the aircraft must ensure that wind conditions make it possible to carry out a safe landing.

2.2.3 Possible sensory illusions during the approach and landing

Sideways blowing snow may cause sensory illusions for pilots. This has been addressed in many books[16] on aviation physiology, and aircraft manufacturers' manuals also warn of the phenomenon. When snow is blowing sideways, a pilot may see an illusion when approaching the runway where the aircraft's track is deviating from the intended track or the runway bearing. The illusion is stronger at nighttime when the aircraft's landing lights are on.

For example, if the pilot makes a control input that causes the aircraft to level out over the runway at a more gradual approach slope, touchdown occurs farther down the runway. If there are no runway centreline lights the pilot may get a sensory illusion of sideways motion. Dimming the runway edge lights only further intensifies the phenomenon.

---

15 ICAO (2016) Aerodrome Design Manual. Part 1: Runways. https://store.icao.int/aerodrome-design-manual-runways-3rd-edition-2006-doc-9157-part-1-english-printed.html. Date viewed 16.7.2019.

16 Hawkings, F. H. (1987) Human Factors in Flight. Aldershot: Gower Publishing Company.

When the illusion occurs the pilot, in sideways blowing snow, experiences a sideways motion of the aircraft which, in reality, is not happening. The snowflakes illuminated by the landing lights take the pilot's attention away from the runway edge lights. In such a case there is the danger of the pilot compensating for the illusion by making an unnecessary corrective control input. The control input may result in touching down at the side of the runway.

The Aircraft Operations Manual[17] states that there are no absolute rules for controlling the situation. The manual recommends that pilots recognise the situations in which sideways blowing snow or rain may generate sensory illusions. Pilots are also recommended to avoid using taxiing lights and, when possible, to also turn off the landing lights. Eyes must look straight ahead during touchdown and the landing roll. The aircraft is kept in the correct position with the help of the runway lights.

According to the captain, the landing and taxiing lights were on during the final approach and landing. He felt that the aircraft's landing lights are too dim.

2.3 Personnel, organisations and safety management

2.3.1 Involved persons

The captain of flight MTL650P had the required class and type-ratings and a valid medical certification. He was 61 years old and from 1982 his total flight experience amounted to approximately 20 000 hours, of which 746 were on the Saab 340 type. According to his account he had ample experience in winter flight conditions. He had to wear eyeglasses when flying.

Already in the 1990s the captain had flown on the Saab 340 and as a pilot for RAF-AVIA since June 2017. His annual flight hours at RAF-AVI amounted to approximately 200 hours. Prior to his latest Saab 340 type course he had been flying the Airbus A320 for approximately ten years.

On the occurrence day the captain had woken up at approximately 02:00 in the morning. He had slept 3–4 hours before waking up. As per his account he did not feel tired before or during the flight.

The co-pilot of flight MTL650P had the required class and type-ratings and a valid medical certification. He was 34 years old and his total flight experience was 1 057 hours, of which 837 were on the Saab 340 type. He had been working for RAF-AVIA since August 2017. In 2018 he had amassed 374 flight hours on RAF-AVIA. Prior to the occurrence flight he had been on holiday for three weeks.

The AFIS officer was 45 years old. He had a valid licence and operational ratings as well as a valid medical certification.

Investigation of the flight crew's observations, decision-making and multi-crew cooperation remained insufficient because the cockpit voice recordings were not available. Nevertheless, it is possible to evaluate the flight crew's action and its preconditions on the basis of prior research data and the information gained from the interviews.

During landing pilots have to process great amounts of information which they observe from different sources, both from inside and outside the cockpit. While all observations must be rapidly processed, it is impossible to know beforehand how important a single piece of information will turn out to be. Pilots estimate and determine their position in the airspace in relation to the terrain and objects within it. They actively collect information on potential

[17] SAAB 340B Aircraft Operations Manual, Dec 01/17.

threats and generate situational awareness from different variables associated with the landing. Standard operating procedures used in the cockpit will support the pilots in creating situational awareness and in controlling the situation.[18]

Small deviations or mistakes made by pilots during landing, while alone not critical, can become significant when combined. During the entire approach and landing the pilots must evaluate the impacts of their actions on the development of the situation[19]. Situational awareness is updated during the landing in all of its phases.

If the pilots realise that their approach to the runway is too high, they must take rapid decisions regarding continuing or aborting the approach. Schedule pressures, for example, may also impact their decision. Also, the pilots' alertness affects the manner in which the pilots are able to complete the different phases of landing. While experience does help in recognising the situation, it may also prejudice critical self-assessment.

Having been awake since the early morning hours the pilots were no longer as alert as possible at the time of the occurrence. Research shows that ageing makes it more difficult to cope with staying awake and to manage changes in circadian (24-hour) rhythms. Staying awake may also impact night vision, especially. It was dark and snowing at the time of the accident. The falling snow visible in the beam of landing lights also partly made it more difficult to observe the runway. During the landing there was also a light crosswind. The pilots knew that they did not have much time before the next departure. Together, these factors increased the pilots' cognitive stress during the landing, which was already challenging in itself.

2.3.2 Airline information

RAF-AVIA A/S is a Latvian airline, founded in 1990. The airline's home is in Riga and it is an air operator for cargo and passengers flights. It provides scheduled and chartered air services in Europe. It also maintains and repairs other air operators' aircraft.

At the time of the occurrence the company's fleet comprised two Antonov AN-26B, one Saab 340A, two Saab 340B as well as one ATR 42 and one ATR 72 aircraft. The Latvian Civil Aviation Agency issued the company an Air Operator Certificate (AOC) and an EASA Part-145 approval certificate for maintenance.

The company's occurrence report information was available at the Latvian Civil Aviation Agency. In 2016 there were five deviations concerning the airline, in 2017 five, and in 2018 nine deviations, five of which were reported in March 2018. Since March 2018 there have been personnel changes in the company, following which fewer deviations have been reported.

The Latvian Civil Aviation Agency's compilation did not include the serious incident which occurred in Sweden on 9 October 2018, which was when the airline's ATR-72-202 veered off to the side of the runway during the landing roll at Trollhättan/Vänersborg airport and knocked over one runway light fixture. The airline did not file a deviation report. Rather, the occurrence was later detected from the damage that had been done to runway fixtures and from markings on the runway. The Swedish Accident Investigation Authority (Statens haverikommission SHK) investigated the occurrence. The findings of the investigation are presented in chapter 2.8.1 of this report.

---

[18] Sarter, N. B. & Woods, D. D. (1991) Situation Awareness: A Critical but Ill-Defined Phenomenon. The International Journal of Aviation Psychology, 1(1): 45-57.

[19] Weick, K. (1988) Enacted Sensemaking in Crisis Situations. Journal of Management Studies, 5(4): 305-317.

Within the period 2/2018–10/2018 the Finnish aviation authority entered three deviations concerning the airline and one deviation concerning Sprint Air, their subcontractor, into the European ECCAIRS[20] database. The airline had entered one accident and incident report concerning a deviation, and it was also recorded in the Latvian Civil Aviation Agency's database. According to the airline, the company files 3–4 reports each month at the Latvian CAA. In his interview the captain said that he had filed three occurrence reports within the past year.

Investigations into the airline's prior incidents are addressed in section 2.8.1 of this investigation report. The most serious incident occurred on 14 February 2012 in the vicinity of Mariehamn airport where the company's airliner nearly collided with the terrain.

There have been shortcomings in the airline's flight safety, which its incidents and the observations of the Latvian Civil Aviation Agency indicate. According to the Latvian CAA the greatest threats to RAF-AVIA's flight safety include: 1) shortcomings in pilot skills and decision-making, 2) shortcomings in crew resource management (CRM), as well as insufficient support by the airline's management and shortcomings in supportive procedures regarding flight operations.

The average age of the airline's captains was nearly 60 years and that of co-pilots approximately 40 years. Captains would accrue approximately 200 annual flight hours on average. Flights, for the most part, last 1–1.5 hours. Normally, airline pilots fly approximately 700–900 hours each year. The number of flight hours and landings has an effect on the pilots' flight proficiency. The little amount of work combined with their salary level has caused personnel turnover. The average age of captains has risen as younger captains have sought employment at other airlines. The interviews revealed that when the company moved from four-pilot flight crews (AN-26) to two-pilot crews it caused readjustment problems for the pilots.

The application of the airline's safety management system exhibits shortcomings. Significant shortcomings are associated with occurrence reporting, risk management and unclear responsibilities in safety management tasks. Not all of the safety management postholders have completed an international level safety management course.

The airline's custom has been to not file occurrence reports at all regarding deviations. This can be seen from the Latvian safety management authorities' audit reports and statements as well as from the observations of Safety Investigation Authority Finland. The Latvian CAA audit reports of 3 August 2018 and 18 October 2018 state that the airline's "reporting culture is not sufficient, so as to be effective". On the basis of contacts with the Latvian CAA the airline's inadequate reporting culture originates from the time when Latvia was part of the Soviet Union. In the society which preceded Latvia's independence pilots would often avoid occurrence reporting because they could have been punished for doing so. Even though punishment is no longer a part of the airline's procedures, it has been challenging to mitigate the fears of especially the older pilots.

The company's action in reporting does not comply with the principles of the safety management system manual. According to the manual "RAF-AVIA will provide all the necessary resources to run an aggressive Safety Management System which will encourage reporting any trends that effect or could affect the company safety…It is always the responsibility of every employee to report all issues that could affect safety".

On the basis of the interview with the airline's safety compliance manager the airline files 20–25 internal safety deviation reports each month. When compared with the company's monthly

[20] European Co-ordination centre for Accident and Incident Reporting Systems.

flight hours this number seems high. The airline's monthly flight hours have remained low. For example, in March 2019 the company flew altogether 275 hours.

Occurrence reports are first sent to the safety compliance manager, who then draws up a separate report and sends it to the accountable postholders. Hence, the safety management postholders, the accountable manager included, get the information on deviations late. The nominated postholders mentioned in the Air Operator Certificate (AOC) should receive the occurrence reports without delay so as to be aware of them and to take corrective action.

The airline does not make a lessons-learned compilation for the company's personnel regarding internally reported deviations. Correspondingly, the company only rarely reports deviations to the Latvian CAA.

In contrast, there are no significant shortcomings in the formal development or documentation of the airline's safety management system. The airline's safety management manual and the Operations Manual (OM-A) provide instructions on how to file occurrence reports. For a small airline, these instructions are comprehensive, detailed and extensive. They instruct captains to immediately report any observed dangers to air traffic control and of incidents that occurred to the aircraft. The instructions also advise personnel to report deviations within the airline's own organisation using the company's internal reporting systems. The OM-A advises that, working together with the company's safety compliance manager and the flight operations manager, reports be made within 72 hours of the occurrence to the Latvian CAA regarding accidents, serious incidents and incidents. All crew members are liable for reporting. According to the instructions, company personnel may independently file an ECCAIRS flight safety report, albeit the company's safety department should be contacted first.

The OM-A includes reporting templates for different types of incidents and deviations, including a template for observed fatigue. Different types of deviations have also been categorised and listed to assist the reporting. The manual also provides contact information for the company's internal occurrence reporting as well as the authorities' contact information and web links. The handling process for the reported deviations is also described in the OM-A. The instructions say that people who report deviations will receive feedback and information regarding the progress of the matter.

The airline has regularly organised internal safety meetings. The company says that the Safety Action Group (SAG) meets once a week. Correspondingly, the Safety Review Board (SRB) convenes annually.

The Aircraft Operations Manual (OM-B) provides general instructions for landing. When it comes to landing it states, among other things, that the landing gear must touch down in a controlled manner and that the aircraft must be kept on the runway centreline. The manual also includes the checklists that airlines routinely use as well as emergency procedures.

The airline's safety management system includes procedures for providing crisis support in accidents. The company contacted the captain once in February, at which time he received feedback regarding his occurrence report. No psychosocial support was offered to the captain following the occurrence.

2.3.3 Air operator information

The Finnish ground handling and logistics company Maavoima contracted air services for the Helsinki–Savonlinna route with RAF-AVIA A/S. Maavoima was awarded with the contract for

the route; the public tender was launched by the Finnish Transport Agency for the years 2018–2020.

In addition to passenger services Maavoima provides ramp services, baggage handling, aircraft cleaning services as well as anti-icing and de-icing services.

During the contract period which began in 2018 Maavoima has used two air operators in arranging air services for Savonlinna. This was agreed in the contract with the Finnish Transport Agency. The operators are the Hungarian Budapest Aircraft Service KFT and the Latvian RAF-AVIA. In the beginning of the contract period Maavoima used Budapest Aircraft Service KFT, but on 5 March 2018 Maavoima replaced the operator with RAF-AVIA. This was done for commercial reasons rather than safety considerations. Maavoima has had good experiences with both air carriers and has not observed any safety deviations in either of the air operator's actions.

Pursuant to EU practices, Maavoima relied on the fact that air operator certificates and operating licences ensure that the air operator acts in a safe manner. No separate queries on their safety levels or their domestic flight safety records were done from the EASA's or ICAO's databases. Once the flight operations commenced, Maavoima supervised the on-time performance of flight schedules. Maavoima, in their safety management system, did not have any procedures or the obligation for assessing the airlines' operating safety. Such models can be regarded as representative for aviation service providers of this size. Typically, airlines have more detailed procedures for investigating and continuously assessing the safety of air services they purchase.

2.3.4 ANS Finland

Air Navigation Services Finland (ANS Finland) is a wholly state-owned special assignment company. The company is responsible for managing the use of Finland's airspace, and for flight route and air navigation services at Finnish airports. The company also maintains the Aeronautical Rescue Co-ordination Centre (ARCC) which is responsible for the supervision and coordination of aeronautical search and rescue (SAR) operations in accidents and incidents, and for aeronautical SAR until the aircraft which is being searched for has been located.

Air navigation service units are responsible for the safety and quality of their own action in accordance with safety and quality management systems. ANS Finland encourages air traffic controllers to act safely and to avoid risks even at the expense of traffic delays. For instance, runways can be closed for the duration of runway maintenance due to safety considerations.

The Air Traffic Controller's Manual (Lennonjohtajan käsikirja LJKK) is used by personnel for the purpose of providing air navigation services. The manual is based on the International Civil Aviation Organization ICAO's documents or on nationally certified procedures. In addition to the manual, air navigation service units have their own, local manuals. The Alerting Service Manual contains alerting instructions for the control tower and approach control or the AFIS unit and, if required, to the other personnel working at the aerodrome.

2.3.5 Finavia

Finavia is the aerodrome operator at Savonlinna airport. Finavia's aerodromes (21) use the company's common safety management manual. Individual aerodromes have their own, local safety management manuals. Finavia uses a risk management system which complies with EASA10 regulations. Finavia carries out annual internal audits.

2.3.6 Savonlinna airport maintenance

In wintertime the normal shift of Savonlinna airport maintenance starts on Mondays at 05:00. The shift comprises three or four persons, one of whom is the shift supervisor who determines the required runway clearance. The time at which runway clearance begins depends on the past weekend's weather conditions and possible snowfall. If it is snowing, the clearance is timed to be completed just in time for a landing. After the final runway clearance the runway's friction level is measured using the Skiddometer PB11. The estimated runway friction is communicated to pilots decoded. The numerical values are only provided when specifically requested.

The runway inspector enters the information on the conditions into a system[21] which creates a SNOWTAM bulletin and sends it for distribution. From the SNOWTAM bulletin the AFIS officer gets information about the extent of the cleared area, depth of deposits and the estimated runway friction on each third of the runway, critical snowbanks as well as the conditions on taxiways and the apron.

2.3.7 City of Savonlinna

On 7 March 2017 the City of Savonlinna delivered the city government's decision to the Finnish Transport Agency. In the decision it was proposed that the Finnish Transport Agency impose a public service obligation for the Helsinki–Savonlinna route for 2018–2020. Savonlinna city government also proposed that the Finnish Transport Agency launch a public tender for the said flight service. The city government also tried to increase competition by making it possible to submit tenders to a 'marketing company' which would sign a binding contract with the air carrier.

Preserving a flight connection to Helsinki and improving charter air services were mentioned in Savonlinna's tourism development plan. Promoting tourism in the region was a central goal of organising the Helsinki–Savonlinna route. Regular air services were also deemed beneficial to regional business activities.

2.4 Authorities' actions

2.4.1 The Finnish Transport Agency

The Finnish Transport Agency[22] launched a public tender for scheduled air services between Helsinki and Savonlinna. The proposal for this came from the City of Savonlinna. On 3 April 2017 the Finnish Transport Agency decided to impose a public service obligation for scheduled air traffic on the Helsinki–Savonlinna route for the period of 8 January 2018 – 18 December 2020. The Finnish Transport Agency and the City of Savonlinna were identified as clients in the public tender.

The public tender complied with Article 17 of EU regulation on common rules for the operation of air services in the Community[23] (Air Regulation). The client reserved the right to turn down bids owing to excessive price and circumstances or changes in the fundamental preconditions

---

21 Runway Reporter

22 As of 1 January 2019 certain functions of the Finnish Transport Agency, the Finnish Transport Safety Agency and the Finnish Communications Regulatory Authority were reorganised into two new agencies, the Finnish Transport Infrastructure Agency and the Finnish Transport and Communications Agency. The Finnish Transport and Communications Agency is nowadays responsible for the former tendering and contracting functions of the Finnish Transport Agency.

23 (EY) N:o 1008/2008. REGULATION (EC) No 1008/2008.

for organising the traffic. The client also reserved the right to change the date when the air service was planned to begin.

The tender comprised the tender documents which included, among other things, the invitation to tender, the tender conditions, terms of the contract, the public service obligation as well as tendering forms.

The terms of the public tender required that the air operator have an operating licence and an air operator licence issued by the competent authority of a Member State. Should the tenderer use a subcontractor, said subcontractor was also required to have valid operating and air operator licences. Information pertaining to the subcontractor was to be submitted beforehand, i.e. concurrently with the other tender documents of the. Other accounts to be submitted included documents regarding proof of the tenderer's creditworthiness and financial status.

The award was solely decided on the basis of the lowest price offered. After the decision, a transport acquisition contract would be signed between the client and the carrier that had been selected. A transport acquisition contract was signed for the provision of air services for the Helsinki–Savonlinna route.

Two bids that met the conditions were submitted for the provision of scheduled Helsinki–Savonlinna air services. The Finnish Transport Agency selected the one with the lower price, i.e. that of Maavoima. The Finnish Transport Agency and the City of Savonlinna, the clients, and Maavoima, the carrier, signed the transport acquisition contract on 28 December 2017.

The contract more or less corresponded to the invitation to tender, documents included. The most significant difference in the contract pertained to the section describing the subcontractor. The terms of the public tender and the associated public documents stated the possibility of using one subcontractor, but Maavoima, in its bid, said that it would use two air carriers. Moreover, Maavoima also reserved the right to use other subcontractors that meet the Air Regulation's requirements as long as the clients first approved them. This section that concerns subcontracting was not included in the contract itself.

No additional conditions for safe operations were stipulated in the public tender launched by the Finnish Transport Agency. While the Air Regulation does not specifically prohibit setting additional terms, the Finnish Transport Agency had a strong suspicion that the EU would interpret any safety-related extra conditions as a restriction of competition. Any extra condition set by a national authority for a public service obligation brings the possibility of it being interpreted as a restriction of competition and infringement of Community law.

The EU Commission, pursuant to Article 18 of the Air Regulation, may request a Member State to communicate documents justifying the need for the public service obligation to determine, inter alia, whether they have infringed Community law or national rules implementing Community law.

The primary criterion in the terms of the public tender was an air operator that is properly licenced for the activity. The air carrier could also use one subcontractor so long as it, too, had the required licences for air operations.

Nevertheless, the transport acquisition contract was signed with an air carrier that used two different subcontractors. Subject to a specific notification process the contract permitted the transfer of air services to a company owned by the carrier or to one which operates within the same consortium as the carrier.

The acquisition included two daily return flights on weekdays between Helsinki and Savonlinna (altogether 1 282 return flights) for a three year period. The costs were divided so

that the City of Savonlinna is responsible for at least 50 % of the costs and the Finnish Transport Agency for 50 % of the costs, at maximum. The condition for the decision to enter into force was that Parliament, by the end of 2017, appropriate one million Euro for the year 2018. Yet another condition for the decision to enter into force was that the City of Savonlinna appropriate the required funds. The aeroplane to be used was to provide 29 passenger seats for each leg at a minimum. The maximum price for a single air fare was EUR 200. On these terms the Finnish Transport Agency imposed a public service obligation for air services for the Helsinki–Savonlinna route for the period of 8 January 2018–18 December 2020.

The purchaser organising the public tender for air services and the client can evaluate the air carrier's domestic safety level through the EASA's and ICAO's country-specific assessments. They take into account the quality of the local aviation authority. Furthermore, the purchaser and the client can assess the air carrier's safety from the national aviation authority's safety audits. It may be possible to include the air carrier's safety level as a condition for signing a transportation acquisition contract. It is also possible to monitor the air operator's safety during the contract period.

It was the Finnish Transport Agency's prerogative whether, and how much, safety was to be used as a condition in competitive tendering for the air service. In practice, purchasers and clients do not use air carriers' and their Member States' safety levels as criteria in the EU's internal competitive bidding. Rather, price and on-time performance are highlighted. This practice encourages airlines to lay emphasis on these two factors. Clients of air services deem it a risk that the EU could interpret safety criteria as a restriction of competition.

According to the Finnish Transport Agency, competition between air carriers in air traffic such as the one concerning Savonlinna has been so fierce that the air carriers that lose public tenders have routinely appealed the contract awards. Hence, acquisitions have gone to court. This has resulted in protracted stalemates and purchasers have had to seek special permits from courts to commence air service with the selected air carrier because the appeal process has been ongoing. This, in part, has made the Finnish Transport Agency very sensitive about making absolutely certain that the competitive tendering criteria unquestionably meet the EU Regulations. Safety, in reality, has not been a criterion in competitive bidding.

2.4.2 The Finnish Transport and Communications Agency

The Finnish Transport and Communications Agency (Traficom) is the aviation oversight authority in Finland[24]. It supervises traffic licensing and registration. The agency carries out aircraft ramp inspections in accordance with EASA standards. The requirements of the inspection vary, depending on the nationality of the air operator in question. The inspection findings are placed in three categories. Ramp inspection is risk and performance based. The findings are recorded in the database maintained by the EASA.

In 2018 Traficom inspectors carried out three SACA[25] inspections on the aircraft that flew the Helsinki–Savonlinna route. The first inspection resulted in one Category 2 finding, i.e. a significant finding affecting flight safety, and one remark. The remark concerned the listing of portable extinguishers in the minimum equipment list and a comment on a missing screw on the right engine shroud. The company reported that corrective action would ensue. In the second inspection the inspectors noticed that the Airworthiness Review Certificate (ARC) had

24 Until 1 January 2019 the Finnish Transport Safety Agency
25 Safety Assessment of Community Aircraft.

expired. The valid document was presented to the inspectors by e-mail. No deviations were found in the third inspection.

The reason for the aforementioned inspections was that Traficom had become aware of RAF-AVIA's safety problems. Traficom felt that the competition legislation limited its ability to intervene in the airline's action in other ways. Primarily, it was the Latvian Civil Aviation Agency responsible for supervising the airline's action.

2.4.3 The Latvian Civil Aviation Agency

The Latvian Civil Aviation Agency supervises RAF-AVIA's activities. Oversight has revealed safety problems, which are described in the previous subchapter 2.3.2, regarding the air carrier. According to the Latvian CAA the airline's most serious safety shortcomings are associated with pilot skills and decision-making. Moreover, according to the Latvian CAA, RAF-AVIA's occurrence reporting practices are not as good as those of other air carriers they supervise.

According to the Latvian CAA the greatest challenge to supervising RAF-AVIA's safety has been in modernising old-fashioned safety thinking. The Latvian CAA says that, through oversight, it has succeeded in improving RAF-AVIA's previously immature safety management system. Recently, the problem has been that the air carrier has not been able to fully implement its safety management system. While, according to the Latvian CAA, the airline's safety is improving, the change process has been slow.

The Latvian CAA has regularly audited the airline's safety management system. The key finding in the audits concerns the airline's inadequate and ineffective occurrence reporting culture. Additionally, among other things, the May 2018 audit found that:

- Not enough personnel were dedicated to safety management.
- The safety compliance manager's latest safety management training took place in 2008.
- The airline's safety guidelines were not communicated to the entire staff.
- Personnel did not receive feedback regarding the safety culture survey.
- The boundary between acceptable and unacceptable conduct was not clearly defined.
- The operator, in its action, had not implemented risk identification, interventions based on safety investigations or risk management regarding organisational and business-based decisions.
- Safety management was not goal-oriented; the airline had no formal process for creating safety goals, and the established safety goals were not systematically compared with the performance level.

In October 2018 the Latvian CAA approved the corrective action to these deviations. The positive aspect in the August 2018 audit was that the airline's safety manual system was well prepared and maintained.

2.4.4 The European Union Aviation Safety Agency (EASA)

It is the task of the EASA to ensure safety in European civil aviation. The EASA maintains registers on the level of flight safety among European countries. The actions of different countries' aviation and safety investigation authorities are audited to establish the countries' safety levels. In practice, however, this information is not used in Europe when selecting air operators because the clients feel that the EU interprets safety criteria as a restriction of competition.

The EASA has ordered that all cockpit voice recorders (CVR) recording on magnetic tape should be replaced by two-hour memory CVRs by 1 January 2019.

In 2013 the EASA did not set a requirement for replacing magnetic-tape FDRs because the aircraft types using them would, in practice, be decommissioned by 2019. Annex 6, in paragraphs 6.3.1 and 6.3.2 to the Convention on International Civil Aviation, recommends that the use of magnetic tape FDRs and CVRs be discontinued by 1 January 2016.

2.4.5 The safety implications of safety management system oversight

Following the deregulation of commercial aviation competition among airlines was liberated and the operators' safety self-monitoring was increased. These days, commercial air carriers are required to have safety management systems that comply with ICAO standards. Safety oversight has increasingly moved towards supervising operators' safety management systems. The authorities' safety oversight has focused on scheduled safety management system audits. The requirement for establishing safety management systems has endeavoured to improve the safety of aviation. In addition to ensuring flight safety, a carefully designed safety management system pays particular attention to occurrence reporting, analysis and lessons learned. At best, the new oversight mechanism that concentrates on safety management systems has resulted in air carriers investing in improving their own safety. Oversight authorities now have a more well-defined instrument at their disposal for assessing airline safety. Supervision of safety management systems has progressed to safety requirement management oversight and performance-based supervision has been reduced.

The aforementioned trend has also had negative impacts on safety. An airline's safety management system does not necessarily represent the air carrier's true action or its character. Nor are the procedures described in the safety management system always followed in practice, as was the case with the airline subject to this safety investigation. Airlines may paint a more positive picture of their action to oversight authorities by presenting impressive safety management system documentation and taking care of on-time performance, but safety deviations may remain unreported and the airline may deny any involvement in incidents.

2.5 Rescue services and preparedness

2.5.1 Airport rescue service

Finavia maintains Savonlinna airport. According to aviation regulations aerodromes are required to provide suitable rescue services and capabilities to deal with accidents. Rescue service manning as well as the quality and level of service provided is determined by the rescue fire category, appropriate to the largest aircraft flying into the aerodrome.

Some aerodromes can have two different rescue and firefighting services (RFFS) categories. Savonlinna airport belongs to RFFS category[26] for scheduled air traffic is 5 or 7, depending on the size of the aircraft that operates from the aerodrome. Other traffic must ascertain the required RFFS category in advance when the airport is open. Finavia's rescue service manual[27] provides for the RFFS category and the required rescue service preparedness. Thus, the amount of equipment and number of personnel varies between categories 5 (1+1) and 7 (1+2). The airport has two fire trucks that carry altogether 12 500 l of water and 740 l of foam as well as 250 kg of chemical powder as an additional retardant. The response readiness requirement for the units is three minutes. The total manning of rescue services is 7 people, some of whom are qualified to act as Lento P3. According to their job description, people participating in rescue

[26] Higher RFFS categories also raise the requirements for rescue equipment and personnel. The highest category is 10.

[27] The rescue service manual is based on Commission Regulation (EU) No 139/2014 and the EASA's subsequent Acceptable Means of Compliance and Guidance Material AMC4 ADR.OPS.B.010.

service actions also carry out aerodrome maintenance or other duties. The task of the airport rescue service is to act as part of the rescue organisation.

The airport is responsible for providing rescue services to aircraft in accordance with the requirements of aviation regulations. Lento P3 commands rescue actions during exercises and aviation accidents at the airport until the competent rescue authorities have been informed of the accident and assume command. The shift supervisor acts as Lento P3.

Savonlinna airport is responsible for the rescue actions and preparednesses which, pursuant to the Rescue Act, are not the responsibility of regional rescue services.

Aviation regulations (EASA) stipulate that the aerodrome control towers must have an alerting system meant for alerting the rescue services. In addition, the alert is to be made on the rescue service's VIRVE Terrestrial Trunked Radios. The emergency alert is made by calling the Emergency Response Centre.

Emergency exercises held at regular intervals are part of the emergency plan and its testing in practice. Aviation regulations (EASA) define two different types of emergency exercises. Full-scale exercises are held once every two years and are carried out together with the rescue and other authorities. The full-scale exercise tests the functioning of the airport's entire rescue service as well as cooperation among the authorities. In addition to these, the airport organises smaller exercises.

2.6 Recordings

2.6.1 ANS Finland recordings

The investigation team had access to the recordings of the Savonlinna airport AFIS frequency, the airport ground traffic frequency and the AFIS station's telephone calls. All recording devices worked properly and the recordings were of good quality. The AFIS officer's voice on the recordings was clear.

The recordings established the AFIS officer's communication between the flight crew, airport maintenance, the ARCC and the ERC. The weather and runway information provided by the AFIS officer, and the read-back, could be established from the radiocommunication between the AFIS officer and the flight crew. Telephone recordings established the AFIS officer's communication between the ARRC and the ERC.

2.6.2 Flight Data Recorder

The Aircraft's Flight Data Recorder (FDR) was Model 209F[28], manufactured by the Lockheed Aircraft Service Company (LAS). Its recording capacity is 25 hours. The model is commonly used in airliners manufactured in the 1980s. According to the airline, the FDR's latest maintenance took place on 4 August 2015 and it was installed on the aircraft on 16 August 2016. No fault reports have been made on the device after it was installed.

[28] P/n 1077A500, s/n 3163.

Figure 7 The longitudinal stripes visible in the photo are telltale signs of wear. Tapes that are in good condition do not show stripes. (Photo: AAIB)

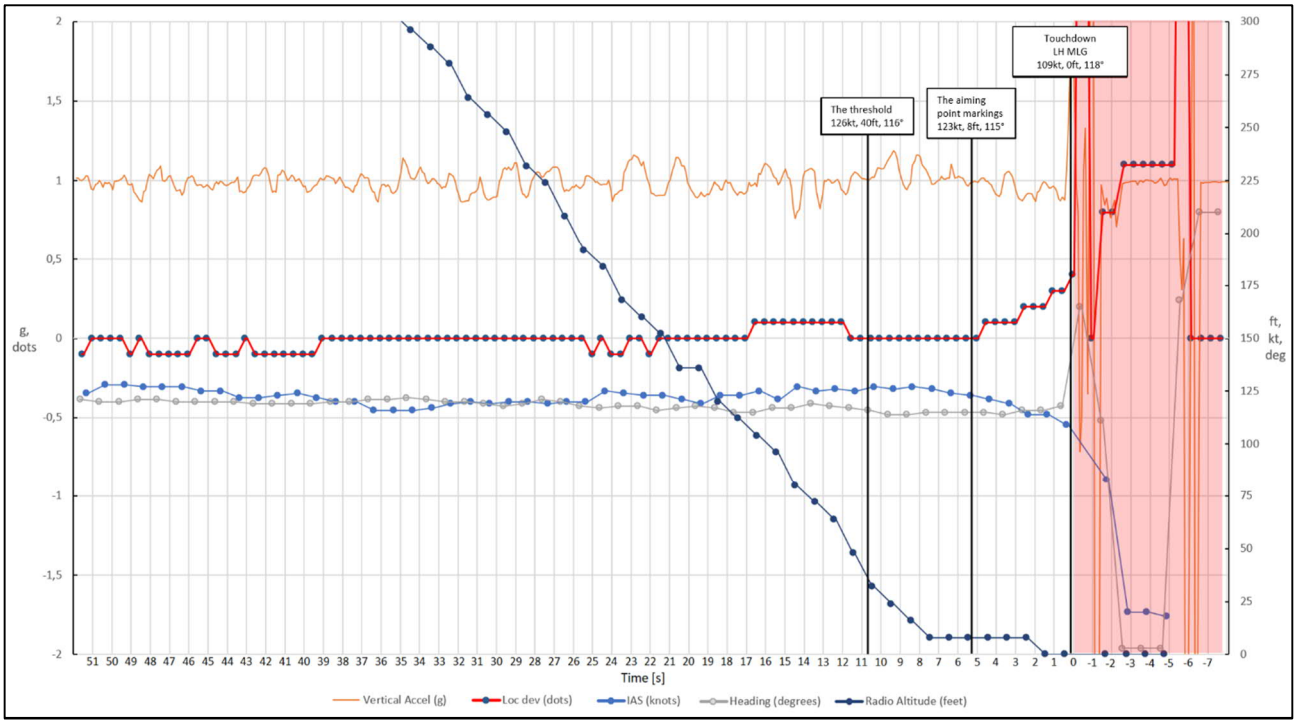

Figure 8. Graphs of the basic parameters during the final phases of the flight, drawn on the basis of FDR data. Owing to defects and noise in the recording, the values in the red zone are not representative. (Image: SIAF)

The FDR data was first downloaded at the laboratory of the UK Air Accidents Investigation Branch (AAIB). While the device had recorded the data, the recording was of poor quality and parts of the recording were missing. In all, several hours' worth of data were missing from the tape, considering its total capacity. The recorder was further examined at the laboratory of Muirhead Avionics under the supervision of the AAIB. It became evident that the magnetic tape used for the recording was in very poor condition and worn. The tape was removed from the FDR and the AAIB continued its examination in their own laboratory. The further examination retrieved more information to the data, but the electronic signal still contained a lot of noise.

According to the FDR recording the approach was normal and the aircraft was established on the ILS localiser and glide slope. The recording reveals that airspeed (IAS) on the short final was 10–17 knots higher than the one recommended (110 kt) by the aeroplane operating manual. Over the threshold the airspeed was 126 knots and 123 knots at the touchdown markings, respectively. The aircraft touched down at the airspeed of 109 knots.

Radio Altitude decreases constantly as the aircraft approaches the runway and is approximately 40 ft at the threshold. After passing the threshold the radio altitude decreases for the following four seconds, levelling at 8 ft. Judging by the radio altimeter the aircraft floats close to the surface for the following 6–7 seconds. A normal landing does not include such a level phase. During the level flight the aircraft begins to deviate from the localiser (Loc dev), veering off from the runway centreline. Following this, increased vertical acceleration (Vertical Accel) can be seen, which is caused by the aircraft touching down. In all, it takes approximately 10 seconds from passing the threshold to touchdown. Right after touchdown the recorded parameters contain defective values and noise. Hence, no reliable recording is available from the landing roll and the moment when the aircraft skidded into the snowbank. The resolution and sample rate of recorded parameters vary, depending on the given parameter. Nevertheless, the recording provided a sufficiently accurate picture of the approach and landing for the investigation.

Following an incident that occurred on SE-MHF, a BAe ATP airliner, on 3 May 2018 the AAIB issued a safety recommendation[29] regarding magnetic tape recorders. The AAIB recommended that the European Union Aviation Safety Agency (EASA) set an end date to prohibit the use of flight data recorders that use magnetic tape as a recording medium. In its response to the AAIB on 28 June 2019 the EASA said that this would not be justified because, by 1 January 2019, the proportion of aeroplanes fitted with a magnetic tape FDR was estimated to be close to zero, and they not directly improve the survivability of aircraft accidents.

When it comes to CVRs, the EASA has prohibited the use of recorders that use magnetic tape as a recording medium effective 1 January 2019.

2.6.3 Cockpit Voice Recorder

The Aircraft's Cockpit Voice Recorder (CVR) was Model FA2100[30], manufactured by L-3 Aviation Recorders. The aeroplane's original 30-minute memory CVR had been replaced with a two-hour memory[31] CVR. According to the information received from the airline the latest inspection of the recording system was carried out on 4 July 2013 and was at the time in satisfactory condition. Operational checks of the recording system must be carried out at regular intervals in accordance with EASA Guidance Material[32] so as to ensure its functioning and proper condition.

The CVR data were downloaded at the AAIB's laboratory in Britain. While the recording was being listened to it became apparent that the recorded data were not from the occurrence flight. The recorder was probably in working order because it contained information from flights that had been flown in December 2018. However, the quality of the recordings was extremely poor

---

29 AAIB (2019) Investigation of a serious incident to British Aerospace (BAe) ATP, SE-MHF. AAIB Bulletin: 5/2019: 3-17. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/797029/AAIB_Bulletin_5-2019_Lo_Res.pdf. Date viewed 16.7.2019.

30 P/n 2100-1020-00, s/n 000744458.

31 ICAO (2018) Annex 6 to the Convention on International Civil Aviation, Operation of Aircraft, Part I — International Commercial Air Transport — Aeroplanes. https://store.icao.int/annex-6-operation-of-aircraft-part-i-international-commercial-air-transport-aeroplanes.html. Date viewed 16.7.2019.

32 AMC1 CAT.GEN.MPA.195(b).

and especially on channel 1 there was a lot of noise. The noise probably originated from the aircraft's recording system rather than the recorder itself.

When the cockpit was investigated on the day of the occurrence it was discovered that the recorder's circuit breaker was closed, i.e. the device had not been shut down in accordance with the Aircraft Operations Manual. It is possible that the circuit breaker was in another position during the flight. The lack of cockpit voice recordings significantly hampered the investigation of the sequence of events.

In 2016, EASA initiated a rule making task[33] which intends to improve the reliability and quality of data recorded by FDRs and CVRs. The proposal[34] related to this task has been sent for comments on 13 November, 2019.

2.7 Rules, regulations, procedures and other documentation

2.7.1 The airline's operating manuals

According to the Operations Manual (OM-A) the crosswind limits given by the Aircraft Operations Manual (OM-B) must be followed during landing. However, the OM-A also says that if the estimated runway friction is poor, crosswind landings are prohibited. In other words, then the crosswind component should be zero knots. In this occurrence the AFIS officer informed the pilots that the runway friction was poor. If the estimated runway friction is poor, the OM-A's overriding restriction makes it very difficult to comply with the OM-B's crosswind limits.[35]

According to the OM-A an approach must be aborted if it is, or becomes, unstable. An approach is considered to be unstable if, among other things, the aircraft is not on the correct flight path or if the vertical speed exceeds 1 000 ft/min. An approach must be aborted if, during the landing, the wings are not level and the aircraft is not on the extended runway centreline by the time it reaches 300 ft.

The landing and taxiing lights were on during the final approach and landing. Section 8.3.8.9 of the company's OM-A[36] mentions the risk of using the lights, among other things, during heavy snowfall because they may degrade visibility and cause sensory illusions during landing. The Aircraft Operations Manual OM-B's[37] section 1.13.2 states the same thing.

According to the OM-B the final approach speed (V_{fa}) is used at the approximate height of 600 to 50 ft over the runway, from when on airspeed should be reduced to the reference speed (V_{ref}[38]) for landing. The goal is to increase the controllability of the aircraft, reduce the danger of stalling and to ensure that the airspeed will at no phase decrease below the minimum landing speed. In icing conditions, V_{ref} ICE shall be used which is normally 10 knots above V_{ref}.

The airline's operating manuals give instructions on how to check that the flight recorders are functioning and how to save the recordings. According to the OM-B the pilots must check that both flight recorders are working before the flight. The commander of the aircraft checks that the flight recorder's fault condition warning light turns off after starting the engines. The co-pilot presses the CVR test pushbutton and makes certain that the device's meter needle rises to and remains within the green section of the meter scale.

---

33 RTM: 0249 (MDM.051)

34 NPA 2019-12

35 According to the Aircraft Operations Manual the maximum crosswind component is five knots when runway friction is poor.

36 The OM-A contains the airlines' operating principles, instructions and procedures that are not aircraft type-specific.

37 The OM-B contains the aircraft's type-specific instructions and procedures.

38 V_{ref} is the minimum airspeed during the final approach and landing

According to the company's OM-A the commander of the aircraft must ensure that both flight recorders are shut down by opening their circuit breakers. It is prohibited to erase the data contained by the recorders following an accident or an occurrence which must be reported. Only the competent safety investigation authority may give the permission to switch the recorders on again. Barring any other instructions from the safety investigation authority, the company must preserve the information contained by the flight recorders for 60 days. It is particularly important to preserve the memory content of the CVR as its recording time is normally shorter than that of the FDR.

2.7.2 The airport's runway winter maintenance

Finland's aerodromes have four winter maintenance categories (IA, IB, II, III). Savonlinna airport is in winter maintenance category III (summer surface/winter surface). Finavia's winter maintenance manual defines this category in general terms as follows: The aim is to keep the runway snow and ice free, at least at the minimum required width. Snow can be on the surface on the runway as long as weather conditions permit and that satisfactory conditions for air traffic can be achieved. The other areas and taxiways can be covered with snow so long as they are kept sufficiently smooth and at sufficient friction. The areas forward of the ILS system are to be kept clear.

2.7.3 The European aviation safety regulations

The EU's aviation safety regime at the time of the tendering and signing of the contract was based on Regulation (EC) No 216/2008[39]. The goal of the Regulation is to establish common rules in the field of civil aviation in Europe and thereby maintain safety in civil aviation. The Regulation introduced standardisation inspections to monitor compliance among Member States. In addition, the European Union Aviation Safety Agency EASA was founded by means of the Regulation. For the purpose of applying this Regulation the European Commission adopted implementation rules which are directly applicable in all Member States; they do not need to be incorporated in national legislation.

In the European Union the Member States are primarily responsible for implementing EU legislation. This being the case, the competent authorities conduct most certification and oversight tasks required by the Regulation at the national level. In certain precisely defined cases, however, the EASA is the competent authority, authorised to issue certifications and carry out relevant implementation measures.

Pursuant to Regulation (EU) No 376/2014[40] on the reporting, analysis and follow-up of occurrences in civil aviation, airlines should regularly inform their staff of the analysis of occurrence reporting as well as the preventive and corrective action to be implemented. In addition, the occurrence reporting system should provide effective feedback to the person who reported the occurrence.

The EU Air Safety Committee is one of the three EU committees operating in the field of civil aviation. It participates[41] in updating the EU Air Safety List, a list of air carriers that are restricted from operating within the European Union.

Member States are responsible for ensuring flight safety in their own area and in their airspace, even though the largest part of the EU's flight safety legislation is adopted at the EU

---

39 Repealed by Regulation (EU) 2018/1139. Transition period ongoing.
40 376/2014. Regulation (EU) No 376/2014
41 (EY) N:o 2111/2005. Regulation (EC) No 2111/2005.

level. Most certification tasks provided by the basic Regulation[42] and its implementation rules, such as national certifications, are carried out at the national level. Member States monitor personnel and organisations, carry out audits, assessments and inspections, and implement measures to ensure compliance.

The European Union Aviation Safety Agency (EASA) conducts standardisation inspections on Member States in order to monitor the application of the national competent authorities of the Regulation[42] and of its implementing rules, and reports to the Commission.

The Commission Implementing Regulation[43] lays down the working methods for conducting and monitoring standardisation inspections, and for monitoring the application of safety legislation by the competent aviation authorities of the Member States. The EASA is responsible for standardisation inspections and for monitoring the follow-up of findings stemming from inspections. In the continuous monitoring approach the frequency, scope, extent as well as the size and composition of the inspection team should be tailored to each Member State's specific situation.

2.7.4 Regulation of the acquisition of air services

The European Single Market imposes obligations on public services. The transport sector is a key regulated area which aims to carry out the objectives of a well-functioning Single Market and free movement. In this market, air traffic, like as other forms of transportation, must primarily be arranged on a commercial basis. Market conformity eliminates the discriminatory public subsidies which distort business competition. If the market does not provide sufficient commercial incentives for organising commercial services, Member States can impose a Public Service Obligation (PSO) to arrange the traffic.

The EU's Air Services Regulation[44] provides for common rules for the operation of air services in the Community. The Regulation's introduction refers to the possibility of imposing a PSO and to associated tender procedures which "should allow a sufficient number of competitors to take part in the tenders".

Appreciating the shortfalls in business competition the introduction of the Regulation states: "Recognising the potential link between the financial health of an air carrier and safety, more stringent monitoring of the financial situation of air carriers should be established". Article 8 of the Regulation specifically mentions that "In case the competent licensing authority suspects that financial problems of a Community air carrier might affect the safety of its operations, it shall immediately inform the authority competent for the air operator certificate (AOC)".

Article 16 of the Air Services Regulation provides for general principles for public service obligations. If certain conditions are met a Member State "...may impose a public service obligation in respect of scheduled air services between an airport in the Community and an airport serving a peripheral or development region in its territory or on a thin route to any airport on its territory any such route being considered vital for the economic and social development of the region which the airport serves".

The Act on Transport Services[45] provides for Finland's national legislation on public service obligations (Part IV concerning passenger transport services). The Government bill (HE/2016) explored the possibility of there being non-market based public service obligations

42 (EY) N:o 216/2008. Regulation (EC) No 216/2008
43 (EU) N:o 628/2013.
44 (EU) N:o 1008/2008.
45 (320/2017).

by, for example, designating some company as a universal service organisation which would be obligated to provide air services for a reasonable price. That option was excluded. This being the case, public service obligations cannot be imposed on national decisions alone which would in advance limit the opportunity of businesses from becoming service providers. When the authorities act in accordance with the Air Services Regulation, they must first ensure EU-wide access to the market, as far as possible.

The Act on Public Procurement and Concession Contracts[46] does not apply to this process. The basic premise of the Act is that State and municipal authorities and other contracting entities shall arrange competitive tendering for their procurements and concession contracts. However, the Act does not govern[47] the acquisition of such air services to which the EU's Air Services Regulation applies[48].

A public tender must be arranged. When imposing a PSO under the Air Service Regulation it shall be conducted according to the procedure set out in Article 17, i.e. by arranging a public tender procedure for the public service obligation. The Article gives emphasis to transparent parameters and to the possibility of monitoring the cost of the compensation required from the Member State concerned. The Member State shall inform the Commission of the result. The Commission may also, on its own initiative, examine the service after the tender process. The remarks regarding safety in the Air Services Act are associated with the air operator's financial situation.

The Air Services Act contains eleven safety-associated observations. Safety considerations are emphasised in situations where the air carrier has financial problems. Already in its introduction the Act states that "Recognising the potential link between the financial health of an air carrier and safety, more stringent monitoring of the financial situation of air carriers should be established". Indirect references to safety are included in the provisions regarding air operator certificates and operating licences. The introduction states that air carriers have operational bases in several Member States. Therefore, in order to ensure the efficient supervision of these air carriers, the same Member State should be responsible for the oversight of the air operator certificate and of the operating licence. In certain conditions (Art 9) the competent licensing authority can even revoke the operating licence. Proof of good repute (Art 7) is associated with the phase when the operating licence is issued and refers to good financial repute. Good repute, for instance, is not associated with situations where the air operator's actions are estimated to contain failings in flight safety.

2.8 Other research

2.8.1 Previous investigations regarding the air carrier's incidents

A risk of runway collision between two airliners at Helsinki-Vantaa Aerodrome occurred on 29 December 2011. The Safety Investigation Authority investigated this serious incident[49] involving RAF-AVIA's Saab 340A airliner. The aircraft entered the active runway without an air traffic control clearance, ahead of a landing ATR72. The RAF-AVIA aircraft was transporting cargo to Mariehamn with a two-person flight crew.

---

46 (1397/2016).

47 Section 9(1), para 15.

48 The Air Service Regulation 1008/2008 which repealed Council Regulation (EEC) No 2408/92.

49 Safety Investigation Authority Finland (2012) Risk of Runway Collision Between Two Airliners at Helsinki-Vantaa Aerodrome on 29 December 2011. Investigation report L2012-01.

The serious incident occurred because the flight crew misinterpreted their ATC clearance. They crossed the illuminated stop bar and taxied onto the active runway. Their multi-crew cooperation was also inadequate.

Among other things, Safety Investigation Authority Finland recommended that the Latvian Civil Aviation Agency ensure that the pilots of RAF-AVIA Airlines are familiar with the procedures related to stop bars, and that RAF-AVIA pilots possess sufficient multi-crew cooperation skills.

On 14 February 2012 there was a risk of an airliner colliding with terrain in the vicinity of Mariehamn airport. In 2012 Safety Investigation Authority investigated the serious incident[50] to RAF-AVIA's Saab340A airliner, which occurred during the approach near Mariehamn airport. The RAF-AVIA aircraft was transporting cargo with a two-person flight crew.

During the approach the aircraft ended up in an unusual flight attitude where the maximum bank angle was 50 degrees to the left and the maximum pitch angle was 19 degrees downwards. The pilots managed to recover the aircraft at 150 ft AGL (45 m).

The serious incident was caused because the captain continued the approach in a situation which did not meet the preconditions of a successful approach and landing. The investigation revealed inadequate multi-crew cooperation between the flight crew. In addition, it was discovered that the pilots did not react to the Ground Proximity Warning System warnings. Nor did the captain comply with the company's OM-A.

Among other things, Safety Investigation Authority Finland recommended that the Latvian Civil Aviation Agency ensure that RAF-AVIA pilots receive additional Crew Resource Management training and that pilots receive additional training as regards the operating procedures of the Ground Proximity Warning System.

On 9 October 2018 RAF-AVIA's ATR-72-202 airliner veered off during the landing roll at Trollhättan/Vänersborg airport in Sweden. There were two pilots and one technician on board. Nobody was injured. The Swedish Accident Investigation Authority (SHK) investigated the incident[51].

During the landing, which took place with a crosswind from the left, the aircraft came off the runway on the left side, damaged a runway edge light and thereafter rolled back onto the runway.

The runway excursion was not reported by the crew. The damaged edge light and the tyre tracks were discovered by airport personnel, who noted that the tracks could only have been left by the RAF-AVIA aircraft. This was reported to the Swedish Transport Agency and to the operator.

According to SHK, the incident was caused by the following factors: The operator and the pilots had not read ATR's flight operations information message (FOIM) regarding recommended procedures for crosswind landings, and the operator's pilots lacked full training in crosswind landings on the aircraft model.

---

50 Safety Investigation Authority Finland (2012) Risk of an Airliner Colliding with Terrain in the Vicinity of Mariehamn Airport on 14 February 2012. Investigation report L2012-02.

51 Swedish Accident Investigation Authority (2019) Runway excursion at Trollhättan/Vänersborg airport involving the aeroplane YL-RAI of the model ATR 72-202. Investigation report L-145/18.

The Latvian civil aviation agency has carried out an inspection of the operator. This has led to a number of recommendations regarding measures for the operator to take, for example regarding reporting culture, risk assessments and training initiatives.

The manufacturer of the aircraft has decided to introduce supplementary information on crosswind landings in the flight crew operation manual.

The operator has introduced a number of training measures to improve safety in conjunction with crosswind landings on the aircraft type. Considering the measures already taken, the Swedish Accident Investigation Authority chose not to issue any recommendations.

2.8.2 Other similar incidents that occurred in winter conditions

A serious incident[52] occurred at Lappeenranta airport on 31 January 2008 when a Czech Job Air SAAB 340B aircraft veered off the runway during its landing roll at night while it was snowing. During the landing roll the aircraft veered off to the left side of the runway and skidded off the runway. A 33 m wide runway section had been cleared and runway braking action was poor. Also, the pilots had only limited experience with winter operations. During the course of the occurrence the tips of the left engine propeller blades were broken.

The investigation found the weather conditions to be a contributing factor, where snowflakes illuminated by the landing lights were blowing across the runway, which may have confused the pilots with regard to the course of the aircraft in relation to the runway centreline. Moreover, the centreline markings were completely covered by snow.

A serious incident[53] occurred at Pajala airport in Sweden on 13 February 2013 when an Estonian AS Avies airline's Jetstream 3102 airliner veered off the runway. The incident did not result in any injuries to persons or damage to material. The incident was caused by deficient directional control during the final stage of the landing. Sensory illusions caused by drifting snow and glare from the high-intensity lights were probable contributing causes. The lack of runway centreline lights contributed to the aircraft veering off the runway.

---

52 Accident Investigation Board Finland (2008) Airliner veering off the runway at Lappeenranta airport on 31 January 2008. Investigation report B1/2008L.

53 Swedish Accident Investigation Authority (2014) Serious incident at Pajala Airport on 13 February 2013 involving the aircraft ES-PJB of model Jetstream 3102 operated by AS Avies. Final report RL 2014:01e.

3 ANALYSIS

The Accimap[54] approach, further developed by Safety Investigation Authority Finland, was used in the analysis of the occurrence. The structure of the analysis text is based on the Accimap presentation drawn up by the investigation. The accident is depicted at the bottom of the presentation as a chain of events. The underlying factors of the chain of events are illustrated in the presentation as separate levels of analysis.

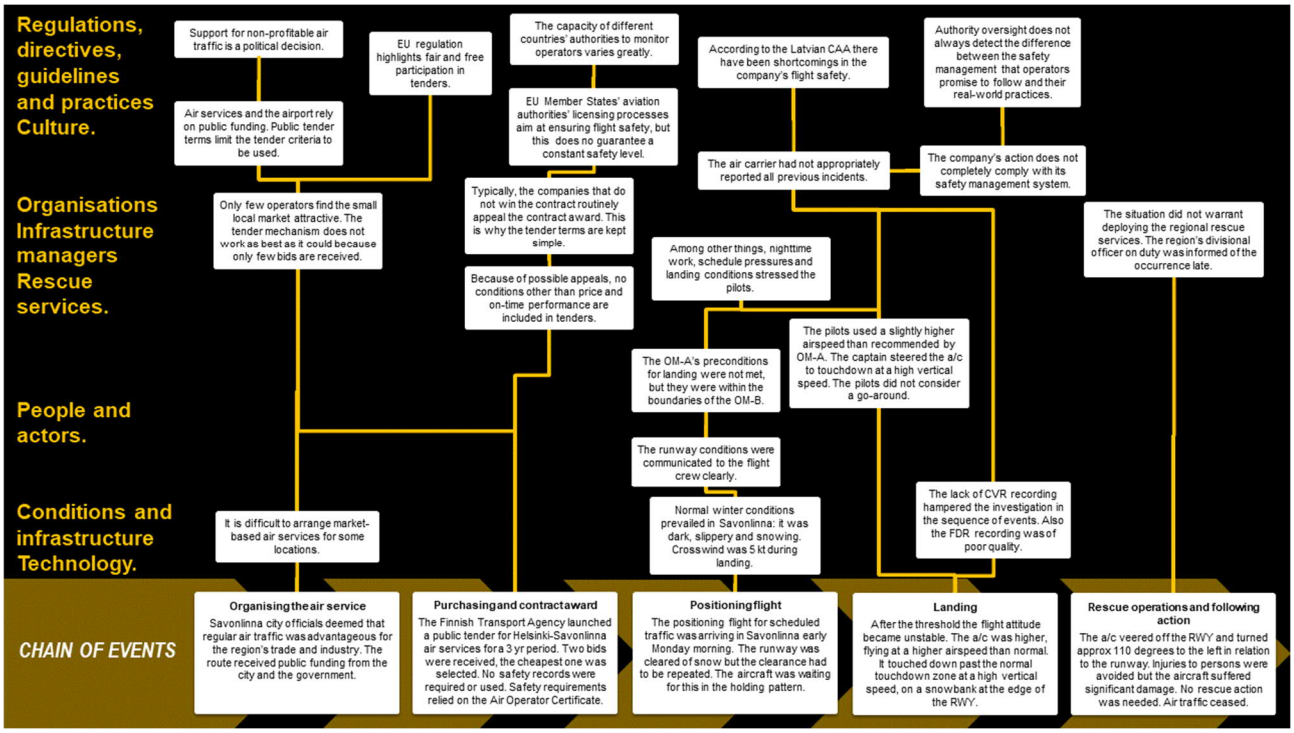

Figure 9. The Accimap presentation.

3.1 Organising the air service

An airliner veered off the runway during the landing roll at Savonlinna airport in the morning of 7 January 2019. The airplane was scheduled to fly to Helsinki after it landed. The Latvian RAF-AVIA was the air operator.

The City of Savonlinna wanted to arrange year-round air services. Regular air traffic was deemed to be advantageous for the region's trade and industry. Nevertheless, Savonlinna, as many similar locations, found it difficult to arrange market-based scheduled air services. The air traffic relied on public funding. Supporting the non-profitable route has been a political decision. Also, special conditions were involved in applying for, receiving and using public funding. One condition was that no rapid and regular modes of other public transport were allowed to be available.

The Finnish Transport Agency organised competitive tendering for air services on behalf of itself and the City of Savonlinna. The EU's competition rules set the framework for the tender. While regulations have aimed at ensuring the most open participation in tendering, they have resulted in overlooking certain specific topics, such as the safety of aviation, as criteria in

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

competitive bidding. Neither has the tendering mechanism fully served markets such as the one in Savonlinna because only few bidders have shown interest.

3.2 Organising the public tender and the contract award

The Finnish Transport Agency received two bids for scheduled Helsinki-Savonlinna air service, of which the cheaper one was selected. The associated air operators' safety records were not required by the public tender, nor were they assessed. The purchaser relied on the fact that air operator certification and licensing ensured that the air operators would act in a safe manner.

The purchaser organising the public tender for air services must decide the topics it wants to take into account and stress in the tendering process. Drawing up invitations to tender requires competency and familiarity with the field because ambiguous quality criteria, for example, easily cause problems. Also the companies that lose in the competitive bidding monitor compliance with the terms by the tender. Typically, the parties who do not win the contract routinely appeal the contract award. The appeal process takes time and, in some cases, requires significant additional work from the purchaser. Various extra requirements in tenders normally complicate the handling of the appeals. Sometimes even the commencement of air service has been delayed because purchasers have had to seek special permits from courts during the process. These issues have easily made purchasers extra sensitive about not breaking competition regulations by including conditions to transport services other than cost and on-time performance.

The objective has been to ensure safety through air operator certifications and operating licences. Nonetheless, the EU Member States' aviation authorities' licensing processes have not succeeded in ensuring constant and uniform safety levels among air carriers, even though many instruments are available to handle the matter. Operator oversight is based on safety management system audits conducted by the authorities as well as on the companies' self-monitoring. Audits do not necessarily extend to the implementation of safety management systems and, hence, the assessment of flight safety. The capacity of the different countries' authorities to monitor operators has varied greatly.

3.3 Positioning flight

During the positioning flight to Savonlinna on 7 January 2019 the weather conditions were normal for wintertime. The runway had been cleared of snow but the clearance had to be repeated to achieve better runway friction. The aircraft had to wait for the landing in the holding pattern, and the landing was delayed. At the time of the landing it was dark, a crosswind was blowing, it was snowing and the runway was slippery. The landing conditions were communicated to the flight crew clearly.

The landing conditions met the OM-B's requirements. Correspondingly, the air carrier's OM-A says that if the reported runway friction is poor, crosswind landings are prohibited. The preconditions of crosswind landings are defined in several different manuals which the pilots must follow.

3.4 Landing

The landing proceeded normally until the aircraft passed the threshold. After that, the flight attitude became unstable. At the final phase of the landing the aircraft floated close to the surface for 6–7 seconds before touchdown, following which the touchdown point moved farther down the runway than normally. Extra airspeed after the threshold partly contributed to this. The captain did not notice that the aircraft began to veer off the runway centreline. He

steered the aircraft toward the ground at a fairly high vertical speed. At that time the aircraft was already over the snowbank at the edge of the cleared area of the runway. Despite the pilot's corrective control actions the aircraft completely veered off the runway into the snowbank. At no time did the pilots consider aborting the approach or landing, i.e. going around. The length of the runway was not a limiting factor for the landing.

No single factor explains the failed landing. It is known that the following factors, combined, stressed the flight crew's performance in this situation: the crew's shift had already begun during the night, and, at the time of the landing, it was dark and a crosswind was blowing, and snow was drifting in the wind. Furthermore, there was only a little time before the next scheduled take-off and the passengers were already waiting. The airline manuals' instructions for the preconditions of landing differed from those of the aircraft manufacturer's manual. Hence, they were difficult to follow operationally. On the other hand, most of the aforementioned factors are part and parcel of normal wintertime operations. It is also known that working at night especially stresses older employees. The captain of the accident flight was 61 years old. Flying low and level over the runway may have made it more difficult to precisely determine the position of the aircraft.

The lack of the cockpit voice recording significantly hampered the investigation of the sequence of events, especially, regarding multi-crew cooperation. The recorder had been replaced with a new type but the recording system operated poorly. The recordings from previous flights were of extremely poor quality and contained noise. The functioning of the recorder had probably not been checked before take-off, and it recorded nothing from the flight. Checking the functioning of the recorder is one of the pre-flight checks.

The flight data recorder (FDR) worked properly during the flight, but its tape was worn which caused defects in the recording. The FDR model was over 30 years old and its sample rate and recording capacity is more limited compared to modern recorders. However, the recording provided a sufficiently accurate picture of the sequence of events for the investigation. Using obsolete technology or worn, or non-functioning, recorders makes it more difficult to ascertain the course of events and, on the other hand, may disguise essential factors for the improvement of safety.

The airline had already experienced incidents in the past. According to the Latvian CAA there had been shortcomings in the company's flight safety. The air carrier had not appropriately reported all incidents. The company's action had not completely complied with its own safety management system.

Oversight authorities do not always detect the difference between the safety management that operators promise to follow and their real-world practices. The authorities' safety audits focus on safety management system documents; the assessment of actual operations has been transferred to companies' self-monitoring. This being the case, maintaining and improving the operator's flight safety is largely left to its own interests.

3.5 Rescue operations and following action

The aircraft landed on the left snowbank and completely veered off the runway outside the cleared runway area. When the left main landing gear hit the outer, harder snowbank, the left side of the aircraft slowed down sooner and the aircraft began to turn to the left. Ultimately the aircraft ended up completely in the snowbank. Within a distance of approximately 300 m the aircraft decelerated from the touchdown speed of 109 kt (202 km/h) and stopped at a 110 degree angle in relation to the runway. Injuries to persons were avoided but the aircraft suffered significant damage.

At first, according to the flight crew, they only needed assistance to extract the aircraft from the snowbank. The airport rescue service carried out the immediate rescue actions and assessed the situation. There was no need for regional rescue services to come to the site.

Following the instructions, the AFIS officer called the Emergency Response Centre and reported the situation as was known at the time. Since the caller said that there was no acute requirement for additional help, the ERC operator, relying on her risk assessment, did not deploy any rescue service units. When no alert was made, and the information was not separately relayed to the region's divisional officer on duty, the situational awareness of the rescue service command remained inadequate at first. This degraded their capacity to deploy additional assistance to the accident site, if it had been required. Pursuant to the Rescue Act, it is the competent rescue authority that commands the region's rescue actions. The aircraft was towed off the runway into a hangar and the runway was opened to traffic in the evening of the accident day. Scheduled flights were cancelled for three days until the air carrier managed to replace the airplane with another one for the route.

4 CONCLUSIONS

The conclusions encompass the causes of an accident or incident. Cause means the different factors leading to an occurrence as well as relevant direct and indirect aspects.

1. The operating licences and air operator licences issued by the EU Member States' aviation authorities do not guarantee constant and uniform safety levels among air carriers.

   Conclusion: In addition to operating licences and air operator licences, competitive tendering for air services requires other practices to verify the safety of airlines.

2. While the EU's regulations have aimed at ensuring the most open participation in tendering, they may result in overlooking the safety of aviation as one criterion in tendering.

   Conclusion: The interpretation of regulations should not result in a situation where qualitative criteria in competitive bidding are discarded because of tendering rules, the risk of challenging a decision or the desire for an uncomplicated process.

3. The purchaser organising the public tender for air services will not necessarily impose any safety-associated criteria because of being cautious about breaking EU competition rules and the court processes launched by losing bidders. Often the price and on-time performance are the tender criteria.

   Conclusion: Tenders for air services may not necessarily assess the operators' safety records at all. Present air service competition rules do not encourage operators to invest in safety.

4. Purchasers of air services do not have suitable and straightforward indicators to assess air carrier safety. Clients and purchasers may also include those that are not deeply familiar with the aviation branch.

   Conclusion: It is difficult for purchasers to reliably compare the safety of air carriers.

5. The airline had not completely complied with its own safety management system. Oversight authorities do not always detect the difference between the safety management that operators promise to follow and their real-world practices.

   Conclusion: Authority oversight does not always extend to the implementation of operators' safety management systems or to actual practices.

6. At no time did the flight crew consider aborting the landing.

   Conclusion: A go-around is always the safe option if the preconditions for landing are not met or if a safe landing cannot be achieved.

7. The airline's operational manuals (OM-A and OM-B) were inconsistent concerning maximum crosswind components. The instructions were difficult to follow in practice.

   Conclusions: Manuals must be consistent in all respects and user-friendly during the different stages of the flight.

8. Regardless of the alert to the Emergency Response Centre, no information about the airliner accident was relayed to the region's divisional officer on duty because, owing to the situation assessment, there was no need to deploy rescue service units.

   Conclusion: The region's divisional officer on duty responsible for rescue operations must be sufficiently informed of an accident occurring in the region, even if the situation did not require deploying rescue service units. The situation may change from the onset, requiring the commencement of rescue actions.

9. The Cockpit Voice Recorder had not recorded anything from the flight in question, and the earlier recordings that were retrieved from its memory were of extremely poor quality. The recording quality of the FDR, when compared to modern recorders, was poor. The magnetic tape of the FDR was worn, which caused defects in the recording.

    Conclusion: The purpose of flight recorders is to make it easier to investigate accidents and incidents so as to improve safety. Aircraft should carry recorders that meet modern-day recording capacity and reliability requirements.

5 SAFETY RECOMMENDATIONS

5.1 Taking safety issues into account in tendering

Operator safety was not set as a criterion in the public tender for air services because the EU's competition rules steer purchasers to carry out the process on financial grounds. Some tenderings have taken safety criteria into account in addition to the financial ones.

The Safety Investigation Authority recommends that

> The Finnish Transport and Communications Agency explore and instruct how operators' aviation safety and safety management performance, as criteria, can be used in tendering for air services, taking the EU's regulations into account. [2019-S54]

When it comes to purchasing air services as a public service obligation the ultimate client can be some other entity or organisation. Then the instructions for taking safety criteria into account should be made available to it.

These days air carrier safety is assessed during the air operator certification process. By advancing the consideration of safety in tendering for air services, it would be possible to create an additional safety-assurance practise.

5.2 Safety assessment among airlines

The EU's operating and air operator licensing process has not succeeded in guaranteeing constant and uniform safety levels among air carriers. There are no universal and straightforward indicators for assessing air carrier safety.

The Safety Investigation Authority recommends that

> The European Commission see to it that a process is created by which it becomes possible to impartially assess operators' safety management performance and safety levels in tendering for air services. [2019-S58]

Safety management performance means the combination of an appropriate safety management system and its practical implementation. The people making decisions in purchasing air services, or in subcontracting, do not necessarily know how to assess air operator safety. Rather, they count on the fact that the air carriers have valid EU air operator licences.

5.3 The goals of audits

Despite the authorities' audits on safety management systems and the operators' self-monitoring, some operators have significant shortcomings in flight safety. The oversight authorities should have the capacity, methods and competency to extend the audits to the implementation of safety management systems and to the assessment of flight safety.

The Safety Investigation Authority recommends that

> The European Union Aviation Safety Agency (EASA) ensure that the audits conducted by the EU Member States on operators also cover the practical functioning and performance of safety management systems. [2019-S59]

5.4 Ending the use of magnetic tape recorders

Flight data recorders (FDR) recording on magnetic tape are clearly less reliable than modern devices. Recordings that are of poor quality, or altogether missing, make it significantly harder for the safety investigation to establish the sequence of events.

The Safety Investigation Authority recommends that

> The European Union Aviation Safety Agency (EASA) set a deadline for the use of flight data recorders recording on magnetic tape. [2019-S60]

On 26 April 219 the UK Air Accidents Investigation Branch (AAIB) also issued a safety recommendation (UNKG-2091-002) to the EASA on ending the use of flight data recorders recording on magnetic tape. In its reply on 26 June 2019 the EASA reported that replacing the FDRs that use magnetic tape would most probably be allocated a low priority.

The process of replacing cockpit voice recorders (CVR) recording on magnetic tape with modern ones is farther ahead. Annex 6 to the Convention on International Civil Aviation has recommended that the use of magnetic tape FDRs and CVRs be discontinued by 1 January 2016. The EASA is the only body which can implement the ICAO's recommendation. The EASA banned the use of cockpit voice recorders recording on magnetic tape effective 1 January 2019, but has not done the same for flight data recorders.

To improve the reliability and quality of data recorded by FDRs and CVRs, EASA initiated a rule making task (RMT. 0249) in 2016. The corresponding amendment proposal (NPA 2019-12) has been sent for comments on 13 November, 2019.

5.5 Implemented measures

There are no known measures that have been implemented since the accident.

REFERENCES

Documents

AAIB (2019) Investigation of a serious incident to British Aerospace (BAe) ATP, SE-MHF. AAIB Bulletin: 5/2019: 3-17. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/797029/AAIB_Bulletin_5-2019_Lo_Res.pdf. Date viewed 16.7.2019.

Hawkings, F. H. (1987) Human Factors in Flight. Aldershot: Gower Publishing Company.

ICAO (2018) Annex 6 to the Convention on International Civil Aviation, Operation of Aircraft, Part I — International Commercial Air Transport — Aeroplanes. https://store.icao.int/annex-6-operation-of-aircraft-part-i-international-commercial-air-transport-aeroplanes.html. Date viewed 16.7.2019.

ICAO (2016) Aerodrome Design Manual. Part 1: Runways. https://store.icao.int/aerodrome-design-manual-runways-3rd-edition-2006-doc-9157-part-1-english-printed.html. Date viewed 16.7.2019.

Safety Investigation Authority Finland (2008) Airliner veering off the runway at Lappeenranta airport on 31 January 2008. Investigation report B1/2008L.

Safety Investigation Authority Finland (2012) Risk of Runway Collision Between Two Airliners at Helsinki-Vantaa Aerodrome on 29 December 2011. Investigation report L2012-01.

Safety Investigation Authority Finland (2012) Risk of an Airliner Colliding with Terrain in the Vicinity of Mariehamn Airport on 14 February 2012. Investigation report L2012-02.

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

Sarter, N. B. & Woods, D. D. (1991) Situation Awareness: A Critical but Ill-Defined Phenomenon. The International Journal of Aviation Psychology, 1(1): 45-57.

Swedish Accident Investigation Authority (2014) Serious incident at Pajala Airport on 13 February 2013 involving the aircraft ES-PJB of model Jetstream 3102 operated by AS Avies. Final report RL 2014:01e.

Swedish Accident Investigation Authority (2019) Runway excursion at Trollhättan/Vänersborg airport involving the aeroplane YL-RAI of the model ATR 72-202. Investigation report L-145/18.

Weick, K. (1988) Enacted Sensemaking in Crisis Situations. Journal of Management Studies, 5(4): 305-317.

Investigation material

1) Site investigation photos, measurements and other data.
2) Photos from the police's accident scene investigation.
3) The Finnish Meteorological Institute's weather data.
4) Interviews.
5) Aircraft damage report.
6) Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR) recordings.
7) The airline's operating manuals.
8) Finavia's runway inspections at Savonlinna on 7.1.2019.
9) Finavia's manuals and guidelines.
10) ANS Finland's Aeronautical Information Publication (AIP).
11) ANS Finland's radio and telephone recordings.

SUMMARY OF COMMENTS TO THE DRAFT FINAL REPORT

The draft final report was sent for comments to the Ministry of Transport and Communications, the European Commission, the European Union Aviation Safety Agency (EASA), the Finnish Transport and Communications Agency, the City of Savonlinna, the Emergency Response Centre Administration, the National Police Board, Finavia, ANS Finland, the Rescue Service Region of South Savo, the Swedish Accident Investigation Authority (SHK), the UK Air Accidents Investigation Branch (AAIB), the Latvian Transport Accident and Incident Investigation Bureau (TAAIB), the Latvian Civil Aviation Agency, Maavoima, RAF-AVIA airline, the aircraft manufacturer SAAB as well as the AFIS officer on duty and the crew of the aircraft. Pursuant to the Safety Investigation Act, no comments given by private individuals may be included in the investigation report.

The European Commission (EC), in its comments, considers market access to be important. This is why safety requirements beyond what is required in the AOC process should not be imposed. It is the view of the EC that stricter requirements would unduly restrict market access. The only exception in certain limited cases, according to the Commission, pertains to air carriers complying with local requirements at airports. The European Commission suggests removing the safety recommendation addressed to the EC and redrafting the conclusions in line with the abovementioned reasoning.

The European Union Aviation Safety Agency (EASA) thanks the SIAF for the fruitful discussion maintained during the preparation of the draft report. According to the EASA, the draft report gives the impression of a thorough investigation narrating an important range of safety issues in considerable depth. The EASA particularly mentions the detailed investigation of the chain of events concerning the positioning of the flight and landing flight phases, despite the lack of a CVR recording and the poor FDR data that hampered the investigation into the sequence of events.

The EASA's comments focus on the proposed safety recommendations (SRs). The EASA suggests that the draft SR on setting a deadline for the use of flight data recorders recording on magnetic tape be reviewed. Rather, the safety recommendation should aim at ensuring that national aviation authorities verify that their operators fully comply with CAT.GEN.MPA.195 which provides for the correct handling of flight data recorders.

While the EASA accepts the recommendation concerning audits covering the practical application of SMS, it asks whether the operator's SMS records indicate any weaknesses in, for example, flight crew competencies or crew resource management training effectiveness.

The EASA feels that the investigation report addresses competition aspects at a rather 'high level', and deems it beneficial that the SIAF dig somewhat deeper into the area of assurance of compliance with the existing EU Ops rules. The EASA would also like to know whether the operator and/or CAA-N have taken any action in response to this occurrence. The EASA suggests certain individual changes to the draft investigation report.

The Finnish Transport and Communications Agency suggests changes to the way the safety recommendations 5.1, 5.2 and 5.3 are formulated. According to the suggestions, however, the essence of the recommendations would remain unchanged.

The [municipal government of the] City of Savonlinna states that it does not have any comments to the draft final report. In future public tenders for air services the City aims to take into account the topics presented in the report's conclusions.

The Emergency Response Centre Administration states that the Kuopio ERC had only introduced the new ERICA information system in the spring of 2019. This being the case, the ERC operator's task management is assessed on the basis of the instructions that were in place at the time of the occurrence.

At the time she was receiving the first notification of the accident the ERC operator double-checked if there was a need to dispatch any additional help to the site. There was not. On the basis of the notification she recorded the task under the rescue services category H31 (info, guidance). The instructions for this category do not require making a separate report for the rescue coordinator/commander P3.

The second notification requested a police patrol to the site. On the basis of the AFIS officer's report the ERC operator removed rescue service and health care units from the category's normal response. Therefore, the information was still not relayed to the rescue services' P3.

According to the ERC Administration the noteworthy thing in the occurrence is the fact that the assessments of air traffic controllers or AFIS officers, particularly, may lead the ERC operator to take decisions countering their instructions, as the assessment is coming from an authority responsible for the safety of aviation. This is further emphasised by the infrequent nature of aviation accidents or incidents, because they do not establish routine practices to ERC operators. This, in the opinion of the ERC Administration, should be taken into account in air traffic controller or AFIS officer training.

Especially is the estimate of whether the situation constitutes an 'aviation accident or aviation emergency' significant because it may require the ERC operator to take non-standard decisions on the basis of rescue service guidelines, which, in turn, impact the contents of the response.

The ERC Administration agrees with the premise of the draft report in that the authorities responsible for rescue activities should have been informed of the occurrence so as to implement the required preparedness action and to evaluate the needed measures. The ERC operator, according to the ERC Administration, should have complied with the authorities' instructions by alerting the rescue services and other authorities. Upon comprehensive reflection, the scope of the alert could have then been reduced, as was done on the basis of the second notification.

The National Police Board has no comments to the draft final report.

Finavia, in its comments, clarifies that the company has one common safety management manual which all of its aerodromes follow as such. Finavia also clarifies that, after the runway conditions have been inspected, the information system used by airport maintenance generates a SNOWTAM bulletin and transmits it directly to the AFS network for distribution. Finavia also provides some supplementary information with regard to the draft final report's section on airport rescue preparedness.

ANS Finland, in its comments, clarifies that for reporting runway conditions Savonlinna airport uses the Runway Reporter system which generates a SNOWTAM bulletin. ANS Finland also clarifies that on 21 February 2018 Aviation Regulation AGA M3-11 was repealed and replaced by Aviation Regulation GEN M1-16.

The Swedish Accident Investigation Authority (SHK) finds the investigation report very interesting and considers its findings typical for small, regional airlines. SHK also suggests small corrections on some points of the report.

The UK Air Accidents Investigation Branch (AAIB) suggests small corrections on some points of the report.

Maavoima, in its comments, questions the impartiality of the SIAF investigators in this investigation. Maavoima justifies this on the basis of the investigators' past and present occupations in the field of aviation.

Maavoima says that the Safety Investigation Authority Finland should be wary of favouring motives that support domestic operators flying regional routes even though they could not win market-based tenderings.

On the basis of experience, Maavoima maintains that all airlines have had, and will have, shortcomings in aviation safety. Maavoima believes that the SIAF should have compared the investigated air carrier's shortcomings with those of its peer group.

Maavoima disagrees with the SIAF's finding that the number of the airline's internal safety deviation reports does not sound credible when compared with the company's monthly flight hours. In its comments Maavoima states that the total flight hours of RAF-AVIA's entire fleet in 2018, cargo flights included, were on average one and a half times higher than the number presented in the investigation report. Maavoima also emphasises that FRAF-AVIA has never had accidents resulting in fatalities.

Maavoima underscores that it has no legal obligation to investigate air carriers' safety levels or query their domestic safety records from EASA and ICAO databases when selecting its operators. Maavoima also says that it, in its safety management system, has no obligation to maintain procedures for evaluating operator safety. Maavoima requests that the SIAF remove these findings from the investigation report because there is no legal basis for such requirements.

Maavoima finds the SIAF's findings "the award was solely decided on the basis of the lowest price offered", "no additional conditions for safe operations were stipulated in the public tender launched by the Finnish Transport Agency", and "operator safety [in practice] was not set as a criterion in the public tender" erroneous. Maavoima defends this claim by stating that the purchaser of air services has the right to rescind the transport acquisition contract, should the air carrier lose its air operator licence or operating licence, or continually disregard the quality of service.

The investigation report states that "... in its introduction the [Air Services] Act states that recognising the potential link between the financial health of an air carrier and safety, more stringent monitoring of the financial situation of air carriers should be established". According to Maavoima this quotation from the Air Services Act constitutes an unfounded assertion that RAF-AVIA has these kinds of financial difficulties.

Maavoima deems that the Safety Investigation Authority Finland deliberately chose incidents that happened specifically to Eastern European air carriers as the other comparable incidents in winter conditions for this investigation report.

Maavoima maintains that the investigation report may be attempting to create the impression that an aviation safety regime that complies with EU regulations does not guarantee the safety of aviation, and that a commercial aviation safety consulting business could be established alongside the EU's aviation safety regime.

Maavoima wants to have the following conclusion, regarding operators' self-monitoring systems, deleted from the investigation report: "... maintaining and improving the operator's flight safety is largely left to its own interests". The reason why Maavoima wants this deleted from the report is that it has not identified any such features in the activities of RAF-AVIA, its partner.

Maavoima wants the first four conclusions to be deleted from the investigation report because it deems them to be unfounded. Maavoima believes that the second and third conclusions are erroneous. In addition, Maavoima wants the recommendations “5.1 Taking safety issues into account in tendering” and “5.2 Safety assessment among airlines” to be deleted from the investigation report for being unnecessary.

The RAF-AVIA airline states in its comments that the investigation report contains no evidence of the authentic runway conditions at the time of the accident. The company says that the investigation report presents no verification of Skiddometer measurements, nor does the report mention the weather reporting of the flight crew. The company also says that the investigation report omits the weather information received by the flight crew.

In its comments the airline asks how the friction measuring vehicles were being used on the runway during the claimed 1 hour and 52 minutes as the runway friction remained “poor”. The airline says that its flight crew was never warned about the cleared width of the runway and of the snowbank on the runway. RAF-AVIA states that, according to the AIP, the width of the runway is 45 m.

Through its comments RAF-AVIA wants to ensure that the values from the final stages of the landing are correctly read from the flight data recordings. It also asks how far off from the runway centreline the aircraft was at the time of touchdown. RAF-AVIA clarifies that the person travelling on board the aircraft was a ground engineer. In its comments the company also asks whether the investigation group includes a type-rated pilot for SAAB 340 aircraft.

The aircraft manufacturer SAAB finds the draft report comprehensive, well written and that it describes the course of the event in a good manner. SAAB suggests that the report be more specific and clarify which manuals are referred to in the text. In addition, SAAB would specify the report’s section concerning maximum crosswind components in the airline’s operating manuals.