Corporate Aircraft Collision with Lamp Post during Warm-up Run at Kemi-Tornio Airport on December 5, 2021

L2021-05

FOREWORD

Pursuant to section 2 of the Safety Investigation Act (525/2011), the Safety Investigation Authority of Finland (SIAF) decided to investigate an aircraft accident that occurred at Kemi-Tornio airport on December 5, 2021. The purpose of a safety investigation is to promote general safety, the prevention of accidents and incidents, and the prevention of losses resulting from accidents. A safety investigation is not conducted in order to allocate legal liability.

Master of Arts Kalle Brusi was appointed the investigation team leader. The appointed team members were air transport pilot (retired) Heikki Kasurinen and Master of Science in Aeronautical Engineering Tuomas Tuisku. The investigator-in-charge was Chief Air Safety Investigator Janne Kotiranta.

The Transportation Safety Board of Canada (TSB) and the Air Accidents Investigation Branch (AAIB) of the United Kingdom appointed accredited representatives for the investigation. The European Aviation Safety Agency (EASA) appointed a technical advisor for the investigation.

The safety investigation examines the course of events, their causes and consequences, search and rescue actions, and actions taken by the authorities. The investigation specifically examines whether safety had adequately been taken into consideration in the activity leading up to the accident and in the planning, manufacture, construction and use of the equipment and structures that caused the accident or incident or at which the accident or incident was directed. The investigation also examines whether the management, supervision and inspection activity had been appropriately arranged and managed. Where necessary the investigation is also expected to examine possible shortcomings in the provisions and orders regarding safety and the authorities' activities.

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

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

The investigation report was translated into English by TK Translations.

The investigation report and its summary were published on the SIAF's internet page at *www.turvallisuustutkinta.fi* on December 8, 2022.

Investigation designator: L2021-05
Investigation report 9/2022
ISBN: 978-951-836-640-2 (PDF)

Cover photo: SIAF

CONTENTS

1 EVENTS

1.1 Sequence of Events

A Cessna C560XL aircraft operated by Air Charter Scotland landed at Kemi-Tornio airport on Thursday December 2, 2021. The aircraft taxied to the apron and parked on stands 3 and 4 at an angle relative to the terminal building (**Figure 1**). An apron service worker of Groundpower, which was providing ground handling services, received the aircraft and placed chocks fore and aft of the nosewheel. The return flight to Edinburgh was set to depart on Sunday December 5. The aircraft remained parked for almost three days, and its engines were not operated during this period.

The pilots arrived at the aircraft on the day of departure at approximately 1100 h. After removing the aircraft covers, they conducted an exterior inspection and carried out preparations for warming-up the cold-soaked aircraft. Because no external heaters were available and the aircraft did not have an APU[1], this could only be done by running the engines. Outside air temperature had dropped to approximately -26 ˚C overnight and during the morning. During pre-start checks the pilots noticed that the brake system circuit breaker[2] had tripped and the brake system annunciator light[3] was illuminated. After calling the company's line maintenance controller they assumed that the indication was caused by extended parking in sub-zero temperatures.

Following start-up, engine power was increased in small increments during approximately 40 min, and after approximately 30 min the circuit breaker was reset, but the annunciator light remained on. Oil temperature in both engines increased slowly, and the pilots decided to carry out a deicing systems test. Power was increased on the right engine while power on the left engine was simultaneously reduced.

As a result, the aircraft moved forward unexpectedly. The nosewheel pushed the front chock over a thin layer of compacted snow for a short distance until the chock slid aside, off the wheel's track. The captain applied brakes to stop the aircraft, to no effect. He simultaneously reduced power on the engines to idle and used nosewheel steering to maneuver the aircraft to the right, away from the terminal building (**Figure 2**). However, the left wing leading edge struck a metal lamp post at the edge of the apron at approximately 1238 h. The aircraft rotated approximately 90˚ to the left relative to the direction of travel and came to a halt with the nosewheel in snow at the edge of the apron. The captain cut off fuel supply to the engines soon after the impact. The distance that the aircraft traveled was approximately 20 m.

Another, slightly larger, corporate aircraft of the same operator was parked to the right of the accident aircraft approximately 20 m away and was being prepared for flight by two apron workers. This aircraft was occupied by two pilots. One of the apron workers had observed engine start of the accident aircraft and witnessed the impact.

The impact created a dent in the wing leading edge that extended all the way to the wing spar (**Figure 4**). The cable from a ground power unit (GPU) had been connected to the aircraft. Bending force imparted by the cable plug on the fuselage-mounted receptacle caused deformation of the receptacle. The accident did not result in injuries.

---

1 Auxiliary power unit.
2 PWR BRKS.
3 LO BRK PRESS ANTI-SKID INOP.

The pilots exited the aircraft immediately after the impact. An air traffic controller who had just started his shift in the control tower next to the accident location saw the impact. He alerted the airport rescue service and emergency response center (ERC) service and advised that the aerodrome was temporarily closed to operations.

The times given in this report are Finnish standard time (UTC + h).

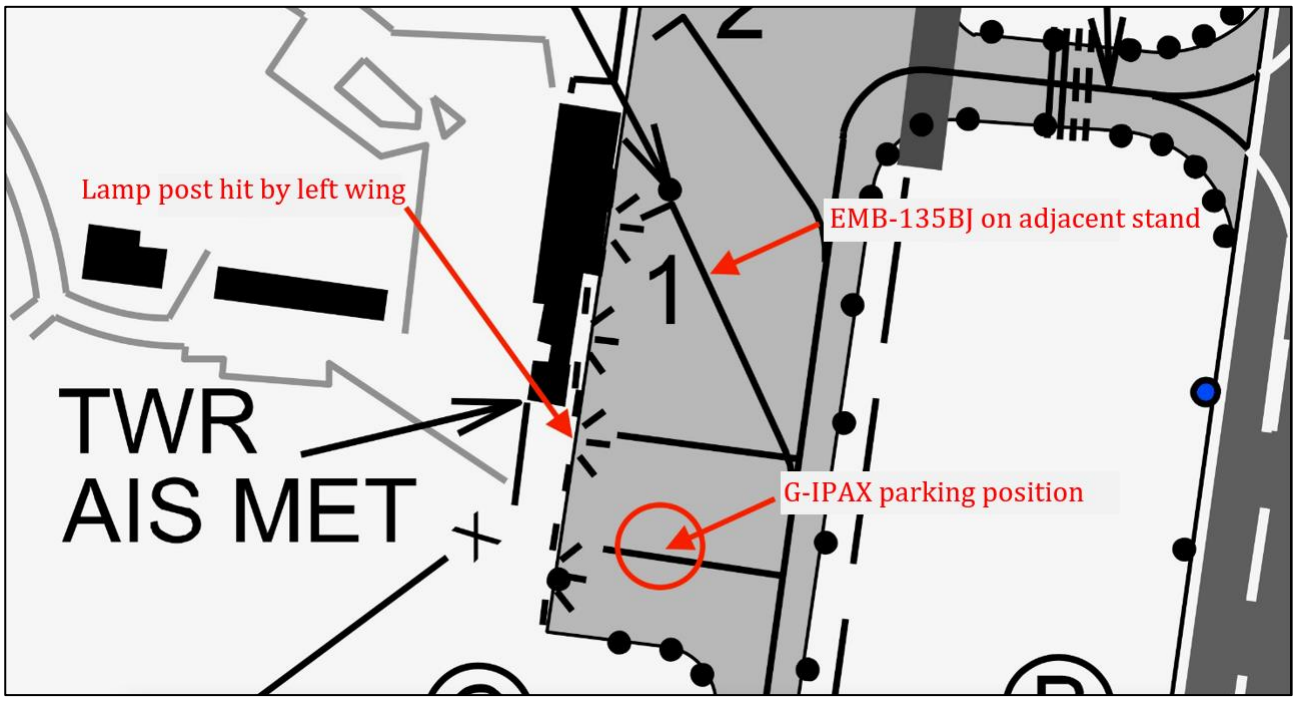


Figure 1 The apron chart of Kemi-Tornio aerodrome with arrows pointing at aircraft locations before the accident. G-IPAX is the accident aircraft. G-SUGR is another company aircraft. The map also shows lamp posts and aerodrome buildings. (Photo: Fintraffic ANS. Annotations: SIAF)

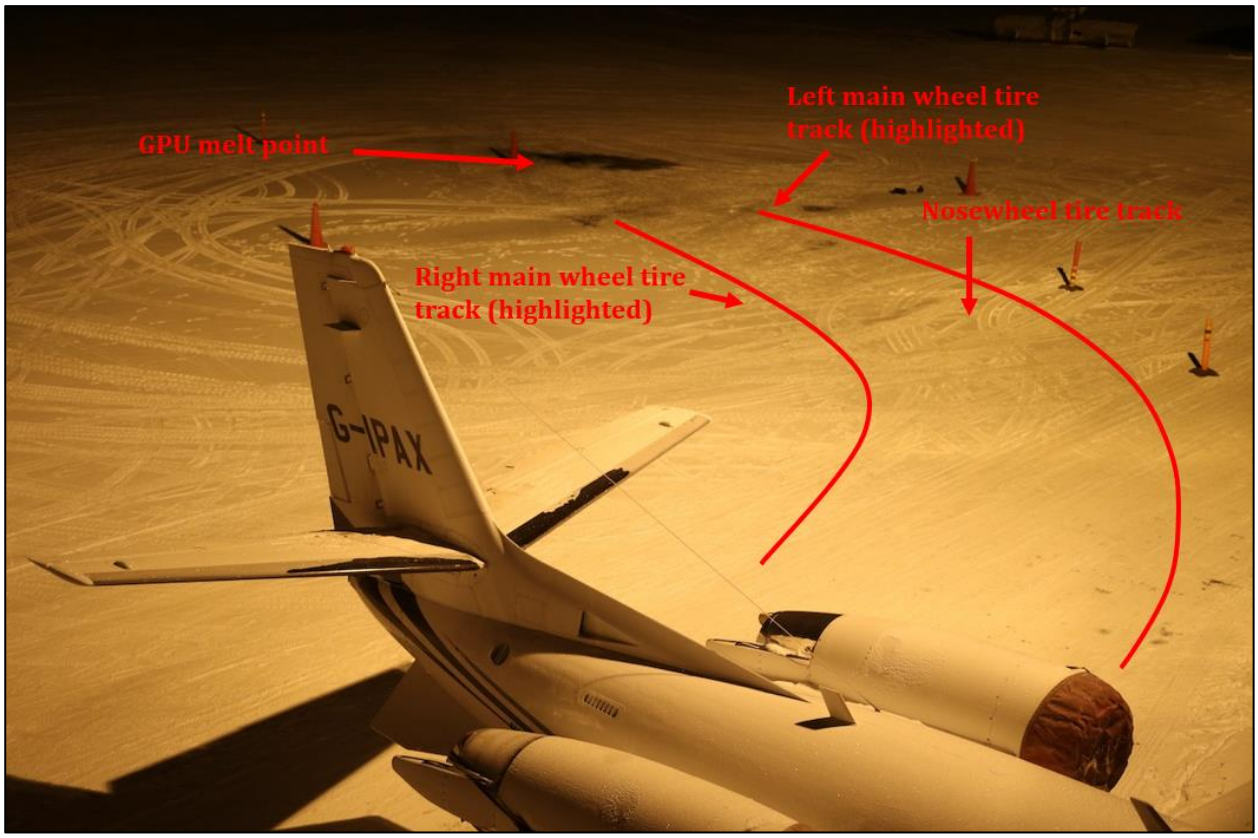


Figure 2 The red lines indicate the tire tracks created during aircraft movement. The photo was taken in the evening of December 5 before the aircraft was moved from the accident location. The wheel chocks on the background are not in their original positions, and the GPU has been removed. (Photo: SIAF)

1.2 Alerting and Rescue Operations

The air traffic controller had just started his shift, and he advised at 1230 h on frequencies that local air traffic control services were available[4]. He saw the impact from the control tower that is right next to the accident location and alerted the airport rescue service to respond to an aircraft in distress. He called the ERC in Oulu at 1241:26 h, and while the call was ongoing, he upgraded the alert to the rescue service to a response to a full emergency. Rescue service units were the first responders to arrive at the aircraft, and their crews made an initial assessment of the situation.

After evaluating the emergency based on the controller's call, the ERC operator rated the occurrence initially as *aviation accident hazard, minor* (code 234B) and initiated a corresponding alert procedure at 1244:17 h. After receiving additional information - a notification of an aircraft swerving at the airport and a wing impacting a lamp post - the operator upgraded the rating *to aviation accident, serious* (232A) and alerted additional units at 1247:23 h.

The first emergency response unit (call sign RLA111) arrived at the aircraft at 1246:58 h. After assessing the situation, the crew chief decided that all alerted units would not be needed and reported this to the on-duty fire officer (P30), who as the incident commander called back other emergency response units. In addition to airport rescue service units, two emergency

[4] When the control tower is manned the aerodrome and its terminal control area are Class D airspace.

response units, a paramedic unit and a police patrol arrived on scene. The rescue operation was under remote command and control from the ERC's situation center. After rescue unit crews had inspected the accident site and interviewed the pilots it was concluded that no additional hazard existed, and the emergency response units and the paramedic unit departed the aerodrome.

The police patrol breath tested the pilots. The results showed 0.00 mg of alcohol per one liter of exhaled air for both pilots. The controller explained that he closed the aerodrome at 1301 h to create a secure working environment for the authorities.

The Safety Investigation Authority of Finland (SIAF) was notified of the accident and began an on-site investigation at approximately 1900 h on the same day.

1.3 Consequences

The leading edge of the aircraft's left wing struck a metal lamp post at the edge of the apron. As a result, the aircraft's direction of travel changed approximately 90° to the left, and the aircraft came to a gradual halt when the nosewheel rolled into a layer of snow at the edge of the apron. The impact with the heavy-duty lamp post created a deep dent in the aluminum leading edge skin that extended all the way to the wing spar. The lamp post showed no bending or impact marks. Damage to the aircraft is described in paragraph 2.1.3.

The cable from a mobile GPU was connected to a receptacle located in the aft fuselage. Aircraft movement pulled the cable tight, which in turn imparted a bending force on the receptacle causing deformation of the receptacle and a depression in the fuselage. The cable separated from the aircraft soon afterwards. No damage to the GPU was reported.

The accident did not result in injuries. The aircraft was occupied by two pilots. Two ground handling company workers were on the apron at the time of the accident preparing another corporate aircraft for flight. This aircraft was parked on an adjacent stand and was occupied by two pilots.

No signs of the leakage of fuel, oil or other liquids were observed on the apron.

2 BACKGROUND INFORMATION

2.1 Environment, Equipment and Systems

2.1.1 Aerodrome

Kemi-Tornio aerodrome (EFKE) is on the coast of the Bay of Bothnia approximately 5 km north of the town of Kemi. It is operated by Finavia, and local air traffic control services are provided by Fintraffic ANS. The aerodrome has a single asphalt runway (18/36), an apron with four parking stands and a terminal building. The stands are marked by lines that are often snow-covered in winter. The aerodrome is in year-round operation. Primary winter maintenance equipment include plow sweeper blowers, snow plowers and de-icer spreaders[5]. The aerodrome has a non-insulated hangar, which at the time of the accident was reserved for an aircraft providing scheduled commercial services to the aerodrome.

The aerodrome's automatic weather observation station provides AUTOMETAR weather information to airmen. Weather forecasts are provided by the associated meteorological office in Rovaniemi. NOTAMs[6] and SNOWTAMs[7] were available for the aerodrome.

The operational hours of the aerodrome and the control tower are given in NOTAMs. A formal request to Finavia will be needed to open the aerodrome outside the promulgated hours.

Figure 3 An aerial view of Kemi-Tornio aerodrome apron and structures. (Photo: Karttapaikka ©National Land Survey of Finland)

5 AIP Finland.

6 Notice to airmen. An advisory, distributed by means of telecommunication, that contains information concerning the establishment, conditions or change in any aeronautical facility, service, procedure or hazard, the knowledge of which is essential to personnel concerned with flight operations.

7 A special series NOTAM notifying, by means of a specific format. the presence or removal of hazardous conditions due to snow, ice, slush or standing water associated with these deposits on the movement area.

2.1.2 Aircraft and Operator

The accident aircraft was a Cessna C560XL corporate aircraft bearing the registration G-IPAX. The serial number of the 2002-built airframe is 560-5228. The aircraft, operated by Air Charter Scotland, has a flight crew of two pilots and can carry nine passengers. The minimum flight crew requirement is two pilots.

The aircraft is powered by two rear-mounted Pratt & Whitney PW545A turbofan engines. The accident aircraft does not have an APU. The length of the aircraft is 15.80 m, wing span 17.17 m and maximum takeoff mass 9,072 kg.

The documents of the operator and the aircraft were valid at the time of the accident and met the requirements for commercial air transport operations. Air Charter Scotland performs passenger and cargo transport operations under an air operator certificate (AOC)[8] granted by the Civil Aviation Authority of the United Kingdom (UK CAA).

The company's 11-aircraft fleet consists of six aircraft types as listed in the AOC.

2.1.3 Wreckage and Impact Information

SIAF investigators examined the aircraft in the evening of December 5 before the aircraft was moved from the apron. Examination showed that the impact had caused substantial damage to the left wing leading edge and the wing spar, which is a structural member of the wing (**Figure 4**). It was also found that the GPU receptacle and adjacent rear fuselage structure had been damaged when the GPU output cable was pulled tight as the aircraft moved forward and imparted a bending force on the receptacle. The receptacle and damaged structure were located aft of the rear pressure bulkhead and therefore were not part of the pressure hull.

The aircraft operator's maintenance organization subsequently carried out damage assessment and repairs in a hangar at the aerodrome. SIAF representatives visited the site twice to observe damage assessment and the progress of the repairs and to gather technical information for the investigation. A representative of the aircraft manufacturer also visited the site to provide guidance on the repairs.

Figure 4 The dent in the left wing leading edge extends all the way to the wing spar. (Photos: SIAF)

[8] AOC no. GB 1291. The operator also holds continuing airworthiness management organization (CAMO) certificate no. UK.MG.0006.

Figure 5 The GPU receptacle pins exhibited bending, and the fuselage skin around the receptacle was deformed under cable tension. (Photo: SIAF)

2.1.4 Brake System

The toe-actuated mainwheel brakes are operated by pressure provided by a self-contained hydraulic system that is independent of the aircraft's main hydraulic system. An accumulator, an electrically operated hydraulic pump and a hydraulic reservoir in the nose compartment provide pressure to the brakes.

The aircraft has a manually operated pneumatic emergency brake system consisting of a nitrogen blow-down bottle in the nose compartment and an emergency brake handle under the left instrument panel. The bottle is accessible via two hinged doors on either side of the nose cone. Pulling on the handle applies equal pressure to the brakes. Releasing the back pressure on the handle will relieve the pressure. The system description states that a fully charged bottle contains sufficient pressure for at least 10 full brake applications.

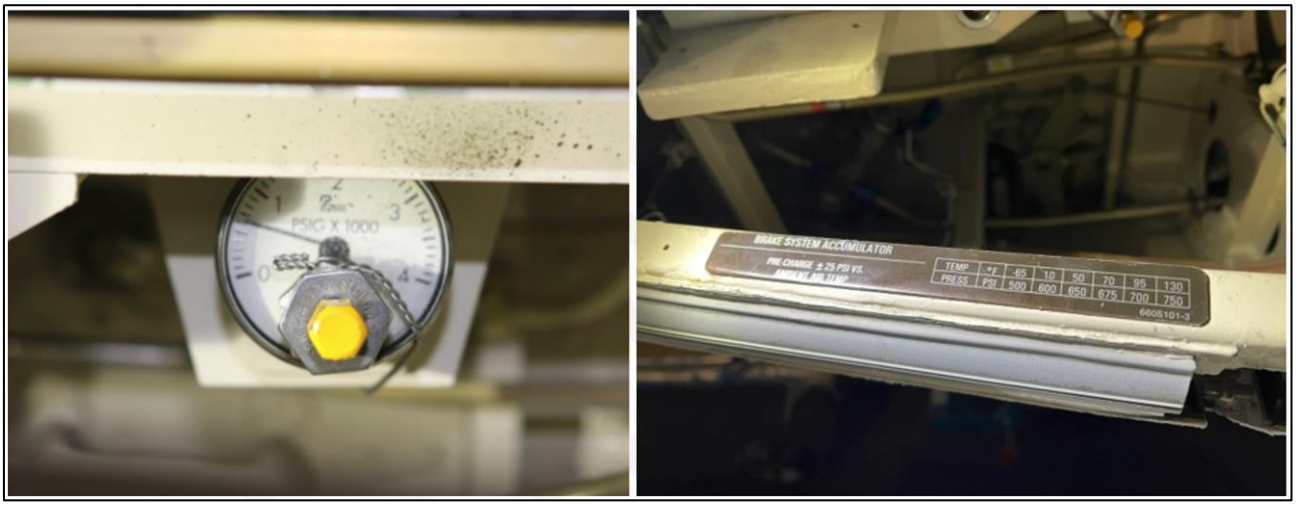
Although the nose compartment is unpressurized and has no thermal insulation, avionics equipment installed in the compartment generate a considerable amount of heat that raises compartment temperature relative to ambient temperature, particularly on the ground but also in flight.

The aircraft's minimum equipment list (MEL) states that the brake system must be fully operational before departure. During the accident, cold-soaked systems were being prepared for departure. By definition, a flight begins when the aircraft begins to move under its own power for departure.

The on-site investigation on December 5 showed that the brake system circuit breaker was tripped. The 15 A circuit breaker is in a panel next to the left cockpit seat (**Figure 6**).

The aircraft was moved into a hangar on December 8 for damage assessment and repairs by the operator's maintenance organization. A SIAF investigator observed brake system examination before the commencement of the repairs. It was found that the accumulator pressure gage read 650 psi. An adjacent placard indicates that pressure in the prevailing hangar temperature of -10 °C (14 °F) should be approximately 600 $\pm$ 25 psi, which means that system pressure had been at or above minimum at the time of the accident.

Figure 6 Left: The circuit breaker panel next to the left seat. The arrow points at the tripped brake system circuit breaker (PWR BRKS), which would not reset during the functional test on December 8. Right: The arrow points at the emergency brake handle forward of the left seat. The location behind the control column - which is partially visible in the photo - may cause difficulty in handle operation. (Photo: SIAF)



Kuva 7 The brake system accumulator pressure gage read approximately 650 psi three days after the accident on December 8. According to the adjacent placard, this was sufficient in the prevailing temperature. Temperature of -10 °C equals 14 °F. (Photo: SIAF)

Kuva 8 The emergency brake system pressure gage read approximately 1,720 psi on December 8. According to the placard, this was sufficient in the prevailing temperature. (Photo: SIAF)

The operator's mechanics performed a brake system functional test three days after the accident on December 8. When the brake system circuit breaker was reset with aircraft systems powered-up, the circuit breaker tripped immediately, and the hydraulic pump - which would have been audible in the cockpit - did not operate. The circuit breaker was replaced. A subsequent functional test revealed that the circuit breaker would remain in the reset position initially, but when the systems were powered-up, it would trip immediately. In the test, the pump started and ran for a very short period of time until the circuit breaker tripped and the pump was de-energized. The circuit breaker is an on-condition item[9].

2.2 Conditions

2.2.1 Weather and Weather Observations

Weather at Kemi-Tornio aerodrome at the time of the accident at approximately 1238 h on Sunday December 5 was dry with clear skies. Outside air temperature was approximately -26 ˚C and wind was from the north at 2 to 4 kt. After the aircraft's arrival on Thursday December 2, the aerodrome weather facility had recorded temperatures varying between -10 °C and -4 °C. Temperature had begun to drop on Saturday December 4 (**Figure 9**), and in the evening and during the following night it had remained variable between -20 °C and -26 °C.

[9] A component that is replaced when its condition is not within approved limits.

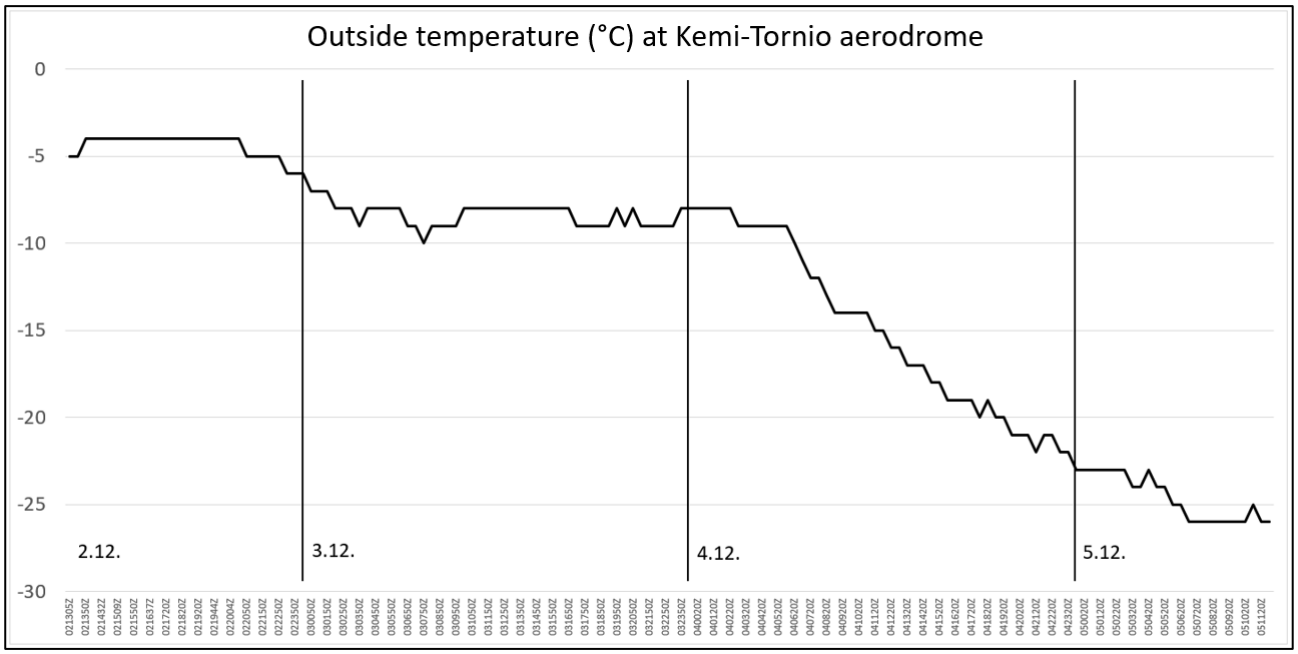


Figure 9 Outside air temperature (°C) at Kemi-Tornio aerodrome as derived from automatically generated twice-hourly meteorological aerodrome reports (METAR). Times are UTC. They are converted to Finnish time by adding two hours to the indicated times. (Photo: SIAF)

2.2.2 Apron Conditions

The on-site investigation and weather information suggested that at the time of the accident the apron was covered with a thin deposit of dry compacted snow and a small amount of loose snow (**Figure 10**). Aerodrome maintenance had reported Skiddometer-measured friction on the apron as medium. Relatively low temperatures but otherwise normal winter conditions existed on the apron.

Examination showed that the aircraft's wheels had made impressions in the snow during the parking of nearly three days, which had increased static friction. Wheel tracks indicated that the mainwheels had rotated during the aircraft’s movement with little or no signs of locking.

Figure 10 A photo taken in the evening of the day of the accident showing the track of one mainwheel tire. The melt spot indicates the parking position of the tire. The track shows that the wheel has rotated most of the time. The apron is covered with a thin deposit of dry compacted snow and a small amount of loose snow. (Photo: SIAF)

2.3 Recordings

2.3.1 Flight Recorder Information

The aircraft's CVR and FDR[10] were removed by the operator's mechanics under the supervision of SIAF investigators on December 8 and sent to French Bureau of Enquiry and Analysis for Civil Aviation Safety (BEA). The BEA downloaded audio data and FDR raw data and made necessary conversions. The accident aircraft's FDR records several dozens of essential regulatory parameters including speed, heading and accelerations. The frequency of the parameters varies. Brake pedal and emergency brake handle positions and the condition of brake system annunciator lights are not recorded.

2.4 Personnel, Organizations and Safety Management

2.4.1 Flight Crew Actions

Arrival at Kemi-Tornio

The planned destination of the inbound flight from Edinburgh on December 2 had been Kittilä, but based on weather information on December 1, the destination was changed to Kemi-Tornio. The pilots reported no anomalies in aircraft systems during or after the flight,

[10] Cockpit voice recorder and flight data recorder.

and the brakes had operated normally. The aircraft was marshaled by an apron worker to snow-covered stands 3 and 4 and parked at an angle relative to the terminal building, which is a standard procedure at the aerodrome to enable taxiing-out under engine power. Apron workers chocked the nosewheel fore and aft and placed safety cones around the aircraft.

The pilots prepared the aircraft for parking and talked to the apron workers, but wheel chocking was not discussed. The flight manual[11] instructs to set the parking brake during normal parking, while stating that parking brake operation has not been tested for extended parking at -15 ˚C or below. The pilots did not set the parking brake.

Warm-up Run and Loss of Control

The return flight was set to depart at 1400 h on December 5. The pilots arrived at the aerodrome in good time, approximately three hours before the departure time, recognizing the freezing temperature and the fact that the aircraft had remained parked for nearly three days. The pilots explained that they had prepared the aircraft for a warm-up run by removing airframe and engine covers from their respective sides, and the first officer stated that he had conducted a walk-round[12].

The pilots had intended to run the engines for approximately 30 min to raise cabin temperature to the required value of +10 ˚C, then shut down the engines and move into the terminal building to continue preflight preparations. Since no high-capacity movable heater was available and the aircraft did not have an APU, the only warm-up option was to run the engines[13].

The captain, on the left seat, powered-up the aircraft, and the FDR and CVR started recording. The copilot occupied the seat behind the captain and had a view into the cockpit over the captain's shoulder. The captain checked aircraft systems using the applicable checklist.

While conducting the checks, before engine start, the pilots noticed that the brake system circuit breaker (PWR BRKS) had tripped and the brake system annunciator light (LO PRESS ANTI-SKID INOP) in the center instrument panel was illuminated. The pilots executed the respective checklist items. The captain decided to call the operator's LMC[14] for advice; after hearing the LMC's opinion, the pilots concluded that the indication was probably due to extended parking in sub-zero temperatures, and it would be necessary to connect an electric heater to the avionics compartment later to warm up the hydraulic pump.

After discussing specific items of the cold-start procedure the pilots started first the right and then the left engine. FDR data showed that engine power was increased during approximately 40 min in small increments after start-up. After running the engines for approximately 30 min, the captain reset the PWR BRKS circuit breaker, which remained reset, but the LO BRK PRESS ANTI-SKID INOP light remained illuminated.

Engine oil temperatures rose slowly, and the pilots elected to carry out a deicing systems test. The pilots explained that while engine and empennage deicing systems tested good, engine power was insufficient for a successful wing deicing test. They assumed - this was corroborated by the CVR recording - that the aircraft was "double-chocked"[15] and had

---

11 Aircraft Flight Manual Revision 13 (July 23, 2015). Normal Operating Procedures, p. 3–114.
12 Exterior inspection of an aircraft.
13 Using engine bleed air.
14 Line maintenance controller.
15 "Double-chocking" means placing chocks fore and aft of the nosewheel and one mainwheel.

remained stationary so far. To complete the test, power was increased on the right engine while power on the left engine was reduced simultaneously.

As a result, the aircraft began to move unexpectedly. Tracks in the snow indicated that the nosewheel pushed the front chock over a thin layer of compacted snow for a short distance until the chock slid aside, off the wheel's track. The captain stated that he applied brakes, but they did not respond, and at the same time reduced power on the engines to idle and managed to maneuver the aircraft to the right, away from the terminal building, by using nosewheel steering[16]. He cut off fuel supply to the engines soon after impact.

The flight manual[17] states that when a tripped PWR BRKS circuit breaker is reset but the LO BRK PRESS ANTI-SKID INOP light remains illuminated, the emergency brake system should be used. This was not done in the accident under investigation. The captain explained that he had acted on "muscle memory" and had not considered the application of reverse thrust.

Winter Operating Procedures

The operator's Operations Manual Part B (OM-B) and the flight manual[18] state that the aircraft manufacturer has tested aircraft operation after extended parking at -40 ˚C. The flight manual instructs that the aircraft's battery should be preheated to at least -10 ˚C before flight and cabin temperature should be raised to +13 ˚C to ensure the correct operation of the emergency oxygen system. Normal procedures do not require engine preheat at or above -40 ˚C, but minor temporary oil leaks may occur. Avionics may require a warm-up period as long as 30 min or more after engine start to operate properly.

The operator's winter procedures[19] contain a wealth of information of cold weather operations, but engine start after several days of parking in extremely cold conditions is given little attention. The procedures instruct that the pilots should ensure that the wheels are chocked, and the parking brake is released to avoid freezing. OM-B instructs the pilots to ensure that suitable chocks are used on the main landing gear[20].

Company Safety Management

The pilots submitted to the operator a detailed occurrence report in which they analyze the causes of the accident and contributing factors. This reflects an open reporting culture within the company.

The report was processed in accordance with the company's safety management procedures, and as a result the company conducted an internal safety investigation into the event. The company used a 13-tier logarithm table[21] to establish the accident's risk factor as 100/2500, which supports the investigation team's assessment. The investigation identified root causes and contributing factors by interviewing the accident pilots and the company's responsible staff. The investigation looked at not only the accident itself but also company functions down to the marketing level.

The investigation yielded five findings: extremely cold conditions may have impacted the pilots' s performance, the GPU may have had an effect on the aircraft's motion, a formal ground operations manual is not available, information of heater availability was inconsistent,

16 Nosewheel steering is operated mechanically by rudder pedal application.
17 Pilots' Checklist, Emergency/Abnormal Procedures, p. 48.
18 Aircraft Flight Manual Revision 13 (July 23, 2015). Normal Operating Procedures, p. 3–128.3. Also OM-B 1.13.3.
19 ACS Winter Brief 2021.
20 OM-B, rev. 3, 2.14.4 Secure the Aircraft.
21 Event risk classification (ERC).

and operational planning as a whole was not centralized and communication between responsible staff members had not been continuous.

As a result, the operator identified five corrective actions: winter operations requirements should be clarified, extended cold-weather parking should be avoided, safety assessment criteria should be evaluated, winter operations training should be increased, and the runway requirement related parts of Operations Manual Part A (OM-A) should be reviewed.

2.4.2 Aerodrome Maintenance

Finavia is responsible for the infrastructure, maintenance and operation of Kemi-Tornio aerodrome. It also owns air traffic management systems and equipment that are operated and maintained by air traffic control.

2.4.3 Ground Handling

Groundpower provides ground services at Kemi-Tornio aerodrome. These services include passenger services, ground handling, deicing and freight and baggage handling.

After landing on Thursday December 2, the accident aircraft was marshaled to stands 3 and 4, and an apron worker placed rubber chocks fore and aft of the nosewheel.

Company Ground Operations manual (GOM 9.6., chapter 4)[22] states that the nosewheel should be chocked fore and aft, and one mainwheel should also be chocked for overnight parking. The apron worker did not notify the pilots of inadequate chocking.

The company was handling three visiting aircraft at the aerodrome on the day of the accident, but only three pairs of chocks were available.

The apron worker filed an occurrence report as prescribed in GOM, but the company did not carry out an internal safety investigation in accordance with its safety management policy. The responsibilities and management system of ground handling companies are described in European Union regulations[23]. The purpose of a management system is to ensure compliance with the requirements, manage safety risks, to aim for continuous improvement and maintain an occurrence reporting system in order to contribute to the aim of improvement of safety.

2.4.4 Air Traffic Control

Air traffic control services at Kemi-Tornio aerodrome are provided by Fintraffic ANS. Local air traffic control services are available during promulgated hours, although services can be provided outside these hours by submitting an advance request. The control tower is normally manned by one person.

At the time of the accident the control tower was open outside the normal operating hours. The controller arrived at the aerodrome just before the accident and heard a jet engine running on the apron. At approximately 1230 h he advised on frequencies that air traffic control services were available. A few minutes later he saw that an aircraft started moving unexpectedly. Speed increased somewhat, until the aircraft swerved and came to a halt close to the terminal building. The controller inquired from an apron worker who was preparing another aircraft for flight whether the accident aircraft had hit anything and asked whether an alert should be issued. The worker recommended that the controller alert rescue services.

---

22 Rev. 4, effective from May 16, 2021

23 Regulations (EU) No 376/2014 of the European Parliament and of the Council, Article 13 and 2018/1139 Annex VII (paragraph 4.2 Management Systems in particular)

The controller carried out the prescribed alert procedure, which is explained in a subsequent paragraph.

2.5 Preventive Actions of Authorities

Commercial air transport and related functions (e.g., maintenance, ground handling, air traffic control services and aerodrome operations) are regulated by international agreements, European Union and national regulations and best practise guidelines. Operators that carry out regulatory activities shall have an operations management system consisting of a quality management system and a safety management system (SMS). The performance of these systems is monitored by audits. In Finland, the regulator is the Finnish Transport and Communications Agency Traficom. Monitoring is primarily risk-based, and the premise is that operators have a functional internal monitoring system.

An SMS must ensure that the operator can carry out appropriate management of change and safety assessment actions when plans for operational changes or a deviation from a normal procedure are under way. As an example, inauguration of operations to a new aerodrome where unfamiliar conditions may be encountered could necessitate an advance preview.

Traficom has contributed to safety improvement by issuing in cooperation with national stakeholders a bulletin[24] that is intended for foreign air operators and contains essential practical information of winter operations to Finland's airports. Among the topics are aerodrome condition reporting, runway excursion risk mitigation and variations in taxiing conditions on aprons.

2.6 Rescue Services and their Preparedness

The Emergency Response Centre Agency was founded in 2001. It consists of administration and a nationwide network of six emergency response centers (ERC). The agency has a statutory[25] mandate to answer emergency calls, evaluate their urgency and forward any calls that require immediate rescue action to the appropriate authority. Evaluation is based on prescribed risk assessment models of various authorities that also indicate appropriate response levels. In a high-workload situation calls are relayed to an available ERC. The calls related to the accident under investigation were processed at the ERC in Oulu.

Lapland Rescue Department is, under the Rescue Act,[26] responsible for rescue actions and preparedness that are under the responsibility of regional rescue services. The department is one of Finland's twenty-two regional rescue departments and its area of operations covers the province of Lapland. The area is further divided into the Southern, Eastern and Western rescue districts. The department has in constant readiness personnel in fire stations at Kemi, Rovaniemi and Tornio. These fire stations are supported by contract fire brigades. In other municipalities in Lapland, rescue services are arranged on a voluntary basis.

Finavia maintains a regulatory round-the-clock rescue service at Kemi-Tornio airport to respond to aircraft accidents and incidents within the aerodrome area.

---

[24] Winter conditions at Finland airports – requirements for pilots and air operators. Traficom 2021. Accessible at: https://www.traficom.fi/sites/default/files/media/file/Winter_Operations_Bulletin_2021.pdf. (Accessed on March 6, 2022).

[25] Emergency rescue center operations are subject to the Act on Emergency Response Centre Operations (692/2010) and the relevant decree (877/2010).

[26] 379/2011.

2.7 Rules, Regulations and Procedures

Rules, regulations and procedures relevant to the accident are described in applicable paragraphs above.

2.8 Other Investigations

The ECCAIRS database[27] was searched for other similar occurrences, but few hits were obtained, and they had no apparent relevance to the accident under investigation. The usability of the search result report could be improved for better utilization of the database.

[27] European Co-ordination Centre for Accident and Incident Reporting Systems, an application developed by the Joint Research Centre of the European Commission.

3 ANALYSIS

A SIAF-developed format of the AcciMap approach[28] was used to support the analysis of the occurrence. The following text is arranged in accordance with an AcciMap diagram created during the investigation and shown below. The occurrence is depicted as a chain of events along the bottom of the diagram. Contributing factors at various levels can be examined by moving up and down the diagram.

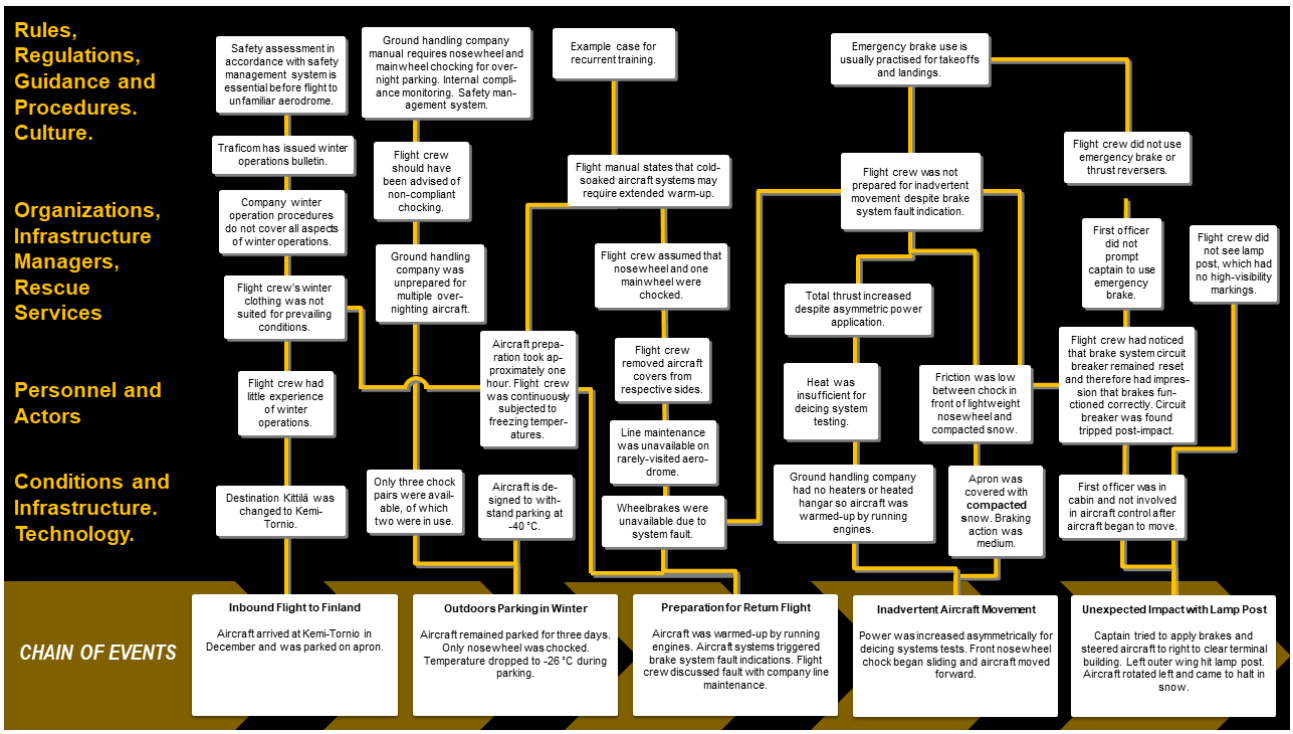


Figure 11 AcciMap diagram, investigation L2021-05. (Photo: SIAF)

3.1 Analysis of Occurrence

3.1.1 Inbound Flight to Finland

The flight from Edinburgh on December 2 was prepared in accordance with the air operator's procedures. The company had operated in Arctic conditions during previous years. The accident pilots had operated only a few flights in extremely cold winter conditions. The company had issued a winter brief[29] but no winter operations manual was available.

Flight planning into Arctic conditions was a complex task, and the change of destination while planning was ongoing presented additional challenges and responsibilities. The company had not conducted a comprehensive safety assessment before the flight to an unfamiliar aerodrome.

Operations of this kind highlight the importance of a proactive safety assessment in accordance with SMS[30] guidelines. A safety assessment[31] would have helped to recognize

---

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

29 ACS Winter Brief 2021.

30 Safety Management System, described in ICAO Safety Management Manual and other documents.

31 Such as the bowtie method commonly used in commercial aviation. The purpose of the method is proactive recognition of risk factors associated with a planned change or activity and potential consequences. Risk prevention or mitigation is achieved by establishing multidimensional barriers and clearly delineated responsibilities.

potential risks, such as the change of destination to another aerodrome with different physical characteristics, limited parking and heating facilities, changing runway conditions, the effects of inadequate winter clothing on human performance and extended outdoor parking.

Aircraft systems operated normally during the inbound flight and parking. Normal winter conditions prevailed at Kemi-Tornio airport. The apron was covered with compacted snow, and braking action was reported as medium.

3.1.2 Outdoor Parking in Winter

Major temperature variations can occur during Nordic winter, and temperature dropped significantly and rapidly during parking. However, the aircraft type is designed to withstand parking at -40 ˚C. The starting of cold-soaked aircraft systems is a non-standard procedure and requires extended preheating. Cold-started equipment will not achieve an optimal operating condition immediately, which may cause higher-than-normal mechanical stress.

The ground handling company did not have wheel chocks for securing multiple aircraft. Company workers and the pilots did not discuss missing mainwheel chocks after parking, and the pilots did not notice this omission. Due to insufficient chock availability, the apron workers did not comply with company procedures.

Chocks are used to prevent aircraft movement during parking. Chocking only the nosewheel(s) will not create sufficient standing friction to prevent movement in winter conditions.

3.1.3 Preparation of Aircraft for Outbound Flight

The pilots arrived at the aircraft in good time, approximately three hours before the departure time. Their intention was to preheat the aircraft before carrying out preflight procedures. They removed airframe and engine covers for a warm-up run. They did not notice the omission of mainwheel chocks during engine cover removal and walk-around[32] . The pilots did not have adequate winter clothing for the prevailing sub-zero temperatures at their disposal. Their winter clothing was suited only for short-term exposure to these conditions.

They prepared the aircraft in accordance with the aircraft manufacturer's cold-start procedure. Engine start after extended parking in cold conditions is given little attention in the procedure. Since only one low-power electric heater was available, warm-up was done by running the engines.

A brake system fault appeared upon powering-up of the aircraft systems. The pilots attempted to troubleshoot the fault and called company line maintenance[33]. The fault had rendered the toe-operated wheel brakes inoperative.

Engine and system temperatures rose to the required value after running the engines for approximately one hour. Although the brake system circuit breaker remained reset, the brake system annunciator light remained illuminated.

3.1.4 Inadvertent Aircraft Movement

The pilots applied asymmetric engine power for a deicing systems test. They wanted to avoid an increase of total thrust and thereby prevent inadvertent aircraft movement.

---

[32] OM-B Normal Procedures 2.7.1: Make sure that the aircraft has the chocks and safety pins on as required.

[33] Air Charter Scotland line maintenance controller.

Friction on the apron, which was covered with compacted snow, was medium, and the aircraft moved forward. This came as a surprise to the pilots. The aircraft had remained stationary during the warm-up run, which may have created an impression of adequate chocking. The front chock, which had seemed inappropriately large for the accident aircraft, was pushed forward by the nosewheel and soon slid aside, off the wheel's track.

The pilots were under the impression that the mainwheels were chocked, and they had not discussed actions in the event of inadvertent movement. Maneuvering space was limited due to apron congestion, aircraft position and prevailing friction conditions.

3.1.5 Impact with Lamp Post

The pilots were perhaps unaware of the brake system failure. The aircraft moved at a brisk walk over approximately 20 m, which allowed over 10 s of response time. The captain applied the brakes to no effect and used nosewheel steering in an attempt to clear obstacles. He did not use the emergency brake system, which was serviceable. Neither did the first officer suggest the use of the emergency brake system or reverse thrust. His situational awareness may have been degraded by his position behind the captain[34]. In addition, the windshield was partially misted-up.

Because the use of the emergency brake system is usually practised in takeoff and landing situations, pilots may not be conditioned to the procedure during maneuvering on the apron. The captain was focused on the aircraft parked on the right. The lamp post, on his left, had no high-visibility markings, which may have made it less conspicuous.

It is likely that exposure to cold had degraded the pilots' performance. The emergency brake system can be used several times before the blow-down bottle requires servicing. Pilots tend to avoid the use of the system.

3.1.6 Post-accident Actions

The pilots' post-accident actions were appropriate. The pilots, the apron workers and the air traffic controller submitted occurrence reports to the respective organizations. The aircraft operator conducted a safety investigation in accordance with the prescribed safety management procedure, identified root causes and decided on corrective actions. An event involving multiple factors, like the investigated accident, would be a suitable teaching case in crew resource management (CRM) or other recurrent training.

The aircraft was repaired at the aerodrome during summer 2022. Although the brake system circuit breaker was replaced, the hydraulic pump did not operate and was replaced. The company sent the defective pump for examination, but no inspection report has reached the investigation team so far.

The ground handling company reported the occurrence to Traficom and Finavia but did not carry out an internal safety investigation and has not implemented procedures for occurrence report analysis and safety hazard identification. Safety hazard identification is necessary in order to determine corrective or preventive actions required to improve aviation safety[35].

The ground handling requirements state that the service provider is responsible for safe operation at the aerodrome, shall have all the means necessary to ensure safe provision of

---

[34] OM-B Normal Procedures 2.7.6 Before Starting Engines: Both pilots must be in their respective seats before engine start.

[35] Regulation (EU) No 376/2014 of the European Parliament and of the Council, Article 13. In addition, EASA is crafting a document (RMT.0728) for the development of safety culture in ground handling as part of total aviation safety effort.

service at the aerodrome and shall provide the services in accordance with the procedures and instructions of the aircraft operator it serves[36].

[36] Regulation (EU) No 2018/1139 of the European Parliament and of the Council, Annex VII. The annex establishes essential requirements for ground handling service providers.

4 CONCLUSIONS

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

1. The aircraft moved forward inadvertently when asymmetric power was applied during a warm-up run because the mainwheels were not chocked. The pilots could not stop the aircraft because the hydraulic wheelbrake system was unserviceable. Medium surface friction contributed to the sliding of the chock placed in front of the nosewheel on the snow-covered surface. The pilots did not notice the omission of mainwheel chocking.

   Conclusion: *An exterior inspection before a warm-up run shall be conducted with care regardless of the prevailing conditions. The* pilots *had not checked mainwheel chocking during parking.*

2. The apron worker of the ground handling company chocked only the nosewheel fore and aft. Company Ground Operations Manual (GOM 9.6., chapter 4) states that also one mainwheel should be chocked for overnight parking. The pilots were not informed of inadequate chocking.

   Conclusion: *The ground operations manual was not complied with.*

3. The pilots did not use the emergency brake system although sufficient time was available and the system was serviceable.

   Conclusion: *The use of the emergency brake system is usually practised in takeoff and landing situations, not during maneuvering on the apron.*

4. The pilots were too lightly clad for extremely low temperatures and felt freezing during parking cover removal and the warm-up run.

   Conclusion: *Cold degraded the* pilots' *physical and mental performance.*

5. The brake system circuit breaker had tripped repeatedly and had been reset each time by the pilots. The system annunciator light remained illuminated during the entire warm-up run.

   Conclusion: *A tripped circuit breaker and an annunciator light indicate an inadequately diagnosed system anomaly.*

6. The air operator had not conducted a formal and comprehensive safety assessment as prescribed by the safety management policy before a flight to an unfamiliar aerodrome.

   Conclusion: *All potential risks had not been assessed properly in advance. Unclearly delineated responsibilities in company management resulted in a situation where potential risks related to operations to a new, unfamiliar aerodrome had not been assessed.*

5 SAFETY RECOMMENDATIONS

5.1 Safety Assessment

The air operator had not conducted formal and comprehensive safety assessment as prescribed by the safety management policy.

The Safety Investigation Authority Finland recommends that

Air Charter Scotland documents and implements criteria for the need for a safety assessment, and any time these criteria are met, responsible persons shall carry out a safety assessment that encompasses all activities related to the change prompting the assessment. [2022-S32]

5.2 Compliance with Ground Operations Manual

The ground handling company did not have an adequate number of wheel chocks for safe ground service. The company did not comply with its ground operations manual and did not inform the pilots of inadequate chocking. The company did not carry out a safety investigation as prescribed in its safety management policy in order to identify risks and determine corrective actions.

The Safety Investigation Authority Finland recommends that

The Finnish Transport and Communications Agency Traficom assesses management system performance and internal compliance monitoring during audits of ground handling companies. [2022-S33]

5.3 Implemented Measures

The SIAF is not aware of any measures implemented during the investigation.

REFERENCES

Written Material

ICAO. (2018) SMS Manual 4th edition, Doc 9859.

ARMS Working Group. (2010) *The ARMS Methodology for Operational Risk Assessment in Aviation Organisations*.

Traficom. (2021) *Winter conditions at Finland airports – requirements for pilots and air operators.* Winter Operations Bulletin.

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

Vaughan, D. (2005) *Organizational rituals of risk and error*. In Hutter, B. & Power, M. (ed.) Organizational encounters with risk, 33–66. Cambridge: Cambridge University Press.

Weick, K. E. (1990) *The vulnerable system: An analysis of the Tenerife air disaster*. Journal of Management 16 (3): 571-593.

Aviation Act (864/2014).

Safety Investigation Act (525/2011).

Investigation Material

1) Photographs (on-site and subsequent phases of investigation)
2) Aerodrome map data
3) Weather information
4) Interviews
5) Recorder (CVR and FDR) data
6) Aircraft technical data, certificates and other documents and maintenance instructions
7) Air operator's operations manuals, FCOM and AFM
8) Pilots' licenses and documents
9) Ground handling company's operations manuals, documents and occurrence information
10) Aerodrome operator's operations manual and occurrence information
11) Aerodrome maintenance instructions and documents
12) Rescue service alert and incident report (in work)
13) Police department report and photos

SUMMARY OF COMMENTS TO DRAFT FINAL REPORT

The Safety Investigation Authority of Finland submitted the draft final report for comments to Air Charter Scotland, Finavia, Fintraffic, Groundpower, the Finnish Transport and Communications Agency Traficom, Pratt & Whitney Canada and the Air Accidents Investigation Branch of the United Kingdom. Pursuant to the Safety Investigation Act, no comments given by private individuals are published.

Air Charter Scotland wished to clarify items related, among others, to the pilots' winter clothing.

Finavia stated that it did not have any comments.

Fintraffic did not submit any comments.

Groundpower did not submit any comments.

Finnish Transport and Communications Agency Traficom stated that the draft final report largely failed to discuss the aerodrome operator's role. The operator is bound by Regulation (EU) No 139/2014 (ADR Regulation). According to the regulation, the aerodrome operator shall ensure that adequate equipment, such as wheel chocks, are provided for air operator customers. The regulation contains no mention of the ground handling company's responsibility for the procurement of a sufficient stock of wheel chocks at the aerodrome.

The air operator had not passed its applicable internal instructions to the ground handling company. The manuals of the latter had been audited by Traficom in July 2021. The audit found that the scope and contents of the manuals were sufficient, as were the equipment available for serving the Saab 2000 airplane of the company's customer. The company's Ground Operations Manual was written to support Nyxair operations, particularly those conducted with the Saab 2000. Chocking instructions are specific to airplane types, and the instructions given in the manual cannot be applied to every aircraft type operating to the aerodrome.

Pratt & Whitney Canada stated that it endorses the engine-related findings of the investigation team and had no additional comments.

Air Accidents Investigation Branch of the United Kingdom wished to clarify some terms in the translated version of the report.