Airliner Overrun at Helsinki-Vantaa Airport on July 11, 2017

L2017-03

SYNOPSIS

Pursuant to section 2 of the Safety Investigation Act (525/2011), the Safety Investigation Authority decided to investigate an incident in which a Boeing 737-800 airliner operated by Norwegian Air Shuttle overran the runway on landing at Helsinki-Vantaa airport on July 11, 2017, and came to a halt on the grass beyond the runway end. 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.

Air traffic control officer (retired) Lars Levo was appointed the investigation team leader. Team members were airline pilot Juha-Pekka Keidasto and Doctor of Psychology Sirkku Laapotti. Chief Air Safety Investigator Ismo Aaltonen acted as investigator-in-charge. The Accident Investigation Board Norway (SHT, Statens Havarikommisjon for Transport) appointed an authorized representative 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 the 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 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 investigation report. No comments given by private individuals are published.

This document is a translation of the original Finnish report. The investigation report and its summary are published on the internet page of the Safety Investigation Authority at *www.sia.fi*.

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1 FACTUAL INFORMATION

1.1 Sequence of Events

At 1523 h UTC[1] on Tuesday July 11, 2017, flight NAX4287 operated by Norwegian Air Shuttle departed from Arlanda Airport, Stockholm, on a service to Helsinki. The captain was pilot flying.

The en-route portion of the flight was normal. The flight crew assessed[2] the landing distance for the prevailing conditions and conducted a briefing on the essential aspects of the approach. The assessment of the landing distance was based on an ATIS[3] message in effect for the aerodrome. The aircraft left the cruise altitude at 1546 h to commence an ILS[4] approach to Helsinki-Vantaa airport. The initial approach to runway 04L was normal. Rain clouds were present in the area and winds were moderate.

The touchdown was light and slightly beyond the optimum touchdown point at an airspeed that was almost right for the prevailing conditions. The captain selected reverse thrust at the moment of the touchdown, and reverse thrust became effective three seconds after the touchdown. The speedbrakes (spoilers) had been armed, but due to the light touchdown they did not deploy automatically. The captain deployed the spoilers manually one second after the touchdown. The autobrake system had also been armed and began to decelerate the aircraft normally upon spoiler deployment.

During the approach, the flight crew had planned to vacate the runway via high-speed turn-off WK. Due to the high speed, the captain elected to pass turn-off WK and vacate the runway via a taxiway at runway end. The captain canceled reverse thrust, and moments later also stowed the spoilers and deselected the autobrake system, which resulted in a marked reduction in the rate of deceleration. The captain applied light and full manual braking with approximately 850 and approximately 570 meters of runway remaining, respectively.

As the aircraft approached taxiway WH with approximately 300 m of runway remaining, the captain reselected reverse thrust and continued to apply heavy wheel braking. At this point, the aircraft was traveling at 64 kt (119 km/h). Because the captain had stowed the spoilers previously they did not deploy automatically. The captain attempted to steer the aircraft onto taxiway WD, which is the last taxiway at runway end. The captain canceled reverse thrust when the aircraft was traveling at approximately 25 kt (46 km/h), but due to excessive speed was unable to turn the aircraft onto the taxiway. The first officer called “brace”[5] via the passenger address system.

The tires impacted the runway light fixtures by the time aircraft heading had diverged approximately 20 degrees from runway 04L heading. Both nosewheels and three mainwheels came to rest on the grass while the fourth mainwheel remained on the paved area.

The captain elected to not evacuate the aircraft. The air traffic control declared a local standby phase, and aerodrome rescue service units secured the aircraft. The aircraft was moved off the grass by a pushback tractor and towed to a position in front of the terminal building.

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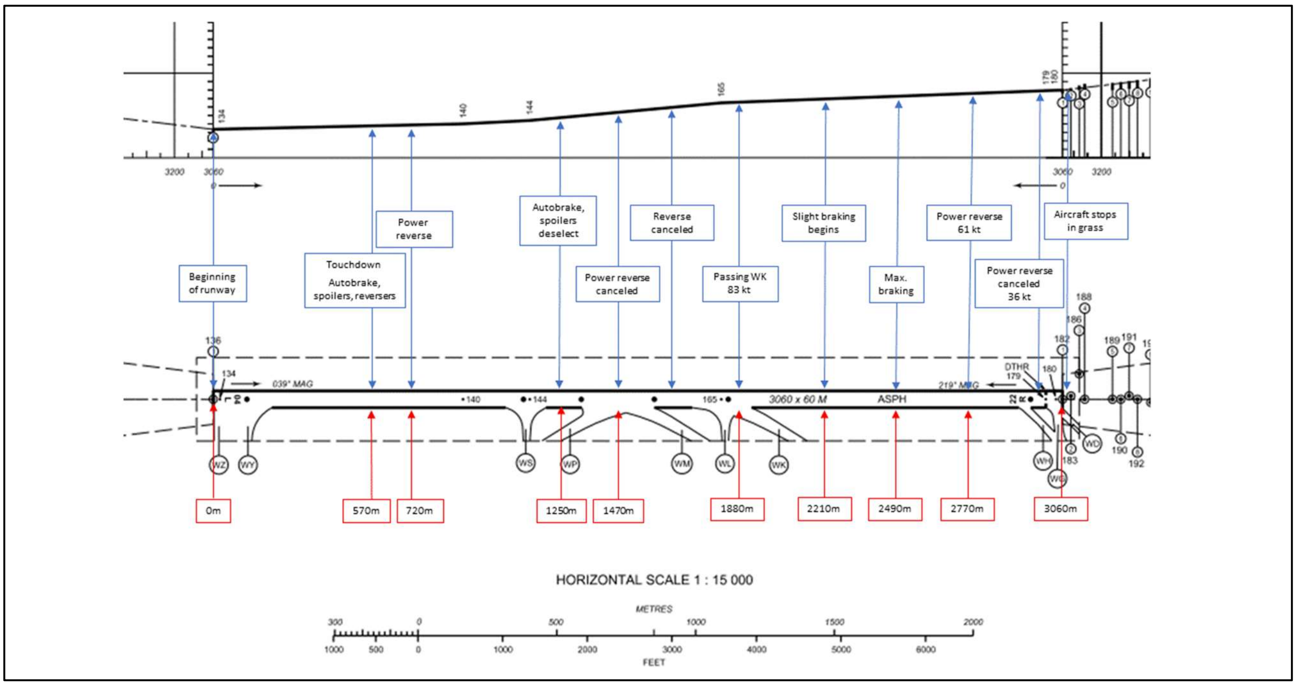
1 Universal time coordinated, used in this investigation report unless stated otherwise. Finnish time was UTC + 3 hours (daylight saving time).
2 OM-B 4.8
3 Automatic terminal information service
4 Instrument landing system
5 A “brace” call warns of an impending impact.

In accordance with regulations, airport maintenance units inspected the runway after the incident. The runway remained closed for about one hour.



Picture 1. Graphic representation of the incident sequence. Distances are approximate and calculated from runway 04L threshold. (Basemap: ©ANS Finland Oy, overlays: SIAF)

Picture 2. Thrust reverser deployment and final position of aircraft. (Plan view: Orthophoto ©National Land Survey of Finland 4/2018, overlays: SIAF)

1.2 Alerting and Rescue Operations

At 1607 h, the air traffic control officer observed flight NAX4287 stationary at an unusual position and inquired of the flight crew whether they were able to proceed to the apron. The flight crew advised that the nose wheels were on the grass and the aircraft was disabled. Upon receiving this information, air traffic control immediately closed runway 04L to air traffic and issued alerts in accordance with the local standby procedures checklist[6]. The crews of the first emergency vehicles to arrive on the scene observed that the aircraft was completely off the paved area and lighting fixtures had sustained damage.

A heavy-duty pushback tractor was obtained to move the aircraft off the grass and tow it to a position in front of the terminal building. The rescue services secured the aircraft but no rescue actions were needed, and the passengers remained on board throughout the event. An airport electrical maintenance team was also alerted to go the scene.

Air traffic control called the police via a rescue department since the contact information for the police field director were not updated in the alert checklist available at the air traffic control. A police patrol breath tested both flight crew members after the aircraft was parked at the terminal building. The results showed 0.00 per mil.

Runway 04L was reopened to traffic at 1755 h after repairs to the light fixtures and runway inspections.

1.3 Consequences

The incident did not result in injuries to persons.

The aircraft and runway end lights sustained damage. Two runway light fixtures were toppled and damaged upon impact by the aircraft wheels. The wheels sustained damage upon impact with the metal mounting stakes of the light fixtures, and the fan blades of one engine received foreign object damage[7].

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[6] A local standby procedure is executed, for example, when weather conditions deteriorate below a specified minimum, radio contact with an aircraft is lost, an aircraft fails to arrive within 30 min or is lost or missing. An alert is issued in accordance with the aerodrome emergency plan, which is part of the air navigation services (ANS) series of aviation regulations.

[7] A foreign object damage (FOD) is typically caused when an engine ingests rocks or other loose debris.

2 BACKGROUND INFORMATION

2.1 Environment, Systems and Equipment

2.1.1 Aircraft

The incident aircraft was a Boeing 737-800. Its landing gross weight on the incident flight was 61,100 kg. It carried six crew members and 168 passengers including two infants. The aircraft carries the registration LN-NHF.

The aircraft is fitted with an automatic wheelbrake system, automatic spoilers on the wing upper surfaces and a thrust reverser system. The autobrakes and automatic spoilers can be armed during approach, and they activate automatically at touchdown to decelerate the aircraft. The thrust reverser system can only be activated by flight crew action.

The spoilers are panels that are extended from the wing upper surface to reduce speed or increase sink rate. They can also be deployed during the landing roll to reduce lift generated by the wing; as a result, lift becomes insufficient to support the weight of the aircraft, which in turn increases the effectiveness of the wheel brakes. Deployed spoilers also increase drag for aerodynamic braking.

The flight crew can arm an automatic ground spoiler function in flight by operating a lever in the cockpit. The function activates when the thrust levers are at idle and two mainwheels spin-up or a sensor mounted in the right-hand main landing gear detects a weight-on-wheels condition.

In the Boeing 737-800, **reverse thrust** and its setting can be selected with thrust reverse levers mounted on the thrust levers. Activation of thrust reverse levers causes the rear section of the engine cowling to translate aft and open an annular slot, through which engine bypass is redirected forward at an angle. When a flight crew member wishes to use reverse thrust, the thrust levers should first be retarded to idle with the aircraft on the ground; the thrust reverse levers should then be raised to deploy the engine-mounted thrust reverser system that will redirect engine bypass air forward at an angle.

The flight crew can arm the **autobrake** system in flight by operating a switch in the cockpit. In the Boeing 737-800, four autobrake settings are available to select the rate of deceleration during landing. Setting 1 offers the lightest speed reduction while setting 4 refers to the most abrupt deceleration. Setting 2 was in use on the incident flight. The wheelbrake system has an anti-skid function which prevents the wheels from locking and thereby increases the rate of deceleration and improves the controllability of the aircraft during braking.

Automatic braking activates when the thrust levers are at idle and sensors mounted on the main landing gear units detect wheel spin-up.

Heavy rain was present at the time of the incident. Immediately after the incident and during subsequent hearings the flight crew presumed that the aircraft had aquaplaned during the landing roll. **Dynamic aquaplaning** happens when a tire cannot displace water due to a high speed and, as a result, rides on a cushion of water formed between the tire and the surface. The risk of aquaplaning can be broadly assessed using a method called Horne's formula[8], which produces the minimum speed for the initiation of dynamic aquaplaning. **Viscous aquaplaning** is a condition where friction between a tire and a wet runway has reduced, but not to such an extent that would have an effect on the rotation of the wheel. While the tire is in

[8] $V = 9\sqrt{p}$, V = speed in knots, p = tire pressure

partial contact with the runway, water remains trapped between the tire and the runway. A smooth surface and contaminants present in the water will result in the further loss of friction. Viscous aquaplaning can occur at considerably lower speeds and with smaller amounts of water present than dynamic aquaplaning. Dynamic and viscous aquaplaning may occur concurrently.[9]

The operator provided the investigation team with a calculation of the aquaplaning speed of the Boeing 737-800 which showed that the aquaplaning speed of the type is approximately 122 kt. FDM[10] data of the incident flight showed that the aircraft was traveling at a speed considerable below the dynamic aquaplaning speed when the flight crew reinitiated heavy braking with approximately 570 m of runway remaining.

2.1.2 Runway

The aircraft landed on runway 04L, which is the newest of the three runways serving Helsinki-Vantaa airport, and was completed in 2002. The landing distance available is 3,060 m. The runway was designed and built in accordance with the AGA M3 series of aviation regulations. It has a crowned cross-section to ensure the drainage of rainwater towards the wells arrayed along the runway edges. The runway was renovated between April and June 2012.

Picture 3. The final 900 m portion of the runway is indicated by alternating red and white centerline lights. (Photo: SIAF)

All runways at Helsinki-Vantaa airport have a lighting system, and the intensity of the lights can be adjusted from the air traffic control tower as required. The runway centerline, runway edge, and touchdown zone lights are white for most of their length. The centerline lights change to alternating red and white lights for the last 900 m before the runway end; the final portion 300 m before the runway end is indicated by red lights only. The runway edge lights

9 Skybrary, https://www.skybrary.aero/index.php/Aquaplaning
10 Flight data monitoring

are yellow over the final 600 m portion of the runway. Red lights at the runway end indicate the end of the runway.

The incident aircraft used a runway equipped with an ILS. The system consists of two separate antennas that transmit radio beams. One of these beams, called localizer, is aligned with the runway centerline; the other is called glideslope, which on this particular runway is angled 3 degrees above horizontal. Cockpit displays show the position of the aircraft relative to these beams.

The runway has an upslope of approximately 14 m over its length of 3 km.

2.2 Conditions

2.2.1 Runway and Traffic

Runway 04L was wet from heavy rain. ATIS information indicated that 1 mm thick water patches were present on the runway. The flight crew estimated that the amount of water on the runway was larger than indicated.

Traffic intensity was normal for an early evening, and flight NAX4287 was not required to expedite vacating the runway due to other traffic.

2.2.2 Schedule of Flight

The incident aircraft had previously flown from Helsinki to Stockholm as flight NAX4286. The scheduled and actual time of departure had been 1300 and 1337 h, respectively. The scheduled time of departure of flight NAX4287 from Stockholm to Helsinki was 1430 h. The flight departed at 1523 h and was approximately 42 min behind schedule on landing at Helsinki.

Airspeed during the en-route portion of the flight was normal, but during climb and descent the flight crew used higher-than-normal airspeeds in accordance with procedures laid down in company manuals. However, at no phase of the flight did they exceed the maximum flight manual airspeeds.

Norwegian had planned for approximately 30-minute turnarounds at both Stockholm and Helsinki. During a turnaround, the passengers disembark and new passengers board the aircraft, which is cleaned, fueled, and loaded.

2.2.3 Weather Conditions

An analysis conducted by the Finnish Meteorological Institute showed that rain started at Helsinki-Vantaa airport at approximately 1230 h. Rain was initially light and occasionally fell as drizzle, but changed into moderate rain at 1445—1500 h. At the time of the landing of the incident aircraft, at 1555—1610 h, heavy rain was present, and the total rainfall over this time period was approximately 3.0—3.5 mm. The analysis states that these figures are typically associated with heavy rain and are in no way unusual. At 1600—1640 h, during the passing of the weather front, wind backed momentarily to between south and southeast. Average wind speed was 6—8 m/s. Visibility was limited due to rain.

<u>Helsinki-Vantaa Approach automatic terminal information service (ATIS) at 1519 h:</u>

Expect ILS approach. Arrival runway 04L. On runway water patches 1 mm. Transition level 55. Wind 90 degrees at 14 kt. Visibility 4 km. Moderate rain showers. Clouds: few 500 ft (150 m), broken 900 ft (270 m), broken CB 3,000 ft (900 m). Temperature 16 degrees, dew point

16 degrees. Atmospheric pressure 1005 hPa. Becoming visibility 8 km, no significant weather. Broken 1,200 ft (360 m). Broken 2,000 ft (600 m).

Helsinki-Vantaa Approach automatic terminal information service (ATIS) at 1548 h:

Expect ILS approach. Arrival runway 04L. On runway water patches 1 mm. Transition level 55. Wind 090 degrees at 15 kt. Visibility 5 km. Moderate rain showers. Clouds: few 400 ft (120 m), broken 900 ft (270 m), broken CB 2,500 ft (750 m). Temperature 16 degrees, dew point 15 degrees. Atmospheric pressure 1004 hPa. Becoming visibility 8 km, no significant weather. Broken 1,200 ft (360 m). Broken 2,000 ft (600 m).

2.3 Personnel, Organizations, and Safety Management

2.3.1 Personnel Information

The captain of the **aircraft**, age 33, held an airline transport pilot license issued approximately 7 years previously in Sweden. The captain had accumulated approximately 6,300 h of airline flight time on the type and had flown approximately 1,100 h as pilot-in-command. The captain had begun his employment at Norwegian approximately 7 years earlier, and the captain's previous career as a professional pilot spanned 9 years in total. The captain had reported for duty at Helsinki at 1150 h on the day of the incident. The incident flight was the captain's second flight of the day. The captain had accumulated 3 h 17 min of flight time in the last 24 h before the incident. According to the captain's report, the rest period before the first flight of the day had been 15 h 51 min, which was within the established limits.

The first officer, age 27, held a commercial pilot license issued less than 2 years previously in the United Kingdom. The first officer's career as a professional pilot had started in 2016, and the first officer had begun his employment at Norwegian less than 6 months previously. Before being employed as pilot, the first officer had worked for two years as a cabin attendant in commercial aviation. The first officer had accumulated almost 600 h of total airline flight time with two companies. 215 h of this time had been with Norwegian. The first officer had not flown as pilot-in-command. The first officer had reported for duty at Helsinki at 1150 h on the day of the incident. The incident flight was the first officer's second flight of the day. The first officer had accumulated 6 h 24 min of flight time in the last 24 h before the incident. According to the first officer's report, the rest period before the first flight of the day had been 15 h 21 min, which was within the established limits.

The flight crew held valid class and type ratings and medical certificates required for the flight.

The air traffic control officer at the TWR-W (Helsinki Tower West) position of **Helsinki-Vantaa aerodrome control** held a valid air traffic controller's license and had valid ratings and endorsements and medical certificates.

2.3.2 Organizations

The **Norwegian** Group holds several air operator certificates (AOC). The incident aircraft was operated under an AOC held by the parent company Norwegian Air Shuttle ASA (NAS). The company head office is in Norway.[11] The company's fleet includes aircraft registered both in Norway and other countries.[12]

ANS Finland Oy (Air Navigation Services Finland Oy) maintains and develops air navigation services in Finland. It is a wholly state-owned special assignment company steered by the Ministry of Transport and Communications.[13]

Finavia Oyj is an airport operating company that manages 22 airports in Finland. It is responsible for the building and maintenance of airport infrastructures including the information technology, lighting and heating solutions at the airports as well as ground traffic, security checks, and signage and passenger information services in the terminal buildings. Its tasks also include the maintenance of runway infrastructure.[14]

2.3.3 Safety Management at Norwegian Air Shuttle ASA[15]

The Norwegian Air Shuttle ASA (NAS) Organisation's Management Manual (OMM)[16] describes the functions of the company's organization management system as well as company values, policies, processes, guidelines, and responsibilities. The first chapter of the OMM states Norwegian's vision of everyone being able to afford to fly and lists the company's core values, which are simplicity, directness, and relevance. The company's operational priorities are safety and service. The aim of customer service is to offer low prices, good service, and punctuality. The goal is for over 90 % of the company's flights to be punctual within 15 minutes of the scheduled time. Norwegian intends to become the preferred supplier of air travel in its selected markets and to generate excellent profitability and return to its shareholders.

Chapter 4 of the OMM describes safety management in the company. In the company's organizational structure, a safety manager and the directors of three other functional areas (compliance monitoring manager, security manager, and office manager) report directly to the accountable manager. Safety pilots (three, part-time), safety analysts (three, full-time), safety advisors (six, part-time), a fatigue risk manager (one, full-time) and a chief investigator (one, part-time) work under the safety manager. The OMM describes the duties and responsibilities of each group of employees.

The main process of safety management is safety risk management (SRM), where 1. all hazards or safety threats are identified using a hazard identification process, 2. associated risks are analyzed using a risk assessment process, 3. the risk is assessed by comparing with criteria for risk acceptance, and 4. safety actions are proposed to mitigate risk to an acceptable level. The OMM describes the principles and processes in each of these steps.

According to the OMM, sources of safety information include flight data monitoring (FDM), audits, staff surveys, reports, investigations, reports of past occurrences, simulations, formal and informal discussions, interviews, and brainstorming.

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[11] www.norwegian.com
[12] www.iaa.ie
[13] www.ansfinland.fi
[14] www.finavia.fi
[15] The assessment of safety management is based only on manuals received from the company.
[16] Norwegian Air Shuttle Organisation's Management Manual, OMM

Risks are divided into acceptable, tolerable, and intolerable risks. Attempts will be made to eliminate or mitigate tolerable risks according to the ALARP (as low as reasonably practicable) principle based on cost-benefit analysis[17]. The accountable manager of the organization has the final decision on the tolerability of risk for all departments. The safety manager can take action when he is of the opinion that a risk decision is not in keeping with the ALARP principle.

The OMM states that identifying and addressing root causes of accidents and incidents is the most effective way of dealing with a problem that may be of a global nature.

Occurrence reporting is described in OMM Chapter 7 Reporting Scheme and Operations Manual Part A (OM-A)[18] Chapter 11 Handling of Accidents and Occurrences. The OM-A is used daily by the flight crews. The OM-A is subordinate to the OMM in the document hierarchy.

According to the OMM, the reporting system contains three elements: mandatory reporting, voluntary reporting, and hazard reporting. A mandatory report shall be filed within 72 h of an event. The captain of the incident flight filed a report on the day following the event. The first officer filed a voluntary report within 72 h of the event.

Mandatory reporting is divided into occurrence reporting and reporting of serious incidents and accidents. Any incident which endangers or which, if not corrected, would endanger an aircraft, its occupants or any other person shall be reported. Any occurrence that involves an unsatisfactory condition, behavior or procedure which does not immediately create a hazard but would do so in another situation if allowed to continue shall also be reported. The OM-A describes, in a comprehensive manner, examples of reportable events.

The OMM explains that the aim of mandatory occurrence reporting is to monitor, disseminate and record critical or potentially critical safety occurrences. The aim is not to monitor day-to-day defects and incidents since this would increase the workload for both the reporters and the Norwegian Civil Aviation Authority (CAA-N) and clog and obscure more significant safety items[19]. Day-to-day occurrences should be addressed through normal management actions.

The obligation to file a mandatory occurrence report rests on

- the operator or aircraft commander,
- any person carrying out maintenance or modifications,
- any person who signs an ARC[20] or a CRS[21], and
- any person who performs ground handling of an aircraft including fueling, loading, and de-icing.

The OMM states that mandatory reports shall be filed on serious incidents and accidents that occur in or over Norway or elsewhere to aircraft registered in Norway[22]. Serious incidents are defined in OM-A chapter 11, but the obligation to report is not limited to these occurrences.

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17 The ALARP principle is used in the management of safety-critical systems. For example, Technical Research Centre of Finland report (2002, Research Notes 2150) contains the following definition: In the ALARP region, risks have been reduced to the lowest practicable level where a risk is still tolerable. It will be necessary to consider the tolerability of residual risk due to the fact that the ALARP region lies between the intolerable region and the broadly acceptable region. Risks that emerge in the intolerable region are always of such a severity that actions will need to be taken to reduce their severity or the likelihood of hazards.

18 Norwegian Air Shuttle Operations Manual, part A (OM-A)

19 OMM 7.2.1

20 Airworthiness review certificate

21 Certificate of release to service

22 OMM 7.2.3

Reporting is a legal requirement for the aircraft commander or, if the commander is incapacitated, for the aircraft operator, normally taken care of by the safety manager.

Of voluntary reporting, the OMM explains that a voluntary report may be filed by any person not required to report under an obligation. Voluntary reports will be processed in a similar way to mandatory reports. If a reporter wishes that his or her identity is not revealed (confidential reporting or whistleblowing), he or she may choose to mark the report "confidential" and submit it direct to the Civil Aviation Authority of Norway (CAA-N). However, the preferred method of reporting is via the company's SafetyNet reporting system.

OM-A chapter 11 contains a description of the accident and incident reporting procedure. Unlike the OMM, the OM-A does not divide mandatory reporting into occurrence reporting and reporting of serious incidents and accidents. The SafetyNet system is to be used to report all accidents, serious incidents and other safety-related events or defects discovered during operations. The manual contains a comprehensive list of events of which a (mandatory) report shall be filed. The reports shall be in the English language. The manual states that an employee who has filed a report will be treated in a fair manner and not subjected to a punitive action ("just culture") unless he or she has shown negligence towards rules and regulations or repeatedly demonstrated unacceptable behavior. A report can also be filed as confidential for limited distribution.

2.4 Authorities' Actions

The **Finnish Transport Safety Agency** (Trafi) regulates and oversees all modes of transportation in Finland. Air traffic control reported the occurrence by submitting a flight safety report[23] to Trafi. Trafi uses flight safety reports and other sources to monitor the safety of air traffic and produces safety-related statistics. It may request further information on occurrences if necessary. No further information was requested for this particular incident.

The **police** filed the report as a miscellaneous report because there was no explicit reason to suspect a criminal action.

The **Civil Aviation Authority of Norway** (CAA-N) has approved Norwegian Air Shuttle ASA's operating manuals and training curricula, which are based on international regulations issued by competent authorities. CAA-N's register was not examined during the investigation.

2.5 Rescue Services and Preparedness

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 Helsinki-Vantaa airport. According to Aviation Regulation AGA M3-11, Helsinki-Vantaa airport is responsible for rescue actions and preparedness which, pursuant to the Rescue Act, are not the responsibility of the regional rescue services. Helsinki-Vantaa airport maintains an aerodrome emergency plan in cooperation with Central Uusimaa Rescue Department. The plan applies to aviation and other emergencies meant by AGA M3-11 that occur at or near the airport. Medical response was not required during this particular occurrence. The airport rescue and firefighting (ARFF) service ensured safety by executing the local standby procedures. The actions were in accordance with the applicable procedures.

23 The form is used to report, pursuant to Regulation (EU) No 376/2014 of the European Parliament and of the Council, accidents and serious incidents in civil aviation that occur in Finland or elsewhere to aircraft registered in Finland.

2.6 Recordings

2.6.1 Navigation Equipment and Radar

The SIAF had access to advanced surface movement radar data from the Helsinki-Vantaa airport control tower covering the time period just prior to and during the incident. The data showed the speed of aircraft on the runway after landing. Radar data also showed the movements of ARFF units within the aerodrome area at the time of the incident.

2.6.2 Radio and Telephone Communications

The SIAF had access to the cockpit voice recorder data of flight NAX4287 and to radio communication and telephone recordings of air traffic control. Cockpit voice recorder data contains all intra-cockpit conversation and radio communications. Air traffic control's voice communication system recording contains telephone conversations and radio communications.

Discussions between the captain and the first officer during the entire duration of the flight from Stockholm to Helsinki were examined using cockpit voice recorder data. Discussion was in compliance with procedures, only during the landing phase a number of discrepancies were noted.

The captain did not notify the first officer of his disarming of the spoilers and autobrake system, nor did the captain call out the cancelation of reverse thrust, and neither did the first officer react to the disabling of these braking systems. According to standard communication procedures, the first officer shall call out the disabling of the autobrake system, and the captain shall confirm manual braking in use.

The captain and first officer engaged in conversations which were not mandated by the operating procedures during the landing roll and thereby deviated from the sterile cockpit[24] rule.

2.6.3 Flight Data Recorders

The incident aircraft was equipped with a cockpit voice recorder and a flight data recorder. These recorders store data on an integral memory card in an electronic format. When necessary, data can be downloaded into an external server, a memory card, or any equivalent storage media.

A **CVR**[25] captures conversations between the flight crew members and between the flight crew and air traffic control. CVR data of the incident flight contained audio signals from four separate microphone channels. CVR recordings are legally protected and they may be listened to only if approved by the flight crew, or by accident investigation authorities. Most of the data was readable, only the sound level of the first officer's channel was low. CVR data was downloaded at the laboratory of the German Federal Bureau of Aircraft Accident Investigation[26] and sent to the SIAF.

An **FDR**[27] stores several flight parameters. In modern aircraft, the operator can select for recording information from a vast array of aircraft sensors. This information is called flight data monitoring (FDM) data. It can be used by the operator to improve the safety of its

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24 Regulation requiring flight crew to refrain from non-essential activities during critical phases (taxi, departure, and landing) of the flight and concentrate exclusively on actions laid down in the procedures.

25 Cockpit voice recorder

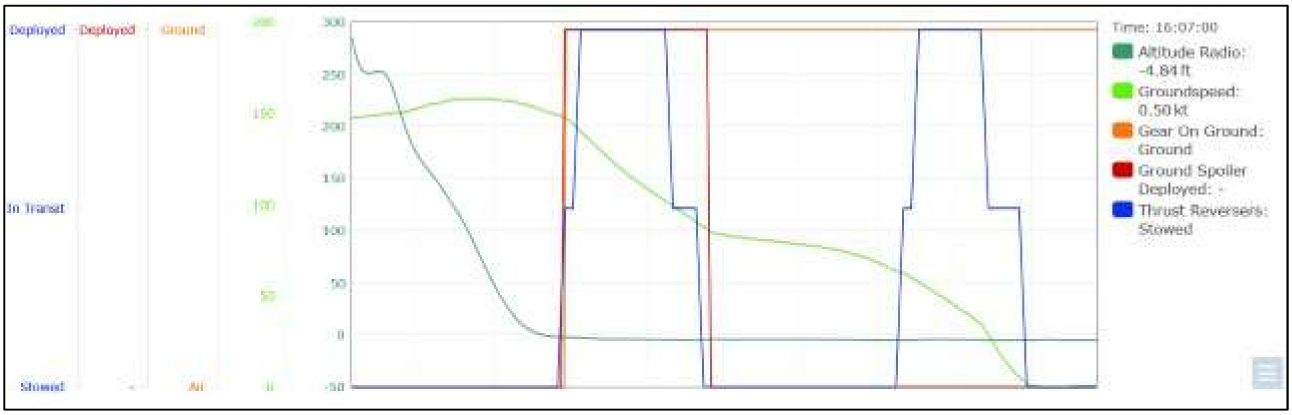
26 BFU, Bundesstelle für Flugunfalluntersuchung

27 Flight data recorder

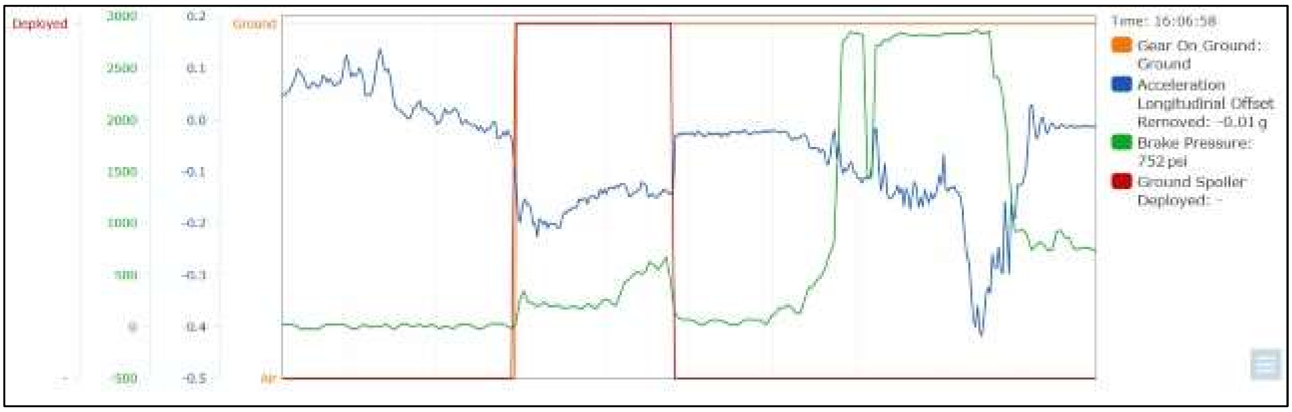
operations. FDR data is usable, among other purposes, for monitoring aircraft faults and in the investigation of serious incidents and accidents.

The investigation team had access to both CVR and FDR data.

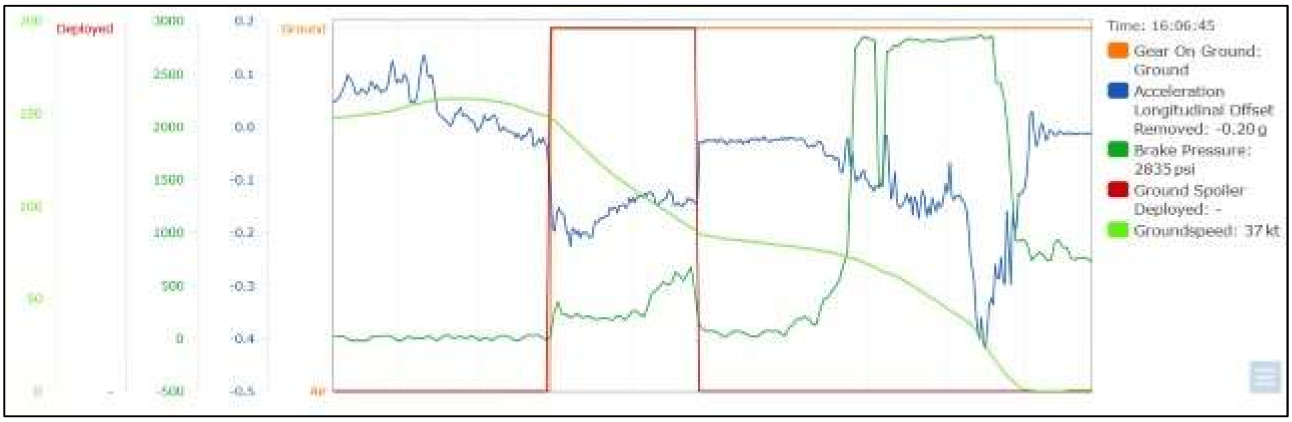
Pictures 4-6 contain a graphic representation of the key parameters obtained from FDM data during the landing and landing roll.



Picture 4. FDM data showing thrust reverser operation (blue), groundspeed (light green), and spoiler operation (red). (Source data: Norwegian Air Shuttle ASA)



Picture 5. FDM data showing spoiler operation (red), longitudinal acceleration (blue), and brake pressure (green). (Source data: Norwegian Air Shuttle ASA)



Picture 6. FDM data showing longitudinal acceleration (blue), brake pressure (dark green), groundspeed (light green) and spoiler operation (red). (Source data: Norwegian Air Shuttle ASA)

2.7 Rules, Regulations, Procedures and Other Documentation

Norwegian Air Shuttle ASA's operations manual[28] establishes procedures for speedbrake (spoiler) and thrust reverser operation. The flight crew should keep the spoilers deployed during the landing roll and stow them only when they steer the aircraft onto a taxiway. The manual, however, states that a flight crew member pilot may deviate from this when conditions allow.

The operations manual states that reverse thrust shall be selected immediately after touchdown. Reduction of engine power should commence after the speed has dropped to 60 kt, and idle reverse thrust should not be canceled until the speed has decayed to a safe taxiing speed.

The manual states that the normal taxiing speed on straight taxiways is 20 kt and the speed should not exceed 30 kt. Turns on dry tarmac surfaces should be done at 8—12 kt taxiing speeds.

Norwegian Air Shuttle ASA's operations manual[29] states that a sterile cockpit rule is to be observed. This rule requires flight crew to refrain from non-essential activities during critical phases (taxi, departure, and landing) of the flight and concentrate exclusively on actions laid down in the procedures.

Finnish aeronautical information publications[30] recommend that medium jet category aircraft vacate the runway via high-speed turn-off WK. The distance from the landing runway threshold to the turn-off intersection is 1,713 m.

The **Helsinki-Vantaa aerodrome emergency plan**[31] lists situations where a local standby procedure is executed. This can be done, for example, when weather conditions deteriorate below a specified minimum, radio contact with an aircraft is lost, an aircraft fails to arrive within 30 min or is lost or missing.

2.8 Other Research

2.8.1 Runway Excursions

Runway excursions involve aircraft running off the end of the runway (overrun) or departing the side of the runway (veer-off). The Australian Transport Safety Bureau conducted in 2009 a worldwide review of commercial jet aircraft runway excursions[32]. The review concludes that runway excursions have become increasingly prevalent although there has been a reduction in the number of other types of aircraft accidents. Runway excursions account for approximately a quarter of all air transport accidents and 96 % of all runway accidents. Between 1998 and 2007, there were 141 runway excursions which resulted in 550 fatalities. The review analyzed 120 runway excursions that happened during the landing phase. Of these accidents, 9 % resulted in fatalities. The review identifies over 300 factors contributing to runway excursions. Over 70 % of these factors were related to flight crew techniques, decision-making, and weather conditions. The factors included, among others, landing too fast or too far down the runway, an excessively light touchdown, and delayed or incorrect braking action. Contributing factors included less than adequate operator and flight crew procedures

[28] Norwegian Air Shuttle Operations Manual part B
[29] Norwegian Air Shuttle Operations Manual part A
[30] AIP part AD2 Helsinki-Vantaa, sub-para. 2.22.3.12 Minimum runway occupancy time
[31] Helsinki-Vantaa aerodrome emergency plan, instructions for rescue operations
[32] Taylor, R. P., Hughes, K. & Godley, S. (2009). Runway excursions, part 1. A worldwide review of commercial jet aircraft runway excursions. Australian Transport Safety Bureau, Aviation Research and Analysis Report, AR-2008-018(1).

for assessing whether the weather and runway conditions are safe for landing and less than adequate awareness of the effect of weather and runway conditions on landing roll length.

As a conclusion, the review distinguishes six categories of factors contributing to runway excursions. Runway excursions resulted from the following conditions:

- unstable approach
- incorrect landing technique
- unanticipated or worse-than-expected weather conditions
- inadequate or inappropriate braking
- unusual aircraft configuration (spoilers, flaps, leading edge slats)
- incorrect crew action or inadequate crew resource management under adverse conditions

2.8.2 Human Factors in Accidents and Serious Incidents in Commercial Aviation

A study conducted in Canada in 2003[33] lists 12 human performance -related factors that contribute to accidents and serious incidents in commercial aviation. SKYbrary[34] calls these factors the "dirty dozen."[35] Although the list is not exhaustive, the listed factors or preconditions can often be found behind a human error.

1. Lack of communication. Essential information may be missing or received information is misunderstood.
2. Complacency and inadequate awareness of potential dangers. Complacency typically arises during a routine activity when an individual considers the task easy and fails to see potential dangers. A relaxation of vigilance occurs, with the individual only seeing what he or she expects to see due to a prolonged exposure to a routine activity. A dangerous relaxation of vigilance can also occur during recovery from a particularly demanding activity.
3. Distraction. Distraction could be anything that draws an individual's attention away from the task on which he or she is employed. Some distractions are unavoidable, such as sudden noises, a problem that requires attention, or a request from a coworker. Most distractions can, however, be avoided or delayed until more appropriate times.
4. Lack of teamwork. Since most tasks and operations in aviation are team affairs workers must rely on and support colleagues and outside agencies. Key teamwork skills include leadership, effective communication, trust building, motivation, and praise giving.
5. Lack or insufficiency of resources. Resources include, among others, personnel, time, tools, support, skill, experience, and knowledge. A lack or insufficiency of any resource can interfere with a worker's ability to complete a task.
6. Pressure. Pressures exist in a dynamic environment. When the pressure to meet a deadline (such as a schedule) interferes with the ability to complete tasks correctly, pressures have become too much. Pressure is often created by a lack of resources, especially time. A worker may come under direct or indirect pressure from the organization, clients, and colleagues.
7. Norms. Informal norms are unwritten rules or practises followed by the majority of members in a group ("the way we do things round here"). They reflect the prevailing safety culture and can have either positive or negative effects on safety.

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33 Human performance factors for elementary work and servicing. Transport Canada. TP14175E (10/2003).

34 SKYbrary is an electronic data source on topics related to flight operations, air navigation services, and general flight safety.

35 https://www.skybrary.aero/index.php/The_Human_Factors_%22Dirty_Dozen%22

8. Fatigue. Prolonged physical or mental stress causes fatigue. We can become fatigued following long periods of work and even short periods of hard work. When fatigue becomes chronic, our ability to concentrate, remember and make decisions reduces, and fatigue will also affect our mood. Fatigue can also be due to external causes, in which case its reasons may be difficult to identify within the organization. We human beings tend to overestimate our ability to cope with fatigue.

The other factors discussed in the study were lack of knowledge, lack of assertiveness, stress, and lack of awareness.

2.8.3 Crew Resource Management

Teamwork training has an important role in the basic training curricula of commercial pilots. The subject is also addressed during continuation and advanced training. The importance of standardized communication is emphasized in training programs. Formal crew resource management (CRM) training highlights preparedness to interfere with situations that are felt to involve a potential safety hazard. However, speaking up is often found to be difficult due to a variety of reasons that can be traced to the working environment and individual traits. Bienefeld and Grote conducted (2012)[36] an interview survey to determine the reasons for and prevalence of cockpit and cabin crew members electing to stay silent. The study looked at so-called latent voice episodes. These were defined as ambiguous situations in which crew members had felt that speaking up was necessary for flight safety. Even though crew members told that they had often intervened in these situations, every interviewee recalled situations where he or she had refrained from speaking up. Of cockpit crew members, captains had only rarely (an average of 13 % of the situations) chosen to stay silent; on the other hand, first officers said that they had very often (an average of 69 % of the situations) decided to not speak up. Interviewees in both groups explained that in most cases the reason was the fear of damaging the relationship with the other crew member. Further to this, some captains also explained that they did not want to embarrass the first officer. Thirdly, most captains justified their staying silent by their wish to avoid a conflict between, on one hand efficiency or comfort, and safety on the other. The second most common reason for the first officers' silence was their feeling of the matter being insignificant; and third, they were afraid of acquiring a bad reputation (of becoming known as a difficult guy).

The study showed that a desire to maintain good team spirit was the primary reason for staying silent. Discussions between a captain and first officer may be affected by the individuals' objective or perceived position in the working community and organization. A first officer may feel that his or her career development is dependent on a good working relationship with the captain and therefore wants to avoid any difficulties. The first officer may also choose to remain silent if he or she feels that speaking up would be of no use; indeed, some individuals may have previous experience of futile intervention attempts. The captains' speaking habits may also be affected by the fact that as aircraft commanders they are responsible not only for safety but also for the efficiency and quality of flying-related functions.

The problem of staying silent could be alleviated by mitigating the social, individual or organizational fears of consequences of speaking up. The researchers maintain that it may be difficult to entice individuals in managerial or equivalent positions to speak more by making them attend training events when the underlying factors are related to a strive for efficiency.

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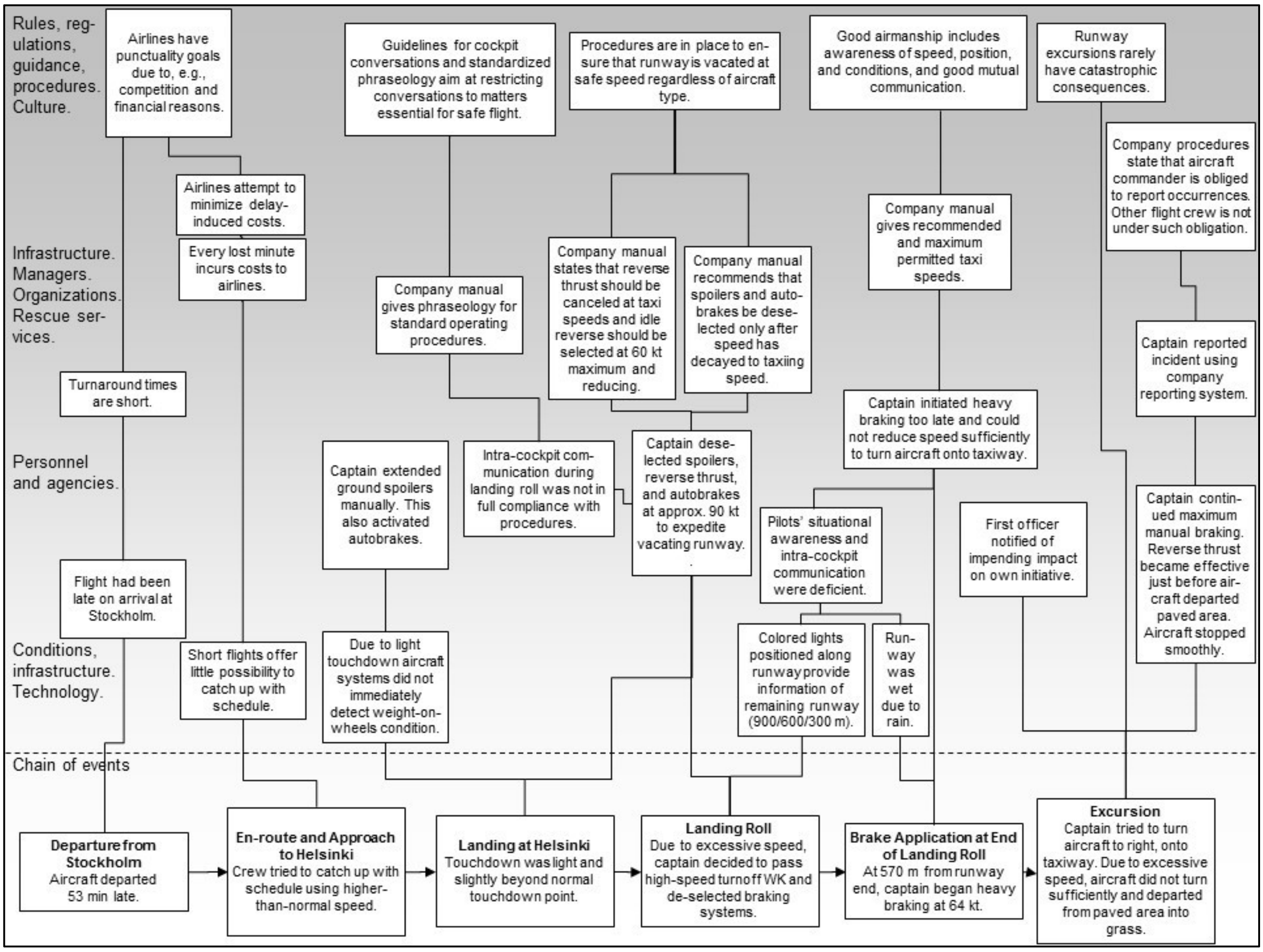
36 Bienefeld, N. & Grote, B. (2012). Silence that may kill. Aviation Psychology and Applied Human Factors, 2, pp. 1-10.

An increasing strive for efficiency affects an entire organization, and it can also have an overarching effect on the operating cultures in commercial aviation.

3 ANALYSIS

3.1 Analysis of Occurrence



Picture 7. Accimap Diagram

3.1.1 Departure from Stockholm and En-route Phase of Flight

The flight departed Stockholm 53 min behind schedule. It had already been delayed during the departure from Helsinki, and the delay had since accumulated. Aircraft turnaround times at airports are short. During the short time available, the passengers disembark and new ones board, and the aircraft is fueled, loaded, and cleaned, and a delay in any one of these operations may easily result in a late departure. Norwegian's manual states explicitly that the goal is for 90 % of flights to be punctual within 15 minutes of the scheduled time since punctuality is an element of good customer service. All airlines operate in a competitive setting and have therefore set punctuality goals. Delays also incur additional costs to the airlines.

Flight crew members generally find themselves in a problematic situation if flights are frequently delayed for reasons beyond their control and feel pressed to minimize the delays to the maximum possible extent. Short-duration flights, like the incident service from Stockholm to Helsinki, allow the flight crew only limited possibilities to catch up with the schedule. The captain used higher-than-normal airspeeds in accordance with the procedures laid down in the company manuals. The delay had been reduced by a few minutes by the time of landing at Helsinki.

Norwegian’s Organisation’s Management Manual (OMM) states that the company's two operational priorities are safety and service. The aim of customer service is to offer low prices, good service, and punctuality. A strive for punctuality or the minimizing of delays may contradict with safety aspects.

3.1.2 Landing and Landing Roll at Helsinki

The touchdown was light and slightly beyond the normal touchdown point. Due to the light touchdown, aircraft systems did not immediately detect a weight-on-wheels condition, and the spoilers and autobrake system did not activate automatically. The captain had to deploy the ground spoilers manually, which also resulted in simultaneous autobrake activation. The braking systems activated after a slight delay, and due to the high speed the captain elected to pass high-speed turn-off WK. It is recommended that medium jets such as the incident aircraft vacate the runway via this particular turn-off. Having made this decision, the captain deselected the braking systems to enable a more expeditious landing roll and to expedite vacating the runway. At approximately 90 kt, the captain stowed the spoilers, canceled reverse thrust, and deselected the autobrakes. Company manuals contain no standard phraseology for the stowing of the spoilers and cancelation of reverse thrust during landing, yet good airmanship presupposes that a flight crew member notifies the other flight crew member of these actions. This maintains situational awareness of both crew members.

The company manual states that the computer software that flight crew members use to assess landing distances is based on the spoilers and reverse thrust being in use until speed has reduced to 60 kt.

The deselection of the braking systems resulted in a low rate of deceleration. Colored lights positioned along the runway provide information on the remaining runway. The captain initiated light braking at approximately 80 kt with 850 m of runway remaining. The captain realized the situation too late and could not reduce speed sufficiently to turn the aircraft onto a taxiway. He applied heavy braking when the aircraft was traveling at 74 kt and with 570 m of runway remaining. Investigation showed that the airplane was not in a dynamic aquaplaning condition during braking. Some viscous aquaplaning always occurs on a wet runway.

The experienced captain was familiar with Helsinki-Vantaa airport. The flight crew was satisfied with the expeditious landing until the aircraft was approaching the runway end. They did not adequately anticipate and take into account the wet runway conditions. Water that was present on the runway reduced friction and consequently the rate of deceleration during the final phase of brake application. Since the captain had stowed the spoilers, the braking distance was extended.

Deficiencies in flight crew communication during landing were noted. The captain did not notify the first officer of the deselection of the braking systems, and the first officer did not react to the captain’s actions. According to standard communication procedures, the first officer shall only call out the deselection of the autobrake system, and the captain should confirm manual braking in use. Good airmanship, good crew resource management, and good situational awareness include the calling out of all actions that affect the flight. There was a significant experience gap between the first officer and the captain. It should have been the first officer's obligation to intervene when he noticed a hazardous situation developing, but he remained confident in the captain's experience and aircraft handling skills. However, during the final phase of the incident sequence the first officer notified, on own initiative, the cabin of an impending impact.

Good airmanship presupposes, among other things, good crew resource management and that all cockpit crew members maintain an awareness of the speed and position of the aircraft and of the prevailing conditions. These requirements were not fully met on the incident flight.

3.1.3 Excursion

The captain continued full manual braking and reselected reverse thrust with approximately 350 m of runway remaining. Reverse thrust became effective after a delay due to the time required for thrust reverser deployment and engine spool-up. The spoilers did not extend automatically since the speed was below 60 kt at the moment reverse thrust became effective. The flight crew could have extended the spoilers by operating the spoiler lever manually but they did not do so.

The captain managed to steer the aircraft towards the taxiway; however, the turn was too shallow and the aircraft departed the paved area. It came to a halt smoothly, and all occupants remained uninjured.

The captain used the company's reporting system to file an occurrence report as required by the applicable procedures. According to the guidelines of the company’s reporting system, reporting is a legal requirement for the aircraft commander only. However, a voluntary report may be filed by any employee who has observed any discrepancy, and in this incident the first officer also filed a voluntary report. The company's occurrence reporting system is described in the OM-A and OMM. The provisions contained in the latter are discussed here, since the OMM is superior to the OM-A in the document hierarchy.

As a rule, the OMM encourages employees to report all events that an individual worker subjectively assesses as reportable. Despite this, only mandatory reporting guidelines are included in the manual, which explains that the aim is not to monitor day-to-day defects and incidents since this would increase the workload for the reporters and the authorities and might clog and obscure more significant safety items. On the other hand, the OMM mentions root cause analysis and states that one of the safety aims is to identify the root causes of accidents and serious incidents. This is contradictory to the concept of not encouraging occurrence reporting. Recurrent anomalies, even though they may appear minor, may be important indicators of root causes and a company safety culture.

The manual also describes a procedure for anonymous reporting, called ‘whistleblowing.’ Anonymous reports are submitted direct to the authority. However, the preferred method of reporting is via the company’s SafetyNet reporting system.

3.1.4 General Airline Competition and Schedule Pressures

Competition and financial reasons have led airlines to set stringent schedule adherence goals. Some flight schedules may even be unrealistic and turnaround times excessively short, which deprives the employees of the possibility of achieving these goals. It is also probable that the employees of companies engaged in the industry are aware of the fact that each lost minute incurs additional costs to the company. Balancing in between the schedule adherence goals and the safety goals may lead to the adoption of procedures that undermine safety.

Repeated delays and failures to attain the required punctuality frustrates the employees; if allowed to continue, frustration will lead to negligence, which may manifest itself in non-compliance with rules and procedures.

3.1.5 Analysis of Rescue Operation

The air traffic control officer alerted the rescue services without delay, and the rescue operation was carried out in accordance with the applicable rules and regulations. Medical response was not required during this particular occurrence.

3.2 Analysis of Authorities' Action

No deficiencies were noted in the authorities' action. The actions of the Norwegian flight safety authority were not scrutinized in the investigation.

4 CONCLUSIONS

1. The flight departed Stockholm for Helsinki 53 min behind schedule. It had already been late on arrival at Stockholm.

    Conclusion: *Competition and financial reasons, among other factors, have led airlines to set punctuality goals. A strive for punctuality or the minimizing of delays may contradict with safety aspects. If a punctuality goal cannot be met, attempts will be made to minimize the delay since each lost minute incurs additional costs.*

2. Since the airplane was traveling at a high speed, the captain elected to pass high-speed turn-off WK. The flight crew aimed at vacating the runway via taxiway WD at the runway end. The distance to this taxiway intersection was approximately 1,200 m. The captain deselected the braking systems, and the aircraft continued down the runway at a speed that was high in view of the prevailing conditions and position.

    Conclusion: *Due to the possibility of other traffic and punctuality goals set for flights, flight crews attempt to vacate the runway as soon as possible.*

3. Colored lights positioned along the runway provide information on the remaining runway. The captain initiated heavy braking too late and could not reduce speed sufficiently to turn the aircraft onto the taxiway. The captain did not anticipate the effects of the wet runway and stowed spoilers on the braking distance.

    Conclusion: *Flight crew members must maintain situational awareness until the very end of a flight.*

4. Deficiencies in flight crew communication during the landing roll were noted.

    Conclusion: *Deficient communication may contribute to degraded situational awareness.*

5. Flight crew actions and crew resource management during the landing roll were not in accordance with the company's standard operating procedures.

    Conclusion: *Adherence to standard operating procedures is the cornerstone of safe flying.*

6. The first officer had been recently hired by the company. The first officer did not explicitly indicate concern over the available runway. The first officer notified the cabin of an impending impact on own initiative.

    Conclusion: *Employees recently hired by organizations may hesitate to intervene in unexpected situations. Organizations should emphasize the importance of good crew resource management during all phases of the flight.*

7. Speed during the overrun was low, and the incident did not cause injuries to persons.

    Conclusion: *Runway excursions rarely have catastrophic consequences.*

5 SAFETY RECOMMENDATIONS

5.1 Requirements for Crew Resource Management Training

Good crew resource management (CRM) is an essential contributor to flight safety. Pilots' basic training and recurrent CRM training emphasize, among other matters, the importance of standardized communication and a preparedness to interfere with situations that are felt to involve a potential safety hazard. Most serious incidents occur on runways and taxiways. Investigation into this particular incident revealed a lack of appropriate CRM-related communication between the flight crew members during the landing roll, which affected their vigilance and situational awareness.

The Safety Investigation Authority recommends that

EASA investigates how CRM training for ground operations can be enhanced. [2018-S33]

5.2 Schedule Pressures

Competition and financial reasons have led airlines to set punctuality goals. Flight schedules may even be unrealistic and turnaround times excessively short, which deprives the employees of the possibility of achieving the punctuality goals. Recognized schedule pressures may affect their work in a manner that degrades flight safety.

The Safety Investigation Authority recommends that

EASA investigates whether the current airline schedules are realistic or not, and also determine their possible negative effects on the procedures of commercial aviation and thence on flight safety. [2018-S34]

An earlier study (Eurocontrol, 2015) has shown that delays in commercial aviation are increasing.

5.3 Implemented Safety Actions

EASA has published on its website safety material on CRM training implementation. In addition, EASA has organized workshops on CRM-related matters for the responsible staff of airlines and national aviation authorities. The workshops took place on November 1, 2016, and August 29–30, 2017.

EASA has carried out a study on runway excursions. One aim of the study was to identify means to improve regulatory action pertaining to runway safety, runway surface condition assessment, and occurrence reporting.

EASA issued a document on runway surface condition reporting on January 18, 2018.

Helsinki, June 29, 2018

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Juha-Pekka Keidasto

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Investigation Material

1) Occurrence reports.
2) Correspondence (e-mail).
3) Recordings of interviews, passenger’s statement.
4) Norwegian Air Shuttle's investigation into the incident, based on flight data monitoring data (Incident at HEL 11.07.2017 with B737-800NG, LN-NHF, NAX4287)
5) Data of persons involved, including experience and licences.
6) Boeing 737-800 performance calculations, technical data, and damage assessment.
7) Helsinki FDM Taxi speed events.
8) Runway maintenance log.
9) Weather information.
10) Recordings (CVR, FDM, surface movement radar, TWR recordings).
11) An analysis conducted by the Finnish Meteorological Institute
12) Aeronautical Information Publication (AIP) Finland.
13) Air Traffic Control Officer's Handbook.
14) Emergency response.
15) Local standby procedures checklist.
16) Helsinki-Vantaa airport operations manual, aerodrome emergency plan, guidelines for rescue operations, and low visibility procedures.
17) Helsinki-Vantaa airport maintenance log.
18) Norwegian Air Shuttle manuals OM-A, -B, -D, and -M.
19) Photographs, maps, and diagrams produced during on-site investigation.

SUMMARY OF COMMENTS TO DRAFT FINAL REPORT

The draft final report was submitted for comments to the flight crew of flight NAX4287, duty air traffic control officer (TWR-W) and the supervisor of the control facility, Finnish Transport Safety Agency, ANS Finland Oy, Finavia Oyj, European Aviation Safety Agency (EASA), Accident Investigation Board Norway (SHT), The German Federal Bureau of Aircraft Accident Investigation (BFU), and Norwegian Air Shuttle airline company. Pursuant to the Safety Investigation Act, no comments given by private individuals are published.

Finnish Transport Safety Agency had no comments on the draft report.

ANS Finland Oy had no comments on the draft report.

Finavia Oyj had no comments on the draft report.

European Aviation Safety Agency expressed its thanks for an invitation to provide feedback on the draft report and stated that its English language translation was most welcome and greatly facilitated the review process. EASA comments that the draft report gave the impression of a thorough investigation, narrating with considerable depth an important range of safety issues concerning the approach and landing flight phases, in particular the landing rollout and deceleration.

EASA states that, while EASA appreciates the aims of safety recommendations, it recommends that draft safety recommendations are reconsidered to ensure that they take the existing regulatory framework into account and that the proposed safety measures are addressed to the responsible parties. EASA suggests that the draft safety recommendation on crew resource management training requirements is withdrawn as the existing regulations, if correctly implemented, should address the issue. The Safety Investigation Authority reworded the recommendation.

Regarding the safety recommendation on schedule pressures, EASA suggests that this is withdrawn or addressed to the operator and/or the competent authority since EASA's view is that it cannot supervise the schedules of individual airlines and related factors.

Accident Investigation Board Norway comments that they expected the draft report to adhere more closely to the principles of ICAO Annex 13, ICAO Doc 9756 Part IV and document (EU) No 996/2010 in matters pertaining to occurrence reporting and acts, respectively. Compliance with reporting principles would have put more emphasis on the interconnections of factual information, analysis, conclusions, and safety recommendations.

The German Federal Bureau of Aircraft Accident Investigation had no comments on the draft report.

Norwegian Air Shuttle divided its response into general comments and detailed comments. In the general comments, Norwegian Air Shuttle states that the draft report contains deficiencies and does not correctly address events that led to the overrun. The investigation has not produced enough evidence to show that on time performance (OTP) is the main contributor to the occurrence.

The response maintains that the primary unaddressed factor is why did the flight crew not manage to stop in time to vacate the runway via exit WK, exit WH or the runway end. Norwegian Air Shuttle states that the draft report does not describe the actual conditions at the runway, and the company presented questions pertaining the conditions and friction characteristics of the runway. The Safety Investigation Authority added more specific information to the description on the basis of the response.

In the general comments, Norwegian Air Shuttle further states that there is a difference between runway occupancy time (ROT) and OTP, and this difference is not discussed in the report. It is an industry standard to be aware of ROTs. If a pilot misses an intended intersection, and there is a long distance to the next, the pilot will let the aircraft roll to minimize ROT even if the flight was ahead of schedule.

In the detailed comments, Norwegian Air Shuttle points out the following matters, and the Safety Investigation Authority added more specific information based on the comments.

- planning of the landing by the flight crew
- description of aircraft systems
- information of runway condition and friction characteristics
- only dynamic aquaplaning was considered, and there was no discussion on viscous aquaplaning
- point of braking initiation
- ATIS information
- airspeeds used during climb, descent, and landing
- description of organization
- advanced surface movement radar data
- captain and first officer's standard callouts during landing roll
- interpretation of company OM-B
- vacating runway to other traffic
- the phrase “when conditions allow” is missing from the recommendation for the use of high-speed turnoff WK

Furthermore, regarding the description of safety management, Norwegian Air Shuttle states that the OM-A, not the OMM, is actively used by crew members. As for damage assessment, Norwegian Air Shuttle states that the Safety Investigation Authority could have examined damage incurred by the airplane.