Laptop Battery Fire in the Cabin of an Airliner on 7 March 2017

Investigation report: L2017-01

SYNOPSIS

Pursuant to section 2 of the Safety Investigation Act (525/2011), the Safety Investigation Authority decided to investigate the laptop battery fire in the cabin of an airliner which occurred on Tuesday, 7 March 2017 at Helsinki-Vantaa Airport. 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.

Airline pilot Jani Holmberg was appointed as team leader for the investigation group, accompanied by Air Safety Investigator Tii-Maria Siitonen and Purser Sanna Winberg. Chief Air Safety Investigator Ismo Aaltonen acted as investigator-in-charge. Special Investigator Heikki Harri was appointed as the expert member specialising in the rescue operation.

Commissioned by, and under the supervision of, the Safety Investigation Authority, experts from the battery manufacturer visited the SIA on 19 September 2017 to inspect the laptop computer and its battery.

Safety investigation examines the course of events, their causes and consequences, 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 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 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, no comments given by private individuals may be included in the investigation report.

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

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Cover photo: Air Berlin

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1 FACTUAL INFORMATION

1.1 History of the flight

Air Berlin flight BER8070 from Berlin landed on Runway 04L at Helsinki-Vantaa Airport on Tuesday, 7 March 2017 at 01:00[1]. The pilots taxied to the stand of gate 29 at terminal T2. The cabin crew disarmed the doors to disengage the escape slides and carried out the normal crosscheck to confirm that they were disarmed. A passenger services agent at the gate manoeuvred the passenger bridge (jetway) to its proper place.

Soon after arriving at the gate people smelled the odour of an electric fire burning and smoke became visible at the front of **the cabin**. The passengers reported this to the cabin crew. Cabin attendant A (senior cabin crew member, SCCM[2]) ordered cabin attendant B (cabin crew member, CCM[3]) to don protective breathing equipment (PBE[4]) and gave her a portable Halon fire extinguisher. Cabin attendant B donned the smoke hood and activated its oxygen generator.

Cabin attendant A reported the smoke on the interphone to the flight deck as well as to attendants C and D at the rear of the cabin. The training captain, seated in the co-pilot's seat, went into the cabin to check the situation and soon returned to the cockpit to report the smoke to the captain and the air traffic control. He also told the ramp crew[5] that they were not to open the cargo doors because the source of the smoke was unknown. The pilots began ascertaining if the smoke originated in the aircraft's systems. Just to be sure they shut off the APU[6] bleed air, as they had turned it on just prior to the smoke being detected.

The passenger services agent knocked on the aircraft door to indicate to the crew that they could now open the front left door. She placed a detached platform (walk ramp) between the jetway and the aircraft. When cabin attendant A opened the door she said that there was a fire on board and that the passengers should be evacuated immediately. Prior to this the passenger services agent had not been informed of the fire. She then reported the situation to the ground handling company's flight operations coordinator.

Cabin attendant A made an announcement in English, ordering the passengers to return to their seats. The passengers at the front of the aircraft obeyed the order and cabin attendant B could proceed forward down the aisle. Cabin attendants C and D could not see the situation because passengers were standing in front of them. Cabin attendant C discussed the situation with cabin attendant A on the interphone, inquiring about the need to don smoke hoods at the rear of the cabin. Cabin attendant A replied that this was no longer necessary.

The passengers were shouting that the smoke was coming from the right side of the aisle, pointing to the footwell of seat 8F. Cabin attendant B noticed that the smoke was coming from a nylon backpack containing a laptop computer. She moved the laptop with her foot so as to make it more accessible and then discharged the fire extinguisher towards it. In addition, she shoved the neighbouring passengers' bags and overcoats to the side and kept monitoring that the fire had been extinguished. She also told nearby passengers to cover their mouths and

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1 All times are in Finnish Standard Time UTC+2h.
2 SCCM = Senior Cabin Crew Member
3 CCM = Cabin Crew Member
4 PBE = Protective Breathing Equipment, a.k.a. smoke hood
5 Persons mainly in charge of loading and handling cargo and luggage
6 APU = Auxiliary Power Unit, located in the rear part of the fuselage

noses with cloth. The sequence from the first detection of smoke to extinguishing the laptop took approximately one minute.

The situation caused restlessness among the passengers in the rear of the cabin at which time cabin attendant C began calming them down. Since there was still acrid smoke in the cabin after the fire had been extinguished, cabin attendant A called cabin attendant D on the interphone and told her to open the left rear door. Cabin attendant D opened the door and placed a barricade strap in front of it because there were no passenger stairs at the door.

Cabin attendant A announced that the passengers should disembark rapidly. Soon after this she made another announcement, telling all passengers to leave their belongings in the cabin. At first, some passengers were confused about which exits they should use. The passenger services agent remained at the door to help people disembark because the walk ramp between the jetway and the aircraft had to be removed as it was too slippery. All passengers deplaned through the front left door.

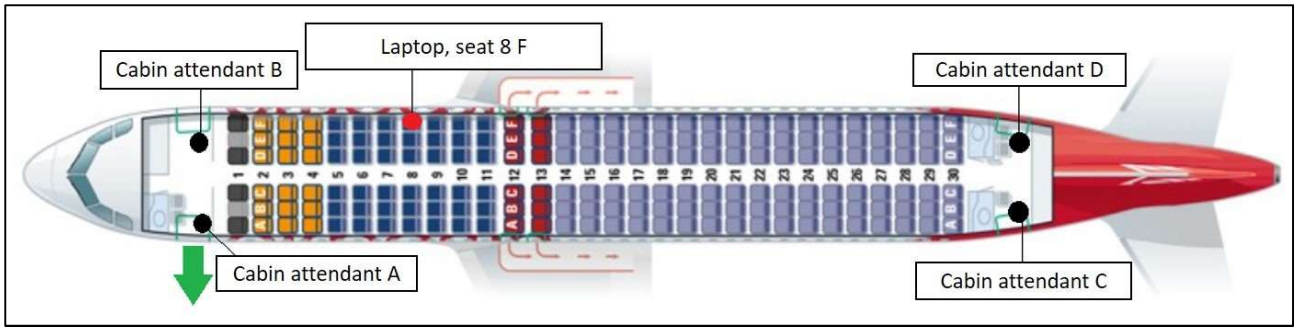

Figure 1. A typical cabin configuration for Air Berlin's Airbus A320 aircraft. The laptop was in the footwell of seat 8F, indicated with the red dot. The passengers disembarked through the front left door in the direction shown by the green arrow. (Plan view: Air Berlin)

Some of the passengers followed the instructions and disembarked without their outer garments or hand luggage. They stayed at the boarding gate to wait for their belongings. Other passengers tried to take their hand luggage with them, which resulted in the aisle being blocked and the deplaning process being slowed down. A wheelchair-bound passenger was the last one to be assisted out of the aircraft. The passage through the jetway to the terminal proceeded unhindered. Once the passengers had left the aircraft the airport police, firefighters and aircraft mechanics entered the cabin.

When the passengers came out of the aircraft there were no airport staff at the boarding gate to guide them. Some of the passengers that had disembarked without their belongings tried to make their way back into the aircraft after seeing that other passengers had taken their belongings with them. Nobody at the boarding gate checked their right to re-enter the aircraft.

An announcement was made inside the terminal for the family who owned the laptop and was seated at seats 8DEF to wait at the baggage claim area. They waited there and explained the course of events to the captain of the aircraft and the police. The child of the family said that the smoking laptop had frightened him so much that he did not dare mention it to anyone.

Once the situation calmed down the cabin crew and the passenger services agent took the carry-on luggage and outer garments from the cabin to the passengers waiting at the boarding gate.

1.2 Injuries and damage

The incident resulted in no injuries to persons.

Inside the cabin the fire left a few burn marks on the lower cushion of a passenger seat as well as on the floor and the wall. The laptop, the backpack and all items in it were destroyed.

1.3 Aircraft and personnel information

The incident occurred inside an Airbus A320-216 airliner operated by Air Berlin, configured for 180 passenger seats. The registration is D-ABZI.

There were six crew members and 167 passengers on board. The flight crew comprised a captain and a training captain, who was seated on the right side in the co-pilot's seat. The training captain was the pilot-in-command of the line training flight. The cabin crew comprised four flight attendants, two at the front of the aircraft and two in the rear. The occurrence flight was the aircrew's third flight of the day and they checked into a hotel for the night after the flight.

1.3.1 Fire detection and fire extinguishing equipment inside the aircraft.

The operator's Airbus A320-216 type airliners have smoke detectors and fire extinguishing systems in the cargo compartment and in lavatories. Lavatories are fitted with automatic fire protection systems; they are positioned in the garbage bin space under the sink. There are also smoke detectors in the avionics compartment under the floor of the cockpit.

The cabin and the flight deck are fitted with fire extinguishing equipment. Flight attendant B, who extinguished the fire, used a *Dräger Oxycrew* smoke hood (PBE). This model covers the head, neck and chest area. It has a chemical oxygen generator which supplies oxygen for a minimum of 15 minutes. The hood is stored inside a foil bag which, in turn, is packed in a plastic container. In all, the container weighs approximately 2.5 kg.

Figure 2. Smoke hood bags and containers as well as a portable fire extinguisher on the table of the aircraft's front galley (Photo: Air Berlin)

The flight attendant used a Halon extinguisher. There are four[7] of these in the cabin. Halon is an effective fire extinguishing agent in closed spaces because it stops the chemical reaction of fire. Furthermore, it does not damage materials or leave any marks. Many countries have stopped using Halon altogether because it harms the ozone layer. However, Halon extinguishers are still commonplace equipment in aircraft. In addition, aircraft are furnished with fire retardant gloves and fire axes.

1.4 Fire

Smoke generation started as the aircraft was arriving at gate 29. While the laptop battery fire generated a lot of smoke, no flames were visible. People felt the acrid smoke in their airways. Some people situated nearby said that it distinctly smelled like an electric fire. The passenger seated next to the window had the laptop inside a backpack in the footwell. He felt the heat against his leg and noticed that the heat came from the backpack. The fire did not spread to the cabin's wall, floor or seat materials.

1.5 Rescue operation and survival aspects

There was one air traffic controller inside the **control tower (TWR)** who controlled traffic on TWR and ground control frequencies. Air traffic was slow at the time of the occurrence.

Soon after parking the aircraft, at 01.09, the training captain called the TWR on the radio and said that rescue units were needed immediately at gate 29. He said that there was smoke inside the cabin and that its source was unknown. The air traffic controller pressed the alarm button and announced the situation to all three rescue stations at the airport.

At the same time the **situation centre (SITCEN) of Central Uusimaa Rescue Department** received advance warning of the situation. The duty officer at the SITCEN announced a preliminary alert to all Central Uusimaa Rescue Department stations of a potential accident at the airport. The Central Uusimaa Rescue Department's fire station situated nearest to the occurrence site is located right by the fences next to the flight operations area.

Kerava Emergency Response Centre (ERC) was also informed of the alert when the air traffic controller pressed the alarm button at 01.09.52. The ERC dispatched the units for "full emergency response – air accident"[8] to the site. The air ambulance FinnHEMS base called the air traffic controller and asked whether they were needed at the site. At some point in the phone call the tower controller assessed that they were not needed for this situation. The controller did not know exactly what was going on inside the aircraft. Rather than going to the site, FinnHEMS continued to monitor the situation over the radio.

At 01.10 the training captain asked the tower controller for an ETA of the rescue units and also requested a frequency for direct contact with them. The controller said that the aerodrome does not have a dedicated frequency for this purpose, but that the TWR would relay information between the aircraft and the rescue units. The ERC made a confirmation call to the air traffic controller and requested additional information. The controller said that the airliner was an Airbus A320, but that they did not yet have precise information as to the number of passengers or the volume of fuel on board. The air traffic controller wanted to give time to the pilots to establish the situation and, therefore, did not ask for all of the details.

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7 Under Commission Regulation (EU) No 965/2012, at least three hand fire extinguishers are required in aircraft whose maximum occupancy is 61-200.

8 The response includes a certain number of rescue and ambulance units as per a contingency plan.

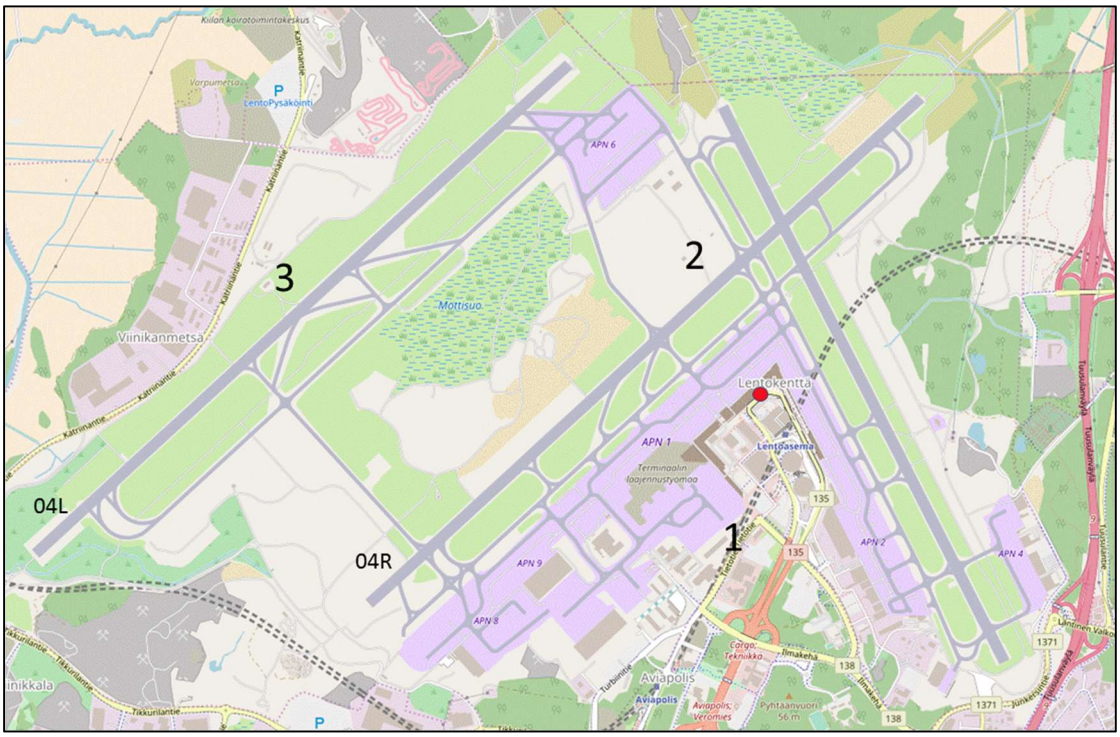

Figure 3. Numbers 1-3 indicate the locations of the airport's rescue stations and the red dot indicates the position of BER8070 at gate 29. (Plan view: © OpenStreetMap)

Airport rescue service units took off from rescue stations 1[9] and 2[10]. Rescue station 3[11] units LENTO 33 and LENTO 34 remained on standby in front of their stations. The units LENTO 23 and LENTO 24 from station 2 crossed runway 04R at 01.11 and arrived at the target at 01.12. One of these rescue units, unusually, also included one of the airport's fire officers (A). In accordance with instructions, fire officer A steered the unit to the right side behind the aircraft and noticed that the training captain was signalling to them from the cockpit window. Fire officer A went out to talk with the training captain. On the basis of information received from the training captain, fire officer A called the airport's incident commander AR 30 and said that smoke generation had ended and that the situation inside the cabin was calm. Fire officer A entered the aircraft and first checked the entire cabin, as the crew had not indicated the source of the smoke, nor did the crew inform fire officer A that an extinguisher had been used in the aircraft. Fire officer A found the burnt laptop on the right side of row 8 and made certain that the laptop was no longer hot and that there were no smouldering fabrics or materials in the cabin. Fire officer A reported this to the airport's incident commander AR 30, following which he received permission to leave the cabin. At this time AR 30 was sitting in a command vehicle, monitoring the situation and relaying information to the rescue units of Central Uusimaa Rescue Department which were en route to the target.

At 01.18 the training captain informed the air traffic controller that they had found the source of the smoke. The incident commander entered the cabin to double-check that the situation had ended and at 01.35 AR 30 cancelled the alert to the rescue units of Central Uusimaa Rescue Department. At no stage did they enter the area inside the gates of the airport.

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9 A rescue station in the technical area of the airport; this is where the incident commander is situated
10 The rescue station between main runways 04R/22L and 04L/22R
11 The rescue station north of the main runway 04L/22R

The ERC relayed the alarm to police patrols at 01.14 and the first police unit was at the target at 01.18. Another police patrol arrived at the site at 01.20. The second patrol, accompanied by the training captain, went to the baggage claim area to meet the family that owned the laptop.

Figure 4. The back side of the laptop computer damaged by the battery fire. The dimensions of the laptop are 27 x 19 x 2 cm. (Photo: SIA)

Central Uusimaa Rescue Department's fire stations were dispatched by Kerava ERC at 01.11. The alert included the units prescribed by the response "full emergency 236 – air accident".

The officer in charge (RKU 30) at Central Uusimaa Rescue Department was listening to the airport rescue service's radio traffic on call group PELASTUS 1, which was broadcasting that there was smoke inside an aircraft and that emergency evacuation was underway.

The position of the aircraft became more precise and the units of rescue station 3 of Central Uusimaa Rescue Department came to the security checkpoint, with the intention of proceeding to the aircraft from there. The checkpoint is situated right next to the fire station. As they were moving to the checkpoint they were informed by radio that the source of the smoke had been established. The airport's fire officer recommended that the alarm be cancelled. The officer in charge (RKU 30) still requested confirmation on the radio that the escape slides at the aircraft doors had not been deployed. He was informed that the passengers had disembarked through the jetway and that there was no longer any need for the rescue department's services. At 01.19 the officer in charge (RKU 30) cancelled the alert to the ERC and other units en route to the site.

1.6 Tests and research

1.6.1 Inspecting the laptop

According to the manufacturer's technical information **the laptop** had a double-cell 3.5 volt (V) lithium-ion polymer (LiPo) battery with a 30 Wh[12] rating. The stated capacity of the battery was 8060 mAh[13]. The family that owned the laptop had bought two laptops approximately six months before the occurrence. Both laptops had their original CE-marked batteries. According to the owner the laptop did not heat up unusually during use. The damaged laptop was switched off for the duration of the flight. Both laptops were X-rayed at the National Bureau of Investigation (NBI) laboratory. The tests confirmed that the fire originated in the laptop battery.

According to the laptop's manufacturer no quality issues had been detected in this model's batteries. Together with the SIA's investigators, and a representative of the NBI, the battery manufacturer's representatives inspected the battery. According to the experts the laptop fire was possibly caused by external damage to the battery. While a hole was detected on the outer surface of the battery, the investigation could not confirm whether the hole had been there prior to the fire or caused as a result of it.

Figure 5. Close-up of the laptop battery's damages (Photo: SIA)

[12] Watt-hour equals voltage (V) multiplied by capacity (Ah)
[13] Milliampere hour

1.7 Organisations and management

1.7.1 Air Berlin's Operations Manual OM-A

Air Berlin was a German airline. The company filed for insolvency on 15 August 2017 and ceased operations on 28 October 2017.

The OM-A is an operations manual drawn up by the operator and approved by the national aviation authority. Its requirements are based on COMMISSION REGULATION (EU) No 965/2012 regarding common rules in the field of civil aviation.

Chapter 2 (Emergency Procedures) of Air Berlin's OM-A states that *Each emergency or abnormal situation is a unique incident and no procedures or instructions can include all possible types of accidents or emergency situations. Proper actions are largely influenced through good Crew Resource Management by using all available resources, skills and knowledge effectively in dealing with the emergency or abnormal situation*.

Chapter 1 (Standard Operating Procedures) of the OM-A directs that the *Cabin Crew will remain seated at their stations with their seat belt fastened, until the aeroplane has reached its parking position*[14] and that they should remain at their stations inside the cabin until the passengers have left the aircraft. Several sections of the OM-A emphasise good communications between the flight crew and the cabin crew in abnormal situations.

In accordance with the OM-A, depending on the situation, any of the following three methods of disembarkation[15] are possible in abnormal situations: Emergency evacuation, catastrophic situation, and controlled disembarkation.

Evacuation, owing to the high risk of injuries, is only used in situations endangering health and safety. The captain makes the decision to evacuate by giving the command "evacuate, evacuate, evacuate, evacuate". The primary responsibility of the crew during an evacuation is to direct passenger evacuation at all usable exits. The goal is to ensure that the passengers and the crew exit the aircraft safely in the shortest amount of time.

A catastrophic situation is defined as a situation in which, for example, the pilots are incapacitated or the aircraft is severely damaged or there is uncontrolled cabin smoke/fire possibly having resulted in several deaths. Such situations require immediate independent action from the cabin crew to initiate evacuation.

Controlled Disembarkation is used in situations where no emergency evacuation is necessary but an indirect risk, or the risk of the situation worsening, makes it necessary to safely and quickly disembark the passengers and the crew. The passengers leave the aircraft through steps, stairs and/or jetways. The cabin crew is responsible for the evacuation of disabled persons or people with reduced mobility as soon as the situation permits. [16]

It is up to the flight crew to choose between controlled disembarkation or evacuation in an abnormal situation. Regardless of the method, passengers should leave their hand luggage when leaving the aircraft[17]. After the evacuation, control of the situation must be handed over to the authorities such as the emergency services or the police[18]. Crew members are

[14] Air Berlin OM-A 1.12.6
[15] Air Berlin OM-A 2.6.2
[16] Air Berlin OM-A 2.6.7
[17] Air Berlin OM-A 2.6.2.2
[18] Air Berlin OM-A 2.6.8

responsible for all action caring for the passengers until a representative of the authorities arrives.

According to the OM-A, malfunctioning or overheating laptop or tablet batteries may possibly cause a fire[19]. Because of the risk of explosion it is not permissible to move a damaged laptop. Halon extinguishers and as much water as possible or some inflammable liquid should be used in extinguishing so as to cool down the device. It must not be covered nor is it permissible to use dry ice to cool it. Only after the fire has been extinguished and the device has cooled down is it possible to safely move it. According to instructions, the device should be placed in an empty metal container that is then filled with water.

The OM-A says that *A fire on board an aeroplane is to be considered as one of the most serious threats likely to be encountered in the aviation industry*[20]. For this reason the fire must be met with immediate and decisive action by the crew. Instructions emphasise smooth and correctly timed action between the flight crew and the cabin crew. The flight crew must be kept informed of the situation.

The following firefighting procedure is to be used[21]:

- Identify the source of the fire and/or smoke and start fighting fire immediately;
- Inform the Flight Crew and Cabin Crew and continue updating the crew about the developing situation;
- Collect all firefighting equipment as necessary;
- Reseat passengers as required;
- Remove oxygen bottles and hand luggage away from the fire location;
- Open air outlets except those located directly at the source of the fire;
- Take all necessary measures to protect passengers against the effects of smoke;
- Observe and check the fire source continuously to avoid any re-ignition.

The Operations Manual assigns specific duties to the cabin crew during a fire[22]. The crew member who discovers the fire is the CCM (fire fighter) and must immediately get the appropriate firefighting equipment and start extinguishing the fire. If the source is a burning electrical device, it must first be switched off. Simultaneously, the CCM must attract the attention of a second crew member who becomes the communicator who must inform the flight crew[23]. A third CCM acts as the co-ordinator, who is responsible for taking overall charge of the situation and co-ordinating the situation. The co-ordinator will incorporate any other crew members as appropriate and see to it that they have sufficient back-up firefighting/protection equipment at the scene. The co-ordinator moves passengers and their luggage as appropriate, and removes portable oxygen from the area. The co-ordinator keeps the second CCM (communicator) informed and makes sure the fire does not reignite.

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19 Air Berlin OM-A 2.9.14
20 Air Berlin OM-A 2.9.1
21 Air Berlin OM-A 2.9.3.4
22 Air Berlin OM-A 2.9.4
23 The source and location of the fire, the colour and smell of the smoke, available extinguishers and the situation with the passengers.

1.7.2 Helsinki-Vantaa airport

Finavia Oyj maintains Helsinki-Vantaa airport. It is in rescue and firefighting service category (aerodrome category) 9. The aerodrome category and the required rescue and firefighting service preparedness are determined by Aviation Regulation AGA M3-11.

Pursuant to the Aviation Regulation Helsinki-Vantaa airport maintains its own rescue services for accidents occurring in the aerodrome area. The minimum manning of its operational shift is 7 persons[24]. The 24/7 readiness of the rescue services comprises one mobile command unit, one rescue unit and four foam tenders located at three rescue stations around the aerodrome. The task of the rescue services is to function as a part of the airport's rescue organisation. According to Aviation Regulations Helsinki-Vantaa airport is responsible for the rescue action and preparedness which, pursuant to the Rescue Act, are not the responsibility of regional rescue services. According to Aviation Regulations all aerodromes maintained by Finavia must have sufficient rescue capabilities and the ability to deal with accidents in accordance with the aerodrome's rescue category.

Finavia's preparedness for possible accidents and incidents at Helsinki-Vantaa airport is described in the aerodrome emergency plan. The airport maintains the plan together with Central Uusimaa Rescue Department. The plan applies to aviation and other emergencies that occur at or near the aerodrome meant by Aviation Regulation AGA M3-11. The latest update to the plan was completed on 18 October 2016. Aerodrome buildings have their own emergency plans.

SAR exercises and training sessions among the authorities are annually arranged at or near Helsinki-Vantaa airport. Several different authorities and aviation companies participate in these. The exercises are either map exercises or conducted in the terrain. The emergency plans of the various actors as well as the joint emergency plans are updated on the grounds of the lessons learned from the exercises.

The task of air traffic control in an accident or incident is to alert Finavia's rescue services and the Emergency Response Centre, to prevent any additional harm and to provide positional information to the rescue organisations. According to Aviation Regulations the air traffic control must have an audible alarm system.

1.7.3 Central Uusimaa Rescue Department

Central Uusimaa Rescue Department is generally prepared for major accidents by maintaining a rescue management guide, a 24/7 situation centre and an ad-hoc rescue command centre.

The largest part of the aerodrome area is within the Vantaa city limits, the northernmost part of the aerodrome lies within the municipality of Tuusula. Pursuant to the Rescue Act the local rescue authority responsible for the city of Vantaa and the municipality of Tuusula, i.e. Central Uusimaa Rescue Department, is responsible for managing accidents at or near the aerodrome. The Department has drawn specific guidelines for aviation emergencies. According to the guide the rescue authority takes charge of the situation and assigns the needed resources and issues orders as required by the situation. While the guidelines mainly focus on aviation emergencies near the Helsinki-Vantaa airport, it is also possible to apply them to other types of accidents anywhere in the Central Uusimaa region. Central Uusimaa Rescue Department participates in the airport's annual SAR exercises.

[24] One fire officer and six rescue crew members.

The Department conducts annual fire inspections at the aerodrome's buildings and the Department's personnel visits the airport's terminals and terminal areas together with the airport rescue services.

1.7.4 The Hospital District of Helsinki and Uusimaa (HUS)

The Hospital District of Helsinki and Uusimaa (HUS) has designated Helsinki-Vantaa airport as a special case in its emergency medical service standard decision. Pursuant to the Health Care Act (1326/2010), joint municipal authorities for hospital districts shall determine the standard of service required of emergency medical services. The Hospital District, its emergency medical care units and its hospitals also participate in the airport's SAR exercises.

The airport applies the Hospital District's guidelines: "Emergency medical services in aviation emergencies at or near Helsinki-Vantaa airport".

The Hospital District has signed a Memorandum of Agreement with Central Uusimaa Rescue Department regarding first response and urgent emergency medical services within the area of the Department. When it comes to first response at Helsinki-Vantaa airport the Hospital District has signed a Memorandum of Agreement with Finavia's rescue services.

1.7.5 Ground handling at the airport

There are three ground handling companies at Helsinki-Vantaa airport. They provide passenger and cargo handling as well as aircraft turnaround services to airlines. Their personnel work on the apron and inside the terminals. Swissport Finland Oy was the ground handling company associated with this investigation.

The duty of the ground handling company **passenger services agent** is to meet the aircraft at the jetway as it arrives. The agent operates the control console to move the jetway up to the aircraft once it has been parked. When the jetway is in place, the agent knocks on the door of the aircraft as a sign that all is clear and the door can be opened. Following this, the senior cabin crew member opens the front left door. When the door has been opened the agent bridges the jetway to the aircraft with a walk ramp. The passengers disembark over the ramp.

The senior cabin crew member notifies the agent if there are passengers on the flight who need special assistance. These can include children travelling alone or people with reduced mobility.

The passenger services agent must also monitor overall security inside the terminal and call 112 or Finavia's central security control centre for help. Such alarms can involve, among other things, disturbances, fires or other things jeopardising security.

The ground handling company's security instructions[25] for passenger services agents do not clearly address fires that occur on jetways or situations when passengers are boarding or leaving the aircraft. They only provide general-level instructions for fires inside the terminal.

[25] Swissport Finland: Customer service contact points' security instructions at Helsinki-Vantaa airport

1.8 Cabin crew training at Air Berlin

Prior to being allowed to work in aircraft a trainee must successfully complete cabin crew **initial training**[26]. It includes theoretical instruction and knowledge examinations as well as practical exercises on, among other things, first aid, firefighting, evacuation, crowd control and communications[27].

Fire extinguishing is trained in a fire simulator in which the student extinguishes, among other things, grease, oven or seat fires. These exercises are carried out with similar equipment as those used in aircraft.

The initial training includes training and exercises for crowd control in normal and abnormal situations and in emergencies, such as evacuation.

Following the successfully completed initial training a cabin crew certificate will be issued to the graduate. In order to operate as a cabin crew member the graduate must undergo aircraft type specific training and the operator's conversion training[28]. Air Berlin's initial training also includes aircraft-type specific training for the aircraft in which the graduate will eventually work. Following the initial training the graduate will fly on two training flights accompanied by an instructor. These flights provide practical training which is relevant to the crew members' duties in a normal working environment.

Cabin crew members undergo recurrent training at least every 12 months to ensure continued proficiency. The period of validity for the recurrent training and associated checking is 12 months.

The recurrent training is grouped into topics that are trained annually and other topics that are rehearsed every three years.

The annual recurrent training covers:

- Emergency procedures, including pilot incapacitation;
- Evacuation procedures, including crowd control techniques;
- Touch drills for opening normal and emergency exits;
- Location and handling of emergency equipment, including oxygen systems and the use of life jackets, portable oxygen and protective breathing equipment (PBE) by each cabin crew member;
- First aid and the content of the first aid kits;
- Dangerous goods procedures;
- Security procedures.

Every three years the recurrent training (in addition to the annually trained topics) also includes:

- Demonstration of the use of life rafts and slides;
- Realistic and practical training in the use of all firefighting equipment, including protective clothing representative of that carried in the aircraft;
- Smoke training exercise, using similar protective equipment carried in the aircraft.

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[26] Air Berlin OM-A 5.3.: Cabin crew

[27] Air Berlin OM-D 2.2.1: Cabin crew. The OM-D is a training manual drawn up by the operator and approved by the national aviation authority. Its requirements are based on COMMISSION REGULATION (EU) No 965/2012 regarding common rules in the field of civil aviation.

[28] (EU) 965/2012, ORO.CC.125

1.9 Lithium-ion batteries and the incidents they have caused on passenger flights

1.9.1 The use of lithium-ion batteries in portable devices

Lithium-ion polymer (LiPo) batteries are the commonly used lithium-ion batteries in portable devices and other small electronic equipment[29]. They do not leak and they can be manufactured in almost any shape or form. They only contain lithium in the form of ions. This battery type has become more commonplace because it is light, long-lasting and has a larger capacity per weight ratio than other battery types.

In this investigation the laptop battery was forced into **thermal runaway**. This can, for example, happen because of an internal or external short circuit, physical damage to the battery, overcharging or exposure to high temperatures. During thermal runaway the reaction between the electrode of the battery's cell and the electrolyte becomes self-sustaining and the reaction propagates autocatalytically. Thermal runaway may result in a battery fire or even explosion. The fire produces toxic gases such as hydrogen fluoride (HF) or maybe even phosphoryl fluoride (POF_3).

The production of lithium batteries requires sophisticated manufacturing technology. For instance, poor separation or insulation in cell packs or impurities in cell structure may cause instability, which can also result in thermal runaway. The batteries must be equipped with safety circuits that prevent undercharging or overcharging during charging and discharging. Since 2012 manufacturers have been required to mark all lithium batteries' energy content on the battery itself. This marking is not always visible on the cover of the device.

Manufacturers for lithium batteries[30] sold in the **European Economic Area** must prepare the applicable documents required by applicable EU Directives and demonstrate that the devices meet all essential requirements of said directives. The manufacturer must prepare an EU declaration of conformity for the devices. The manufacturer must also affix CE markings on the devices as proof of conformity. A CE marking does not infer accreditation by a national authority; there are many products on the market that bear counterfeit CE markings and whose conformity has not been verified. Their safety does not necessarily meet the requirements.

While manufacturers and importers bear the primary responsibility for the conformity of electronic equipment, wholesale and retail traders, too, have their own responsibilities. Electronic devices must include markings that detail, among other things, the name or identifier of the manufacturer or importer, model, nominal voltage and frequency, power and possible ingress protection grading as well as restrictions, if any. The Finnish Safety and Chemicals Agency (Tukes) monitors the safety and conformity of electronic products sold in Finland.

[29] Such as mobile phones, laptops, cameras and electronic mobility aids.
[30] Also applies to the manufacturers of other electronic equipment.

1.9.2 Incidents that lithium-ion batteries have caused on passenger flights

The U.S. aviation authority the FAA[31] has compiled statistics from overheating, smoking, igniting and exploding lithium-ion batteries since 1991. These statistics only show instances reported to the FAA. By the end of 2016 there were in all 138 such occurrences.

In 2016 there were 31 occurrences, a third of which was associated with electronic cigarettes. While there is only incomplete information available on some of the occurrences, in at least 13 cases the cabin crew had to use fire extinguishers. In addition to in-flight incidents the statistics also list occurrences detected during aircraft loading.

1.9.3 General restrictions to passengers and aircrew regarding the transport of lithium-ion batteries in the air

The ICAO's[32] Technical Instructions (TI)[33] for the Safe Transport of Dangerous Goods by Air list lithium-ion batteries as dangerous goods and set restrictions for their transport by air. ICAO member states have adopted the TIs through their national legislation. The instructions recommend that passengers and aircrew carry portable devices in their carry-on luggage.

Passengers get information about restrictions on lithium batteries from the internet pages of airlines and the different authorities as well as from airports. Airlines[34] and countries have issued varying restrictions. Normally it is permissible to carry devices with a 100 Wh maximum rating in carry-on luggage and in the cargo hold if the batteries are installed. The batteries may contain no more than 2 g of lithium[35]. Among other things, such batteries are used in portable electronic devices such as laptops, tablets and mobile phones. Spare batteries up to 100 Wh may only be transported in carry-on luggage. Airlines may pose restrictions on their maximum number.

According to the ICAO's TIs special approval must be requested for the transport of batteries rated at 100-160 Wh. Such batteries are used in medical equipment and large video cameras, among others. Their batteries may contain 2-8 g of lithium. It is only permissible to transport spare batteries rated at 100-160 Wh in carry-on luggage. Airlines have normally limited their number to two.

The ICAO's TIs place specific restrictions on the transport of lithium-ion batteries exceeding 160 Wh used in electric wheelchairs and other mobility aids. According to the investigation's material, operators will not normally transport balance boards or hoverboards on passenger flights.

The transport by air of damaged or defective lithium-ion batteries or those recalled by the manufacturer is forbidden. Each spare battery must be protected against damage or short circuit during transport by carrying them in their original packaging, by taping their terminals or by placing each battery in a separate protective bag. Portable power banks are regarded as spare batteries. Electronic cigarettes are only permitted to be transported in the cabin, but they must not be used or recharged during flight.

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31 FAA = Federal Aviation Administration
32 ICAO = International Civil Aviation Organization
33 Doc 9284, Technical Instructions for the Safe Transport of Dangerous Goods by Air
34 The sampling, used as material in the investigation, included 30 major or medium-sized airlines.
35 The lithium content refers to lithium metal batteries (rather than lithium-ion batteries).

1.9.4 Other restrictions for transporting lithium-ion batteries in the air

In October 2016 **the U.S Department of Transportation (DOT)**[36] announced a ban on a smartphone model for air transportation. Non-US operators joined the ban. The ban was due to the risk of fire triggered by the overheating of the model's batteries. The manufacturer stopped producing the model and announced a voluntary recall on them. The ban is still in effect.

In March 2017 **the Department of Homeland Security (DHS)**[37] and **the Transport Safety Administration (TSA)**[38] banned the transport of electronic devices larger than a cell phone/smart phone on board an aircraft in carry-on luggage or other accessible property if the last points of departure to the United States included ten specific airports in the Middle East. The UK authorities joined this ban. The ban did not apply to medical devices or Electronic Flight Bag (EFB)[39] devices. The equipment affected by the ban was to be secured in checked luggage. The US authorities justified their decision on the basis of a heightened threat of terrorism. Moreover, on 29 June 2017 they announced the enhanced screening of passengers and electronic devices, among other things, as well as heightened security standards for aircraft and international airports in the USA. The ban was lifted on 21 July 2017. Apart from a few exceptions, the UK authorities are still upholding the ban.

On 31 March 2017 **the International Civil Aviation Organization (ICAO)** published Electronic Bulletin EB2017/23 which provided an opinion on the ban issued by the DHS and the TSA. The bulletin states that the ban increases the number of lithium-ion batteries in cargo compartments. States were encouraged to emphasize the need for operators to take this into account through their safety risk assessment procedures. According to the bulletin *operators should provide clear information to passengers explaining that the devices must be completely switched off and packed in protective packaging to prevent unintentional activation* during flight. Furthermore, *operators should consider the potential for higher concentrations of lithium battery powered devices in close proximity to each other in cargo*. Also, *operators should provide information to codeshare and alliance partners and ensure appropriate advice is provided to transfer passengers*. The ICAO is presently preparing a Global Aviation Security Plan (GASeP); its purpose is to improve and harmonise security in aviation worldwide.

On 19.12.2017 the **European Aviation Safety Agency (EASA)** published the Safety Information Bulletin 2017-04R1. The SIB recommends that passengers' PEDs are carried in the cabin (to enable the crew to react expeditiously in case there is an incident) and proposes mitigating actions for when this is not possible and large PEDs have to be consequently carried in checked baggage, whilst reminding operators to request passengers that, in such scenario, any spare batteries or e-cigarettes must be removed from the bag.

The EASA has also published the bulletin SIB 2017-01 on the transport by air of damaged, recalled, defective or potentially hazardous lithium batteries.

The European Aviation Safety Agency (EASA) published a Safety Information Bulletin (SIB 2017-04) on the same topic. The EASA is presently conducting a research project (RES.004) on the transport of lithium-ion batteries in the air.

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36 DOT = U.S Department of Transportation
37 DHS= Department of Homeland Security
38 TSA = Transport Safety Administration
39 EBF = Electronic Flight Bag

The International Air Transport Association (IATA)[40] has published guidelines and regulations[41] for its member airlines on transporting hazardous materials by air. The regulations, which will enter into force as of 2018, state that crew members or passengers may carry up to 15 portable electronic devices (PED) and 20 spare batteries. Exceeding this limit is subject to the operator's approval. Previously there was no upper numerical limit on devices if the capacity of the batteries did not exceed 100 Wh or had less than 2 g of lithium. The IATA says that the restrictions are necessary because some passengers have been transporting large numbers of PEDs for commercial purposes.

[40] IATA = International Air Transport Association is the international trade association for the world's airlines.
[41] IATA Dangerous Goods Regulations (DGR), based on ICAO Annex 18 and Doc 9284 (ICAO TI)

2 ANALYSIS

2.1 Analysis of the occurrence

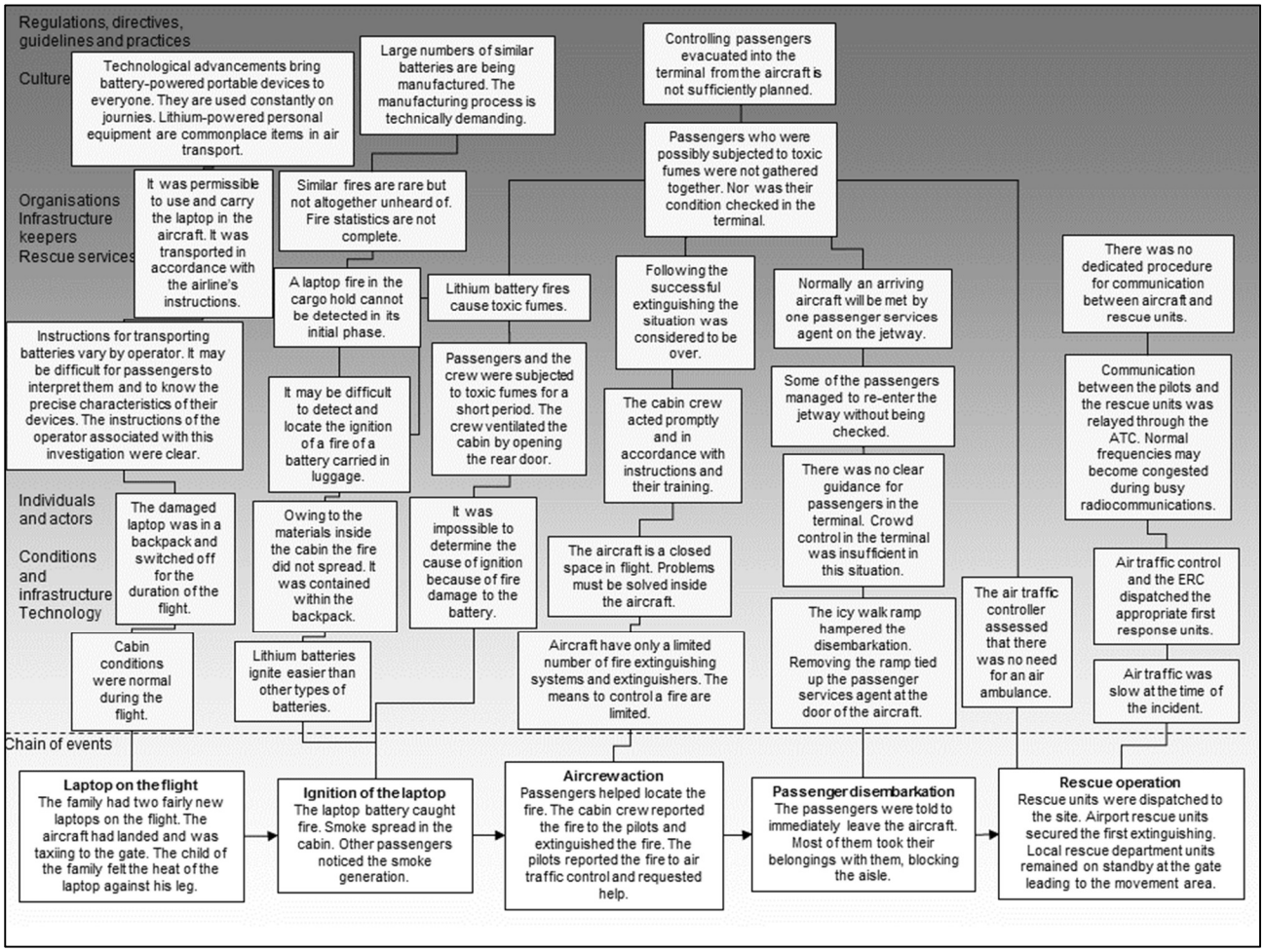

Figure 6. AcciMap presentation

2.1.1 The laptop on the flight

The family had bought two similar laptops approximately six months before the flight; they were carried on the scheduled flight from Berlin to Helsinki, transported in accordance with the operator's instructions and switched off for the duration of the flight. Conditions in the cabin were normal.

Lithium-ion batteries are categorised as dangerous goods and operators have placed restrictions on their transport by air. It is permissible to transport and use devices in accordance with the restrictions. Judging by a sampling taken during the investigation, operators' instructions to passengers vary in content, availability and clarity. A passenger may use many different airlines during one journey, and airlines may observe differing restrictions. Since the restrictions are based on battery ratings and the amount of lithium in the batteries, the airlines' instructions assume that passengers are familiar with the technical features of their devices. However, users may not even be able to see the markings on the battery because batteries are often situated inside a fixed outer shell. If the restrictions are easily available on the airline's internet page and at the airport, and contain clarifying illustrations, it helps passengers to understand the content of the restrictions. The instructions of the airline associated with this investigation were clear.

2.1.2 The ignition of the laptop

After landing, the child of the family felt that his backpack was hot against his leg. When the aircraft arrived at gate 29 the battery of the laptop caught fire and began to disperse smoke into the cabin. Other passengers noticed the smoke and reported it to the cabin crew. Owing to the materials inside the cabin the fire did not spread. Rather, it was contained within the backpack. While the fire generated toxic fumes the passengers and the crew were only briefly subjected to them. The crew ventilated the cabin by opening the rear door.

A lithium-ion battery can be forced into thermal runaway because of, among other things, an internal or external short circuit, physical damage to the battery, overcharging or exposure to high temperatures. Laptop battery fires are rare in flight but they are not altogether unheard of. While different bodies have collected information on these fires, there are no consistent global statistics. The computer had an original battery with a genuine CE marking. The fire damaged the laptop to the extent that it proved impossible to determine the ultimate cause of ignition.

2.1.3 Aircrew action

Apart from the lavatories there are no fire or smoke detectors in the cabin. With the help of the passengers it was possible to rapidly pinpoint the source of the laptop fire in the front of the cabin.

The cabin crew reported the fire to the pilots and extinguished it with a Halon extinguisher. The training captain reported the fire to the air traffic control on the TWR frequency and requested rescue units to come to the aircraft.

It was possible to quickly initiate the firefighting because the fire was at the front of the cabin. One Halon extinguisher was all it took to extinguish the fire. The cabin crew acted promptly and in accordance with their instructions and training.

Since there are only a limited number of extinguishers, they have to be used effectively and correctly. They are positioned to be readily available. The correct and effective use of extinguishers demands practical training.

The ways and means to control fires in the air are limited. An aircraft is a closed space during the flight and this means that it is impossible to eject burning material or get additional extinguishers or other resources. According to regulations the materials used in aircraft must be fire-retardant. Also, according to regulations, the aircraft must carry the required number of extinguishers and have a trained cabin crew.

Even though regulations require fire-retardant cabin materials, the same does not apply to the passengers' clothing or carry-on luggage. Along with the tide of technological advancements portable devices with lithium powered batteries are becoming increasingly commonplace and are also taken along on trips. One person may carry several devices containing lithium batteries, along with their spare batteries.

For the sake of fire safety it is better to carry the devices in the cabin. This is because a potential fire would be detected earlier than it would in the cargo compartment and it is also possible to begin to extinguish the fire in its initial phase.

2.1.4 Passenger disembarkation

The senior cabin crew member announced that the passengers must leave the aircraft as soon as possible and leave their carry-on luggage behind. This was controlled disembarkation, not emergency evacuation. The announcement was made in English, which was appropriate for the situation. The operator's cabin announcement instructions do not provide a ready template for this kind of announcement. Following the announcement the passengers deplaned through the front door to the airport terminal. Some passengers took their hand luggage with them when they disembarked.

The separate walk ramp positioned at the front door of the aircraft impeded the disembarkation because the ramp was icy and slippery. Upon noticing this the passenger services agent removed the ramp and remained at the door to assist passengers. This took so much time that it prevented her from going back to the boarding gate or from calling for extra help. Some of the passengers who had disembarked without their carry-on luggage managed to re-enter the jetway unauthorised.

Normally, an aircraft is met by one passenger services agent. Upon having completed the arrival duties the agent returns to the boarding gate inside the terminal where their duties involve monitoring the movement of people at the gate and preventing unauthorised access to the jetway and the aircraft. The agent's instructions do not clearly state how to call for additional assistance or how to control crowds.

Passenger disembarkation from aircraft and from the terminal must occur in a controlled manner during abnormal situations. For instance, it is imperative to find out whether all persons on board the aircraft have deplaned. By gathering the passengers together it is possible to check their condition and provide additional information to them about the incident. In this situation the passengers at the front of the aircraft possibly inhaled toxic fumes, which is why health care personnel should have checked them to determine the need for possible follow-on treatment prior to them leaving the terminal.

It was impossible to check the condition of the passengers because the airport's emergency plan does not include instructions for gathering passengers together at a previously determined meeting point following accidents.

2.2 Analysis of the rescue operation

Air traffic was slow at the time of the incident which is why the air traffic controller had sufficient time to discuss the situation with the captain on the flight deck. The training captain reported the smoke and clearly requested rescue units be dispatched to the aircraft. The air traffic controller acted in accordance with the instructions and practices and alerted the airport rescue services and the ERC. Following the air traffic controller's alarm rescue units rapidly arrived at the aircraft. They positioned themselves around the aircraft according to their guidelines, to protect it and the terminal. The ERC dispatched the appropriate Central Uusimaa Rescue Department's rescue and first response units to the target.

Helsinki-Vantaa aerodrome does not have a dedicated procedure or frequency for use between aircraft and rescue units. The training captain requested a frequency for this purpose, but the information between the pilots and the rescue units was relayed by the TWR. The normal frequencies that are used between aircraft and the ATC may become congested during busy radio traffic, which may hamper communication between the ATC and the aircraft in distress. The air ambulance FinnHEMS 10 base called the air traffic controller at the onset of the situation. During the call the controller assessed that the FinnHEMS was not

needed. The rescue authority, as the overall situation commander, is in charge of the rescue operation; only the commander has the right to relieve units as required by the situation.

The fire officer riding on one foam tender entered the aircraft and provided situational information from inside the cabin to the airport's incident commander. The fire officer made certain that the extinguishing had been successful and checked the cabin. Following the successful first extinguishing the aircrew considered the situation to be over, which is why their internal communication was not flawless. At first, the fire officer did not receive situation updates about the incident nor of the first extinguishing carried out by the cabin crew.

On the basis of information provided from inside the cabin the incident commander had a good situation picture, making it possible to take the appropriate decisions on the required follow-on action. The incident commander was able to tell the rescue units of Central Uusimaa Rescue Department that were on their way that the situation was under control and that the passengers had disembarked through the jetway. Following this the units remained on standby behind the gate leading to the movement area, ready to come to the aircraft if needed. The alarm was cancelled and the rescue units of Central Uusimaa Rescue Department were called off.

2.3 Analysis of the authorities' action

The national aviation authority[42] approves the operations manuals and training curricula drawn up by the operator, which are based on the aviation authority's regulations. On the basis of this investigation the aircrew was well prepared to control a fire in the cabin because they extinguished the fire promptly. The crew acted in accordance with the airline's training and instructions.

Within the scope of its duties the Finnish Safety and Chemicals Agency (Tukes) monitors the safety and conformity of products sold in Finland. The device associated with this investigation had the appropriate CE marking that indicates conformity in electronic devices. It is mandatory for electronic devices sold within the area of the European Union.

[42] Air Berlin operated under the control of the German aviation authority

3 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 circumstances.

1. The lithium-ion battery of a laptop placed under a seat caught fire as an Airbus A320 airliner, after having landed at Helsinki-Vantaa airport, was taxiing towards its arrival gate.

   Conclusion: *Devices fitted with lithium-ion batteries are routinely transported in aircraft. Laptop battery fires are rare in flight but they are not altogether unheard of. Lithium-ion batteries are categorised as dangerous goods. In light of the investigation material, operators' instructions for transporting lithium-ion batteries by air vary in content, availability and clarity.*

2. The ways and means to control fires in the air are limited. Even a small fire in a closed space is one of the most serious threats to aircraft. For this reason a fire must be met with immediate and decisive action.

   Conclusion: *Ways of controlling fires in the air constitute, among other things, first extinguishing equipment and systems on the aircraft, firefighting training provided to the aircrew as well as the proper placement of luggage.*

3. The crew acted in accordance with their training and the operator's instructions during the fire. First extinguishing was successfully completed and the fire did not spread in the cabin. Following this, the communication between the crew and the fire officer who entered the cabin did not function adequately in all aspects. Therefore, they did not share the same situational awareness at the onset of the events.

   Conclusion: *The aircrew were well prepared to control a fire in the cabin. The extinguishers that were used worked well and they were appropriate for the task. Following the successful first extinguishing the aircrew considered the situation to be over.*

4. After the first extinguishing the crew ordered the passengers to immediately leave the aircraft. The passengers were not gathered together in the terminal following disembarkation. By gathering passengers together it is possible to find out whether all persons on board the aircraft have deplaned, to check their condition, and provide additional information to them about the incident.

   Conclusion: *The instructions of the airline's representative and those of Helsinki-Vantaa airport contained no guidelines for rapid passenger disembarkation in an abnormal situation or for managing the situation inside the terminal after the occurrence.*

5. The training captain reported smoke in the cabin to the air traffic controller and requested rescue units be dispatched to the aircraft. At the same time the captain requested a frequency for communicating with the rescue units.

   Conclusion: *The training captain's request was clear. The air traffic controller acted in accordance with the request for help, alerted airport rescue and relayed the distress call to the Emergency Response Centre. Helsinki-Vantaa had not designated a frequency for communication between rescue units and aircraft.*

6. At some point in the phone call the air traffic controller assessed that the air ambulance was not needed at the site. The events in the cabin progressed rapidly; neither the aircrew nor the air traffic controller had enough time to form a sufficiently accurate opinion of the possible harm to the passengers caused by the toxic fumes or the extinguishing agent.

   Conclusion: *The assessment of the need for an air ambulance at the target must be based on timely and authenticated information received from the site. The rescue authority, as the overall situation commander, is in charge of the rescue operation; only the commander has the right to relieve units as required by the situation.*

7. The fire officer who rode on the foam tender received preliminary information of the fire after the training captain opened the cockpit window. Following this, he went into the cabin to check what was happening and to get a picture of the situation.

   Conclusion: *The incident commander received good situational information from the fire officer that entered the aircraft. He was then able to establish a situation picture and also relay this information to the rescue units of Central Uusimaa Rescue Department.*

8. Lithium-ion batteries are commonly used in portable electronic devices because they are light and long-lasting and have a larger capacity per weight ratio than other battery types. Lithium-ion batteries are becoming increasingly commonplace.

   Conclusion: *The production of lithium-ion batteries requires sophisticated manufacturing technology. An internally or externally damaged lithium-ion battery may ignite in an explosive manner, causing material damage and injuries to persons.*

4 SAFETY RECOMMENDATIONS

4.1 Crowd control in an abnormal situation in the terminal

The instructions of the airline's representative and those of Helsinki-Vantaa airport contained no guidelines for rapid passenger disembarkation in an abnormal situation or for managing the situation inside the terminal after the occurrence.

The Safety Investigation Authority recommends that

Finavia Oyj, together with the representatives of airlines operating at the airport, draw up guidelines for a situation in which passengers must rapidly be evacuated from the aircraft into the terminal. [2018-S05]

4.2 Safety actions already implemented

As of 27 November 2017 Helsinki-Vantaa airport has introduced the EASA's recommendation for designating a common frequency for communication between rescue units and aircraft.

Finavia Oyj is presently creating a process to support airlines in situations in which, among other things, detected smoke or fire forces the evacuation of passengers back into the terminal or outside at a remote stand. The process will describe the airport's support to airlines in, among other things, informing the passengers, defining the assembly area, and in receiving the passengers. Finavia will implement the actions together with the Airline Operators Committee. The process will also support those airlines that have no representatives at Helsinki-Vantaa airport. The updated instructions will be taken into use during the spring of 2018.

Helsinki 5.3.2018

Ismo Aaltonen Jani Holmberg Tii-Maria Siitonen

Sanna Winberg

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Different airlines' restrictions on transporting lithium-ion batteries by air. The sampling included the following airlines: Aeromexico, Air Europa, Air Mauritius, Air New Zealand, All Nippon Airways, American Airlines, American Airlines, China Eastern Airlines, China Southern Airlines, Croatia Airlines, Delta Airlines, Emirates, Ethiopian Airlines, Finnair, Iberia, Icelandair, KLM, Korean Air, LATAM Brasil, Lufthansa, QANTAS, Royal Air Maroc, Ryanair, SAS, Singapore Airlines, South African Airways, United Airlines ja Virgin Atlantic.

Investigation material

1. The flight safety reports filed by the aircrew of flight AB8070 and the photographs they took.
2. The flight safety report filed by the air traffic controller.
3. The flight safety report filed by the ground handling company.
4. The condensed pre-trial investigation report of Eastern Uusimaa Police Department and the photographs taken by the police.
5. The dispatch report and the accidents and emergencies report received from the Finnish rescue services' PRONTO statistics database.
6. The ERC's operational log, dispatch report, action log and voice recordings associated with this alarm.
7. The control tower's radiocommunication and telephone recordings.
8. Interviews conducted during the investigation.
9. Investigation material provided by Air Berlin.
10. Investigation material provided by Swissport Finland Oy.
11. Different operators' restrictions for transporting lithium-ion batteries by air.
12. Finavia Oyj's Helsinki-Vantaa airport operations manual and guidelines for rescue operations.
13. The rescue departments of the city of Helsinki, Eastern Uusimaa, Central Uusimaa and Western Uusimaa: General Guidelines for Managing Rescue Operations, 12 November 2013

SUMMARY OF THE COMMENTS TO THE DRAFT FINAL REPORT

The draft final report was sent for comments to the Finnish Transport Safety Agency, the Emergency Response Centre Administration, the Central Uusimaa Rescue Department, the National Police Board, ANS Finland, Finavia Oyj, the European Aviation Safety Agency (EASA), the International Air Transport Association (IATA), the German Federal Bureau of Aircraft Accident Investigation (BFU), Air Berlin, Swissport Finland, the laptop manufacturer, the aircrew of the aircraft, the air traffic controller and the family that owned the laptop. Pursuant to the Safety Investigation Act no comments given by private individuals may be included in the investigation report.

Finnish Transport Safety Agency

The Finnish Transport Safety Agency had no comments per se, but the report was adjusted on the basis of the remarks which were attached to the reply. The remarks addressed the automatic fire extinguishing system of the aircraft and the number of extinguishers, aircrew training requirements and recurrent training, the clarification of regulations concerning the air transport of lithium batteries as well as conclusions and safety recommendations.

Emergency Response Centre Administration

The Emergency Response Centre Administration reported that they have nothing specific to mention regarding the draft final report and that, therefore, they have no specific comments.

Central Uusimaa Rescue Department

The Central Uusimaa Rescue Department had no comments to the draft final report.

National Police Board

The National Police Board had no comments to the draft final report

ANS Finland Oy

According to the draft final report, air traffic control at Helsinki-Vantaa airport had decided to cancel the dispatching of FinnHEMS to the aircraft being investigated in this report. ANS Finland states that, according to their knowledge, the air traffic control does not have the authority to cancel any alarms dispatched to FinnHEMS by the Emergency Response Centre.

The report was amended and adjusted in accordance with ANS Finland's comments.

Finavia Oyj

Finavia Oyj had no comments to the content of the draft final report

According to the comments Finavia has launched a development project together with the representatives of airlines. The goal of the project is to construct a process at Helsinki-Vantaa airport by which the airport can support airlines in abnormal situations in informing the passengers and in defining the area where people are to gather. This kind of a situation may arise, for example, if detected smoke or fire forces the evacuation of passengers back into the terminal or outside at a remote stand. The possible follow-on actions, after receiving the passengers, may include health checks as well as arranging connecting flights and accommodation.

Swissport Finland Oy

Swissport Finland had no comments to the draft final report

L**aptop manufacturer**

The laptop manufacturer had no comments to the draft final report

European Aviation Safety Agency (EASA)

In their comments the EASA propose that the investigation report make references to up-to-date regulations. One of the regulations was updated while the investigation was ongoing, on 19 December 2017. According to the comments the report should clearly differentiate between regulations concerning cargo flights and passenger flights. Instead of the quotes presented in the draft final report the investigation report now makes reference to COMMISSION REGULATION (EU) No 965/2012.

International Air Transport Association (IATA)

IATA had no comments to the draft final report.

German Federal Bureau of Aircraft Accident Investigation (BFU)

The BFU had no comments to the draft final report.

Air Berlin

Air Berlin had no comments to the draft final report.