aibn Accident Investigation Board Norway

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REPORT SL 2020/14

REPORT ON THE AIR ACCIDENT AT OSLO AIRPORT GARDERMOEN, NORWAY ON 18 DECEMBER 2018 WITH BOEING 787-9 DREAMLINER, ET-AUP OPERATED BY ETHIOPIAN AIRLINES

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As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photos: AIBN and Trond Isaksen/OSL

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AIR ACCIDENT REPORT

Type of aircraft:	Boeing Commercial Airplane Group, Boeing 787-9 Dreamliner
Nationality and registration:	Ethiopian, ET-AUP
Owner:	Ethiopian Airlines
Operator:	Same as owner
Crew:	10 (three pilots + seven cabin crew members)
Passengers:	59 (including one passive crew member)
Accident site:	Oslo Airport Gardermoen, Norway (ENGM), de-icing platform “Bravo North”, de-icing stand 991
Time of the incident:	Tuesday 18 December 2018 19:10:05 hours

All times given in this report are local time (UTC + 1 hour) if not otherwise stated.

ACCIDENT NOTIFICATION

The Accident Investigation Board Norway (AIBN) was not notified of the air accident. However, when the AIBN the day after learned of the accident through the media, the on-call accident inspector contacted Avinor Oslo airport. Three accident inspectors mobilized and started their investigation. In accordance with ICAO, Annex 13 (Aircraft Accident and Incident Investigation), the AIBN submitted notifications to the National Transportation Safety Board (NTSB), the European Aviation Safety Agency (EASA) and the Ethiopian Civil Aviation Authority.

SUMMARY

On 18 December 2018, a Boeing 787-9 operated by Ethiopian Airlines (flight ETH715) collided with a light mast at a de-icing platform at Oslo Airport Gardermoen. There was considerable damage to the outer section of the aircraft’s right wing, but there was no fuel leakage.

ETH715 was by a slip-up from the de-icing coordinator instructed to taxi to a de-icing stand only authorized for smaller wingspan aircraft. The assigned stand was designed for aircraft up to Category C (Max. 36 meter wingspan). Boeing 787 is a Category E aircraft with a wingspan of 60.12 meters.

The investigation showed that the de-icing coordinators did not have adequate technical aids to ensure correct de-icing stand allocation, based on aircraft category. Moreover, SAS Ground Handling was until spring 2020 unable to present work instructions for the de-icing coordinators relating to allocation of de-icing stand for each aircraft category.

As the ET-AUP turned into the Bravo North de-icing area, there were no markings, lights, signage or other technical barriers to indicate to the crew that they had been assigned the wrong de-icing stand. Thus, the crew were unable to stop the aircraft before it hit the light mast to the right. Moreover, the ET-AUP crew did not have details about which de-icing stands at Gardermoen were

authorized for this type of aircraft, as it was not specified in the Aeronautical Information Publication Norway, or in the NOTAM.

As the aircraft approached the light mast, the commander thought that clearance was marginal. The crew decided to rely on the given instructions to taxi to de-icing stand 991. The Accident Investigation Board is of the opinion that some type of anti-collision aid, such as a wing tip camera, would have clearly indicated to the crew that there was insufficient clearance between the wing and the light mast, thus preventing a collision.

The AIBN is issuing three safety recommendations based on this investigation.

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 Ethiopian Airlines had six weekly flights from Oslo via Stockholm to Ethiopia's capital Addis Abeba. Normally, a Boeing 787 Dreamliner is used for this flight (ETH715).

1.1.2 On Tuesday 18 December 2018, flight ETH715 was operated with a Boeing 787-9 Dreamliner with registration ET-AUP.

1.1.3 While the aircraft was at the gate, using datalink, the crew requested de-icing of the aircraft. Data from the A-CDM[1] system entails that air traffic controllers and de-icing personnel receive relevant information about aircraft that need de-icing before departure. The request from ETH715 was submitted approximately 30 minutes prior to the aircraft arriving at the de-icing platform.

1.1.4 There are three dedicated de-icing platforms at Gardermoen. On the day in question, the "Bravo North" de-icing platform at the north-eastern end of the airport was in use. The de-icing platforms are located outside the designated airport maneuvering area. Traffic at the de-icing platforms is thus not subject to clearance or any other type of air traffic control services.

1.1.5 At 1900 hours everything was ready on board and the crew obtained routine clearance for push back to leave the terminal and start the engines. A taxi clearance was then obtained. The duty air traffic controller for ground control east[2] issued clearance for ETH715 to taxi using taxiways "Zulu", "Victor" and "Sierra". As the aircraft approached the "Bravo North" de-icing platform, the air traffic controller gave routine instructions to ETH715 to contact "de-icing" at their frequency 121.855 MHz while continuing to listen to the ground control frequency.

1.1.6 The de-icing services provided by the various de-icing suppliers at Gardermoen are coordinated by SAS Ground Handling (SGH). The SGH office, where the de-icing coordinators were working, is located by the de-icing platform "Alfa South", at the south-western end of the airport, e.g. diametrically opposite the airport (see Figure 8). At the time of the incident, two de-icing coordinators were on duty in the SGH office. To perform their duties, the coordinators mainly used information from the ground radar[3]

[1] A-CDM Airport Collaborative Decision-Making
[2] "Gardermoen Ground East", frequency 121.905 MHz
[3] Belonging to the Avinor Oslo Airport Air Navigation Service

(see Figure 1) and traffic lists from A-CDM as well as several video cameras at the de-icing platforms (see section 1.10). The coordinators also had access to the "Wise"[4] system to help them assign a de-icing stand for the aircraft.

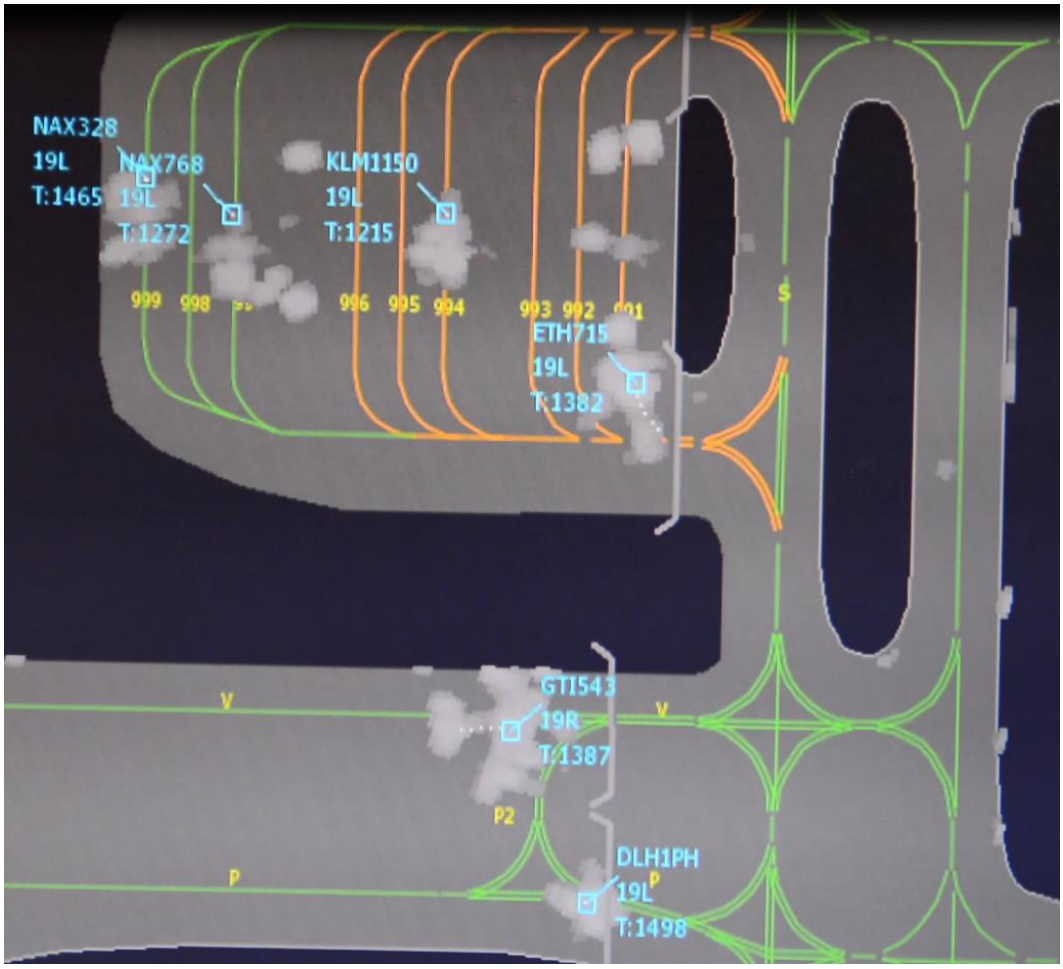

Figure 1: Ground radar screen shot of ETH715 as the aircraft is about to taxi into de-icing stand 991. Three other aircraft were at the "Bravo North" de-icing platform at the time (two aircraft belonging to Norwegian and one to KLM). In addition, the de-icing coordinators have information about the type of aircraft. Source: Avinor. Photo: AIBN

1.1.7 Some minutes before ETH715 approached the de-icing platform, the two de-icing coordinators discussed the current traffic situation. The de-icing coordinators have indicated that the workload was low to moderate at the time.

1.1.8 An Airbus 320 (Category[5] C) operated by Lufthansa was taxiing behind the Ethiopian Boeing 787 (Category E), followed by a Boeing 747 (Category F) operated by Atlas Air. At the "Bravo North" de-icing platform, only de-icing stands 992, 995 and 998 can be used by aircraft larger than Category C (such as Boeing 787 and 747), see Figure 2 and Figure 8. The coordinators found that the most practical solution would be to allow the Airbus 320 to proceed to the platform after the Boeing 747, so that the two large aircraft

[4] "Wise" is used to assign de-icing trucks to the airplanes and for invoice and documentation of the treatment who has been performed

[5] Aircraft are divided into different categories depending on their wingspan; the larger the wingspan, the higher the letter of the alphabet.

would taxi to their respective de-icing stands before the smaller Airbus 320 taxied to the de-icing platform.

1.1.9 The de-icing coordinators concurred and verbally agreed that the two wide-body aircraft (Ethiopian and Atlas Air) should be assigned de-icing stands 992 and 995, respectively[6] (see Figure 2).

1.1.10 According to the de-icing coordinators, it is common procedure to submit an electronic request via the "Wise" system to the performing de-icing personnel only after an aircraft has taxied to its respective de-icing stand. Such a request includes a number of details, such as the aircraft's flight number, aircraft category, de-icing stand, type of de-icing fluid, whether de-icing should take place of the wings only, or also of the fuselage, etc.

1.1.11 The coordinators contacted the air traffic ground controller and asked the controller to instruct the Airbus 320 aircraft to taxi from taxiway "Victor" to "Papa", allowing the Boeing 747 to pass (see Figure 2 and Figure 4). De-icing coordinator No. 2 has stated that his focus was on this reorganization.

1.1.12 When the Ethiopian aircraft approached the de-icing area, the crew contacted the de-icing coordinator (the position of the aircraft is shown in Figure 2):

19:08:57 hours, Ethiopian 715:

De-ice, Ethiopian seven one five.

19:09:01 hours, De-icing Coordinator No. 2:

Good evening Ethiopian seven one five, proceed to stand nine nine one and call me when aircraft is prepared for de-ice.

19:09:12 hours, Ethiopian 715:

Proceed to stand nine nine one, Ethiopian seven one five.

At 19:09:17 hours, de-icing coordinator No. 2 double-clicked the radio button indicating that ETH715 had repeated "stand nine nine one" correctly.

[6]The plan was for the Atlas Air Boeing 747 to enter de-icing stand 995 after the de-icing of the KLM aircraft was completed at 994 (a large Category F aircraft at stand 995 entails that 994 and 996 are occupied).

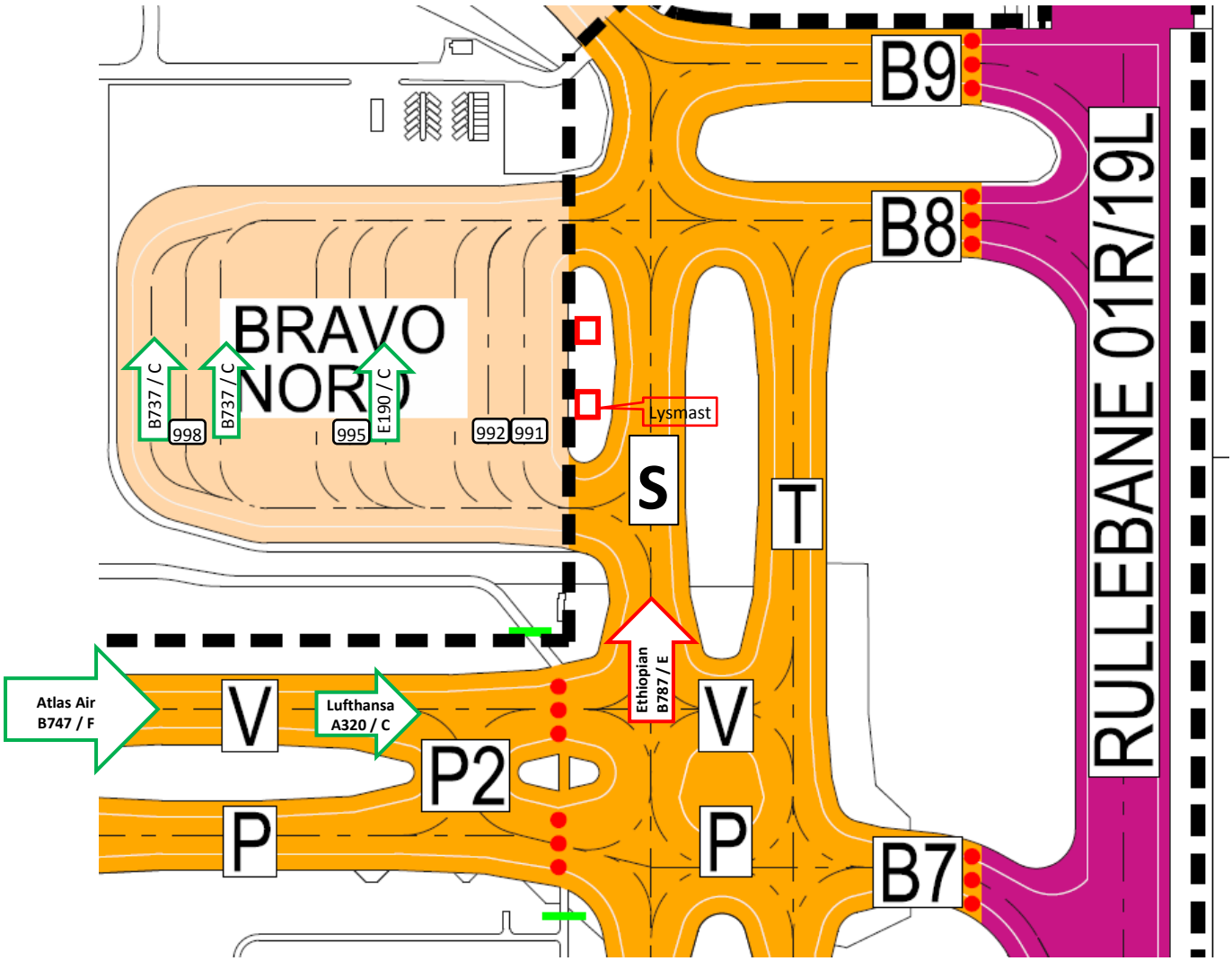

Figure 2: The de-icing platform "Bravo North". The position of the aircraft at the time when de-icing coordinator 2 instructed ETH715 to taxi to de-icing stand 991. Only de-icing stands 992, 995 and 998 are suitable for aircraft larger than Category C, such as the Boeing 787. Source: Avinor. Illustration: AIBN

1.1.13 The Accident Investigation Board has reviewed video recordings of the de-icing platform. The recording shows that the Ethiopian aircraft turned left from the "Sierra" taxiway on to the de-icing platform. It then made a right turn and followed the guiding line towards the assigned de-icing stand 991. The Ethiopian aircraft taxied at a low speed.

1.1.14 The commander taxied the aircraft. He has explained that he saw the light mast and thought that clearance on the right-hand side was marginal. However, he was confident the airport had control of the situation. He did, however, ask the first officer, who was in the right-hand seat, if he could see the distance between the wing tip and the light mast. The first officer could not see[7] the wing tip and had thus limited ability to estimate the distance from his seat. The commander reduced the taxiing speed even more the last few meters.

[7]To be able to see the wing tips in a Boeing 787, the flight deck crew must stand up from their seats and lean towards the side windows. The Air Accident Investigation Unit Ireland (AAII) Report 2015-019 (p. 30) also makes the point that even if the pilot could see the wing tip, it is not possible to accurately estimate the distance between the wingtip and another object.

1.1.15 Before ETH715 was assigned de-icing stand 991, two old SGH de-icing vehicles (No. 11 and 12) were parked at the front edge of de-icing stand 991 (see Figure 1). There was an operator in each of the vehicles. As opposed to the more modern de-icing vehicles, the old de-icing vehicles were not equipped with a VHF radio. This meant that the two operators could not communicate directly with the ETH715 crew.

1.1.16 The driver of de-icing vehicle No. 11 saw the Ethiopian aircraft taxiing on to de-icing stand 991, and he knew that this de-icing stand could not be used by aircraft the size of the Dreamliner. At 19:09:52 hours he called the de-icing coordinators over the internal radio (PMR) and said that the Ethiopian aircraft had to be stopped.

1.1.17 The commander has stated that the crew did not receive any signals from the ground crew informing them that the aircraft was on collision course with the light mast. A video recording of the airport shows that one of the de-icing vehicles started to drive slowly towards the aircraft four seconds prior to the collision.

1.1.18 19:09:57 hours De-icing coordinator No. 1:

Etian[8] seven one five you are going to wrong ….. stop stop Etian stop stop stop

1.1.19 At 19:10:05 hours the tip of the right-hand wing of ET-AUP collided with the light mast to the right of de-icing stand 991 (see Figure 3). After the collision, the aircraft continued to move forward for about another four seconds, coming to a halt approximately four meters further ahead (see Figure 5). Due to right wing torque, the nose of the aircraft turned towards the right and the nosewheel stopped approximately 3/4 meters to the side of the center line.

1.1.20 The commander has explained that as the aircraft approached its stopping position, he noticed the nose of the aircraft pulling right. The commander thought the aircraft had skidded slightly to the side and was not aware that the wing had hit the light mast. He stopped the aircraft and applied the parking brake.

1.1.21 The crew again contacted the de-icing coordinator to inform them of the type of de-icing they required. They were then told that the right wing tip had struck the light mast.

Figure 3: Position at 19:10:05 hours when ET-AUP collided with the light mast. Source: Avinor

[8] Ethiopian

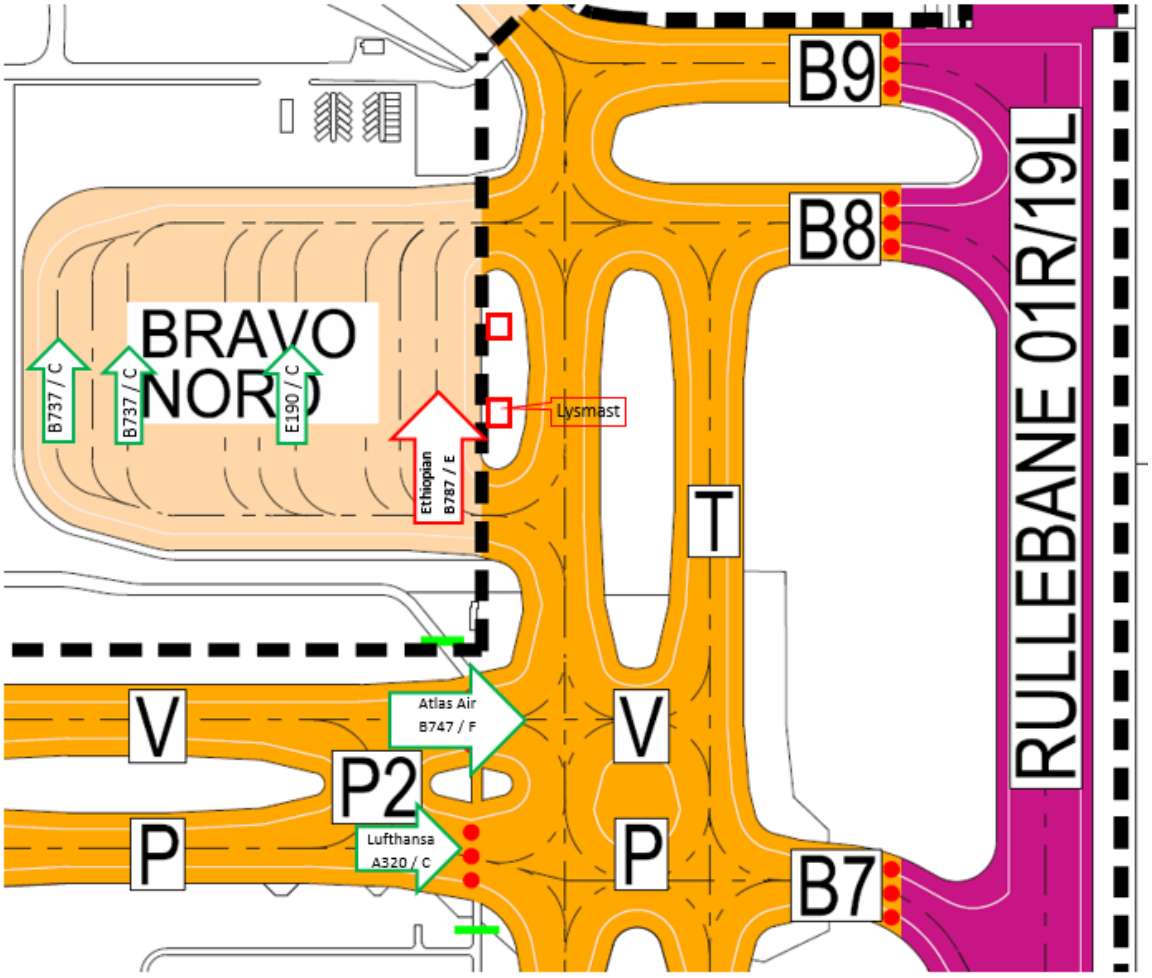

Figure 4: The de-icing platform "Bravo North". The position of the aircraft at the time of collision, according to the ground radar. Source: Avinor. Illustration: AIBN

Figure 5: Position at 19:10:09 hours when ET-AUP had stopped approx. four meters after the collision. Source: Avinor

1.1.22 At 19:15:26 hours, the de-icing coordinator pointed one of the video cameras towards ET-AUP.

1.1.23 At 19:20:43 hours, the first emergency response vehicle reached ET-AUP.

1.1.24 Passengers and crew were not evacuated, but the passengers left the aircraft via the airport ramp stairs.

1.2 Injuries to persons

Table 1: Injuries to persons

Injuries	Crew	Passengers	Other	Total
Fatal				
Serious				
Minor				
None	10	59		69
Total	**10**	**59**		**69**

1.3 Damage to aircraft

The aircraft was significantly damaged, see section 1.12 for more details.

1.4 Other damage

The light mast was significantly damaged and had to be replaced with a new one (see Figure 6).

Figure 6: Damage to the light mast (after dismantling). Photo: AIBN

1.5 Personnel information

1.5.1 Commander

The commander was 44 years old. He had an Airline Traffic Pilot License ATPL (A) and Instrument rating (IR-ME). The type rating for Boeing 777[9]/787 was valid until 15 January 2019.

Rest period prior to duty: 36 hours.

Table 2: Flying hours commander

Flying hours	All types	Relevant type
Last 24 hours	0	0
Last 90 days	232	149
Total	20,137	2,697

1.5.2 First officer

The first officer was 28 years old. He had a Commercial Pilot License CPL (A) and Instrument rating (IR-ME). The type rating for Boeing 777/787 was valid until 27 October 2019.

Rest period prior to duty: 36 hours.

Table 3: Flying hours first officer

Flying hours	All types	Relevant type
Last 24 hours	0	0
Last 90 days	229	146
Total	2,868	1,215

1.5.3 In addition to the commander and the first officer, a third pilot, who was undergoing line training, was present on the flight deck.

1.5.4 SGH de-icing personnel

1.5.4.1 The duty officer (de-icing coordinator No. 1) had worked for SAS for more than 30 years, of which the last 22 involved de-icing for SGH. He had five years' experience as a de-icing coordinator.

1.5.4.2 The deputy officer (de-icing coordinator No. 2) had also worked for SGH for more than 30 years and had extensive experience as a de-icing coordinator. That day, he had started work at 1430 hours. He stated that he had had a normal, good night's sleep. The de-icing coordinator was not relieved of his duties and continued to work until 0015 hours. It turned out to be a busy shift.

1.5.4.3 The two de-icing coordinators took turns as de-icing coordinator No. 1 and 2.

1.5.4.4 According to the A-CDM list of aircraft that have requested de-icing, de-icing coordinator No. 1 enters information that is more detailed in the “Wise” system and

[9] Ethiopian Airlines also operates Boeing 777-200LR and Boeing 777-300ER. These have a wingspan of 64.8 meters, whereas the wingspan of the Boeing 787-9 is 60.1 meters.

submits an electronic request to the de-icing vehicles. De-icing coordinator No. 1 communicates internally with the de-icing personnel via PMR.

1.5.4.5 De-icing coordinator No. 2 is responsible for external communication with the aircraft over VHF, as well as for assigning a de-icing stand and clarifying with the flight crew what type of de-icing is required for each aircraft. De-icing coordinator No. 2 used "Tradis" ground radar for allocation of de-icing stands.

1.5.4.6 De-icing coordinator No. 2 has explained that during his years as a coordinator, he acted as coordinator No. 1 for about 80 per cent of the time and coordinator No. 2 for about 20 per cent of the time. Over the years, he had frequently worked with the colleague who functioned as coordinator No. 1 at this shift.

1.6 Aircraft information:

Boeing 787-9 Dreamliner

Manufacturing year: 2017

Serial number: 38782

Wingspan: 60.12 meters

Aircraft category: E

Mass at the time of the accident: 145,100 kg

Max allowed take-off mass: 254,011 kg

Number of flight hours: 4,305 hours

Number of flights: 1,152

Onboard fuel quantity at the time of the accident: 9,100 kg.

Fuel capacity: 107,500 kg.

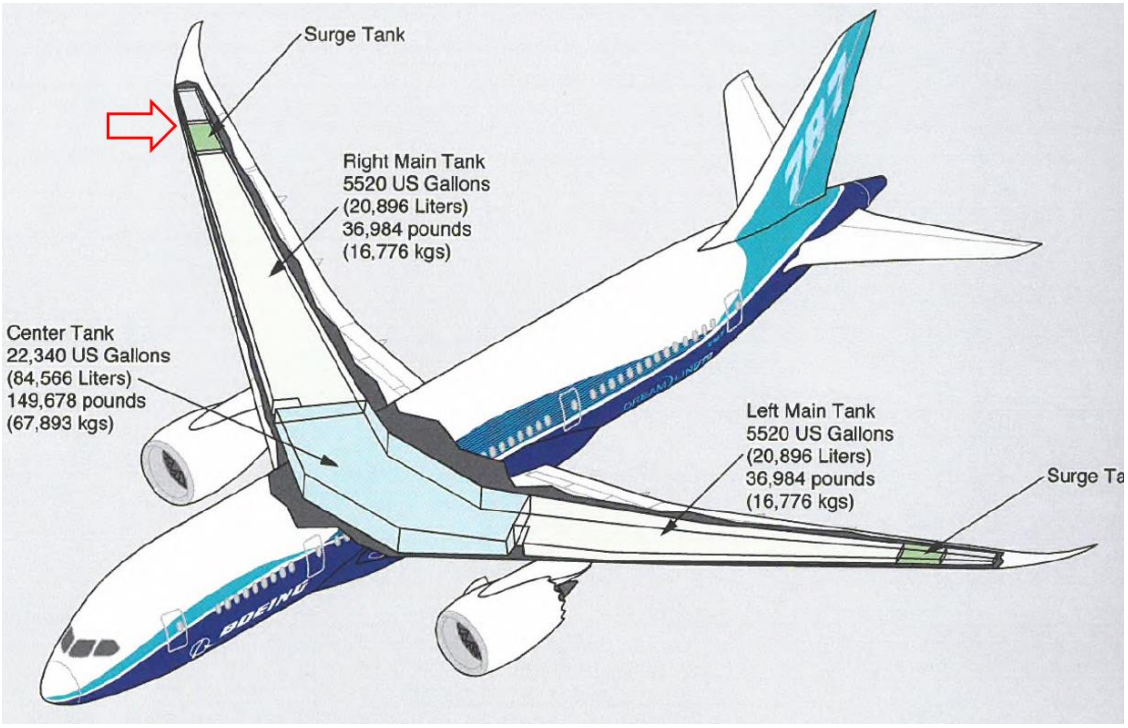

Figure 7: Fuel and surge tank positions on a Boeing 787-9. The red arrow shows where the aircraft was damaged (see Figure 10, Figure 11 and Figure 12 for more details about point of impact). Source: Boeing. Illustration: AIBN

1.6.1 The wings of a Boeing 787 curve slightly upwards. This entails that there is fuel in the fuel tank areas closest to the fuselage. As there was only 9,100 kg of fuel on board, there was no fuel in the fuel tank next to the point of impact, in the right wing of the aircraft. However, there would have been a significant quantity of fuel vapor both in the surge tank and in the otherwise empty sections of the fuel tanks.

1.6.2 Jet aircraft generally use hot air from the engines to heat up the leading edges of the wings to prevent ice formation. However, the Boeing 787 uses electric power to heat up the leading edges (Wing Ice Protection System - WIPS). All leading edge slats on Boeing 787 have integrated electric elements requiring significant amperage when the system is activated. The Boeing 787 WIPS system can only be activated while the aircraft is airborne. Consequently, there was no risk of the WIPS system short-circuiting or arcing when the leading edge was damaged.

1.6.3 Boeing 787 has a Nitrogen Generation System (NGS) which transports nitrogen to the fuel tanks to displace oxygen and thus reduce the risk of ignition.

1.7 Meteorological information

1.7.1 METAR Gardermoen at 1850 hours (20 minutes before the accident):

00000KT 9999 BKN007 M08/M09 Q1022 TEMPO BKN005=

1.7.2 It was dark, but as the light mast lit up the platform and the weather was good, visibility at the de-icing platform was good.

1.8 Aids to navigation

Not relevant.

1.9 Communications

The communication between the de-icing coordinators and the ET-AUP crew was recorded and is considered clear. There were no language problems.

1.10 Airport information

1.10.1 Oslo Airport Gardermoen is the main airport in Norway. The airport has two parallel runways 01L/19R and 01R/19L measuring 3,600 x 45 meters and 2,950 x 45 meters respectively. The airport is located 681 ft above sea level.

1.10.2 Avinor Flysikring AS provides air traffic services at the airport and their air traffic controllers gave the ETH715 the necessary clearances for aircraft maneuvering as it approached the “Bravo North” de-icing platform (see Figure 2). As pointed out in section 1.1.4, the de-icing platforms are located outside the defined maneuvering area. This entails, inter alia, that traffic at the de-icing platforms is not within air traffic control's area of responsibility, nor does air traffic control provide clearances or any other information services.

1.10.3 There were no electronic systems at the airport to automatically warn of an aircraft taxiing towards the wrong de-icing stand.

1.10.4 By way of comparison, at the terminal gates, there is a docking system which monitors and provides information about the nose of the aircraft in relation to its correct position. The system notifies both the crew and the gate personnel in the event of any deviation.

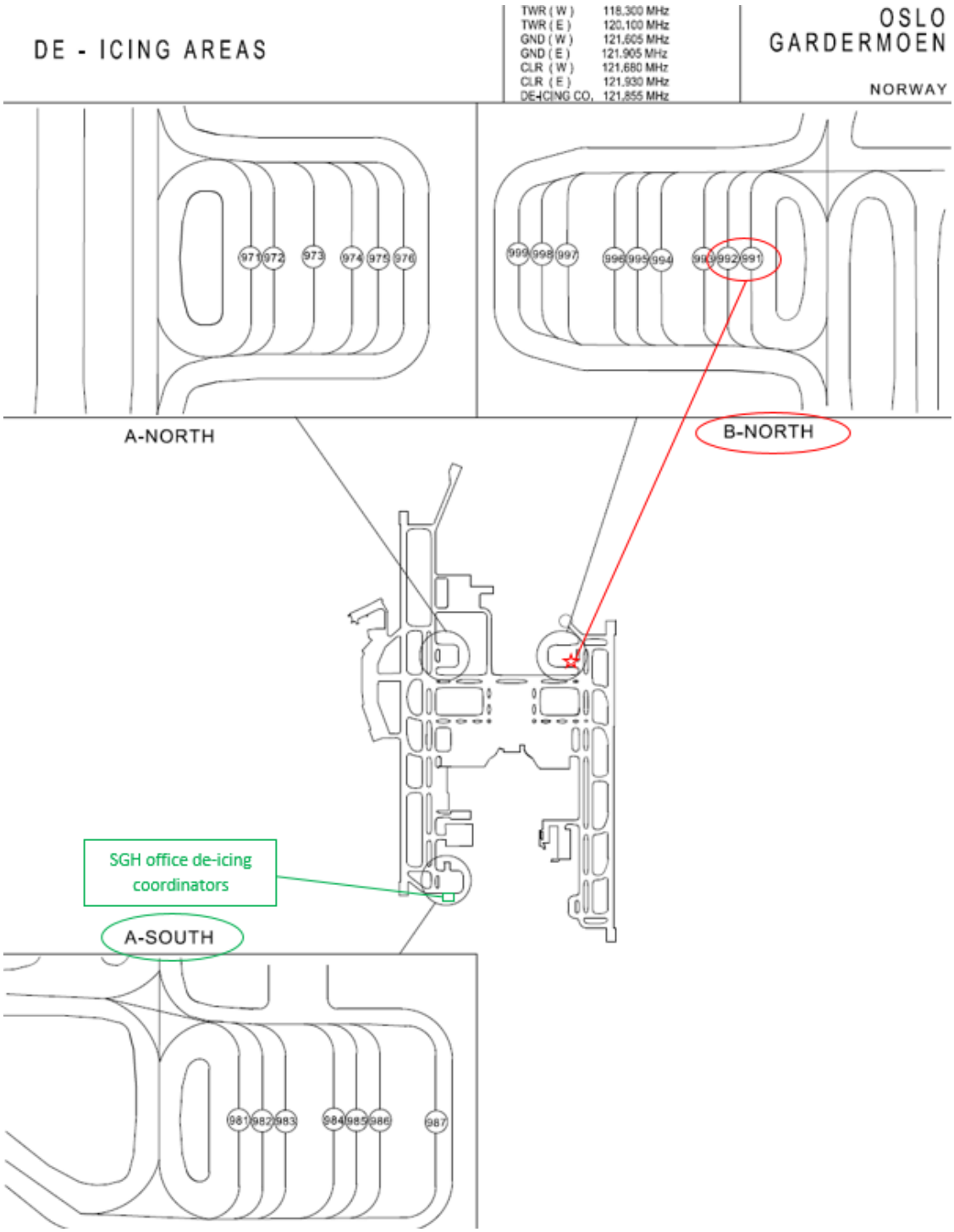

Figure 8: The AIP chart current at the time of the accident shows Oslo Airport Gardermoen with the location of the de-icing areas and the SGH office used by the de-icing coordinators. Source: Avinor. Illustration: AIBN

1.11 Flight recorders

1.11.1 Pursuant to regulations, the ET-AUP was equipped with a Flight Data Recorder (FDR) and a Cockpit Voice Recorder (CVR).

1.11.2 The Accident Investigation Board obtained significant information from voice recordings from the airport, ground radar and pictures. It was thus not necessary to retrieve data from the flight data recorder.

1.11.3 Information on the cockpit voice recorder will be lost after two hours, unless electrical power is removed. As mentioned, the AIBN was not aware of the accident before the day after the accident.

1.12 Wreckage and impact information

1.12.1 The accident site

1.12.1.1 The Gardermoen de-icing platforms have lights in the tarmac along the guide lines leading to all de-icing stands (see Figure 9). From the establishment of Gardermoen as the main airport in 1998 and until 2019, it has been possible to activate individual lights for each guide line. Due to the design of the control panel, it proved impractical to activate individual rows of light.

1.12.1.2 In 2019, testing was initiated to ascertain whether the ground radar system could be used to operate taxiway lights[10] by the terminal building. Due to an update of this system, it was no longer possible to activate individual guide lights at the three de-icing platforms. Evaluation is ongoing to look into whether similar use of ground radar data could be used to operate the guide lights at the de-icing platforms, or, alternatively, to return to a manual operation system (see also section 1.18.1.2 and section 1.18.3).

Figure 9: Shows the center line lights in the tarmac leading up to de-icing stand 991. The photo was taken the day after the accident. Photo: AIBN

[10] Twy "L-blue, -center and –orange"

1.12.2 Extent of damage

1.12.2.1 The ET-AUP suffered substantial damage to its right wing (see Figure 10). The point of impact was at the front of the surge tank (see Figure 11). The surge tank was not punctured (see Figure 12).

Figure 10: Damage to the right wing. Photo: Ethiopian aeronautical engineer

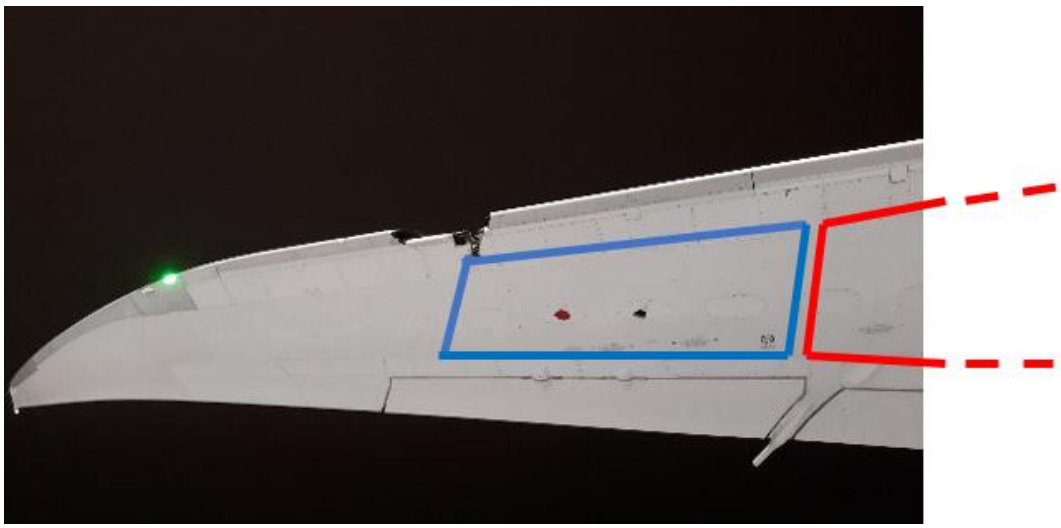

Figure 11: Position of the damage on the right wing. Blue marking: Indicates the position of the surge tank. Red indication: Indicates the position of the wing tank. Photo and illustration: AIBN

Figure 12: The damage. The surge tank can be seen in the background. Photo: AIBN

1.12.2.2 Ethiopian Airlines requested an inspection and repair report from Boeing. Extensive repairs of ET-AUP were necessary. The aircraft remained at Gardermoen for about one month before it was airworthy again.

1.13 Medical and pathological information

Not relevant.

1.14 Fire

No fire occurred.

1.15 Survival aspects

Not relevant.

1.16 Tests and research

Not relevant.

1.17 Organizational and management information

1.17.1 Ethiopian Airlines

1.17.1.1 The airline was founded in 1945 and is fully owned by the Federal Democratic Republic of Ethiopia. Ethiopian Airlines became a member of the airline partnership Star Alliance in 2011.

1.17.1.2 As of September 2019, Ethiopian Airlines[11] operates 116 aircraft, of which 12 are Airbus A350-900, 23 Boeing 787-8/-9, 20 Boeing 777-200 LR/-300 ER, 8 Boeing 757-200/767-300, 30 Boeing 737-700/-800 NG/-8 MAX and 23 Bombardier Dash 8-Q400. The airline has ordered 59 new aircraft.

1.17.2 Avinor AS

1.17.2.1 Avinor is a wholly state-owned limited liability company. It owns and operates 44 state-owned airports, including Oslo Airport Gardermoen. The airport is the largest in Norway and almost 25 million passengers travelled through the airport in 2018. Avinor Oslo Airport owns and operates the technical infrastructure at Gardermoen.

1.17.3 Avinor Flysikring AS

1.17.3.1 Avinor Flysikring AS provides the majority of the air navigation services in Norway. Air traffic controllers employed by Avinor Flysikring at Oslo Airport Gardermoen provided control services related to the movement of aircraft and vehicles inside the maneuvering area only, and thus not for the "Bravo North" de-icing platform.

1.17.4 SAS Ground Handling Norway AS (SGH)

1.17.4.1 SGH provides ground handling services for various airlines at several Norwegian airports.

1.17.4.2 The two de-icing coordinators have stated that it was challenging from the traffic lists in A-CDM to determine whether aircraft approaching de-icing area was e.g. an Airbus A330/A340 or an Airbus A320/A321, based on the traffic lists. It is equally challenging to determine whether it is a Boeing 787 or a Boeing 737. This due to it is only figure difference between the designation of e.g. 737 and 787.

1.17.4.3 Moreover, SGH has stated that, on several occasions, aircraft at Gardermoen have taxied to the wrong de-icing stand. This has occurred as a result of a de-icing coordinator assigning the crew the wrong de-icing stand and also because the crew have taxied to a different de-icing stand than the one they were assigned. Reviewing Avinor's non-conformance system for the last two years (2018 and 2019), most of the registered cases related to crew taxiing to another de-icing stand than the one they were assigned. Some non-conformances were also registered where SGH had assigned the wrong de-icing stand. The Accident Investigation Board has not received any information about how these non-conformances were followed up. SGH has stated that they have not received any copy of the reports they have submitted to Avinor. Accordingly, SGH Quality/safety department has been unfamiliar with the occurrences and not been able to follow-up, look at trends and handle possible risks. SGH has stated that their employees did not report internally as they thought it was sufficient that events were reported to Avinor, but this has now been followed up within SGH.

1.17.4.4 During the 2018/2019 winter season, around 325 flights departed from Gardermoen each day. On days with continuous snowfall or freezing rain, almost all aircraft will need de-icing prior to departure. Such days are particularly hectic for the SGH de-icing coordinators, as they have to coordinate all traffic to the various de-icing stands. As

[11]See the airline's website.

mentioned in section 1.1.7, there was relatively low traffic density in the de-icing area at the time of the accident.

1.17.5 The airport operators' follow-up of the handling operators

1.17.5.1 Avinor Oslo Airport has an audit program which ensures that companies such as SGH are evaluated. Upon request, Avinor stated that there were no available copies of audit reports prior to the accident of 18 December 2018. However, a joint audit of SGH was conducted in 2019.

1.17.5.2 Avinor Oslo Airport conducts monthly coordination meetings with the de-icing operators at the airport, SGH and Menzies Aviation. The meetings are also attended by Avinor Flysikring. The minutes of the meetings show that the accident in question, follow-up of implemented measures and potential future measures because of this accident have been on the agenda for these coordination meetings (see sections 1.18.1.2 and 1.18.3).

1.17.6 Regulations and audits of ground handling service providers and apron management service providers

1.17.6.1 Until now, there have been no pan-European or national aviation regulations for the civil aviation authority regarding oversights and inspections of ground handling service providers and apron management service providers. Consequently, the civil aviation authority has not issued approvals or conducted oversights and inspections of ground handling service providers and apron management service providers. The airline operator is responsible for ensuring that different services are conducted in accordance with requirements based on EU requirements. Some services are conducted on contracts, and it is the airline operator’s responsibility to assure that this is being performed correctly according to contract.

1.17.6.2 The Civil Aviation Authority of Norway conducts oversights and inspections with the airline operators.

1.17.6.3 IATA (International Air Transport Association) is the trade association for the world's airlines. IATA head office is in Montréal, Canada. IATA has through *IATA DAQCP* (De-Icing/Anti-Icing Quality Control Pool) conducted quality control of de-icing handling operators. This takes place whether the airline has full IATA membership or is only a member of IATA DAQCP. The airlines have thus not been required to conduct their own audits of handling operators that perform de-icing but have relied on IATA DAQCP audits and reports.

1.17.6.4 The EU/EASA have now started preparation of the pan-European regulations “Development of requirements for ground handling”. The forthcoming regulations are expected to enter into force 2023. With this regulation into force, the civil aviation authority will conduct oversights and inspections directly with the ground handling service providers and apron management service providers.

1.17.6.5 Responsibility and control of movements on apron, inclusive de-icing platforms, belongs to the airport operator. The EU / EASA regulations are not detailed in this area, but in general, if procedures are required in addition to basic markings, lights and signage, implicit training and competence of personnel who are required to perform related services are required. Other operators on contract may conduct such a service.

1.17.6.6 The Civil Aviation Authority of Norway conducts oversights and inspections with the airport operators.

1.17.6.7 The EU/EASA have made a draft to the regulations concerning "Apron Service Providers". The status for the draft is pr. May 2020, to final approval. It is not decided when the regulation will enter into force. The draft consist of requirements to the organization and management of operational procedures. With this into force, the civil aviation authority will conduct oversights and inspections with the "Apron Management Service Providers".

1.18 Additional information

1.18.1 Aeronautical Information Publication (AIP)

1.18.1.1 Excerpt from AIP Norway, section "ENGM AD 2.20 Local Airport Regulations":

> ***11 De-icing of aircraft***
>
> *11.1 De-icing of aircraft may only be performed on the dedicated platforms, see AD 2 ENGM 2-2 Aerodrome Ground Movement Chart and AD 2 ENGM 2-10 De-icing areas.*
>
> *11.2 On first contact report to Gardermoen Delivery, if the ACFT needs de-icing. ATC will forward the request to the de-icing coordinator.* No call shall be made to the *de-icing coordinator unless instructed by Gardermoen GND when ACFT is approaching the de-icing platform.*
>
> *ACFT equipped with Datalink Departure Clearance (DCL) and requiring de-icing, must enter REQ DEICE into the REMARKS /free text field, when requesting clearance via DCL.*
>
> *11.3 De-icing stands are assigned by the de-icing coordinator. Use full call sign when in contact with the de-icing coordinator.*
>
> *11.4 The de-icing platform, including inbound and outbound lanes, are outside of the maneuvering area. Pilots are reminded to exercise particular caution to avoid danger to vehicles and persons involved in aircraft de-icing.*
>
> *11.5 De-icing is completed when a message including the aircraft callsign, details about the de-icing and the phrase "Equipment removed" is received from the de-icing coordinator via RTF. Do not move the aircraft until the "all clear signal" (thumbs up) is given from the ground crew and taxi instructions are received from ATC.*
>
> *11.6 Listening watch on the last assigned ATC frequency is to be maintained during de-icing. Pilots are requested to maintain listening watch on the de-icing coordinator frequency until the aircraft is leaving the de-icing platform. Request for taxi instructions shall be forwarded to ATC. Specify RTF callsign and the de-icing stand on which the aircraft is parked.*

1.18.1.2 The AIBN's review of the corresponding information in AIP Norway for Avinor's other airports, has revealed that several airports do not provide any information about maximum allowed wingspan at de-icing platforms.

1.18.2 Measures implemented after the accident

1.18.2.1 *Amendments to NOTAM and AIP Norway*

As a result of the accident, which revealed a lack of information for crew about the maximum allowed wingspan at the various de-icing stands, Avinor issued the following NOTAM for Gardermoen a few days after the accident:

```
>>> ENGM (OSLO/GARDERMOEN RWY 01RL/19LR) <<<

MAX WINGSPAN LIMITATIONS ON DE-ICE PLATFORMS.

DE-ICE PLATFORM A-NORTH:
MAX WINGSPAN LESS THAN 36M: STAND 971 973 974 976
MAX WINGSPAN LESS THAN 75M: STAND 972 975
DE-ICE PLATFORM A SOUTH:
MAX WINGSPAN LESS THAN 36M: STAND 981 983 984 986
MAX WINGSPAN LESS THAN 52M: STAND 987
MAX WINGSPAN LESS THAN 75M: STAND 982 985
DE-ICE PLATFORM B NORTH:
MAX WINGSPAN LESS THAN 36M: STAND 991 993 994 996 997 999
MAX WINGSPAN LESS THAN 75M: STAND 992 995 998

AIRCRAFTS WITH WINGSPAN OF 75M OR WIDER WILL HAVE 'FOLLOW ME'
GUIDANCE INTO DE-ICE PLATFORM                    : NOTAM EN/A0016/19
```

Figure 13: NOTAM issued approx. three weeks after the accident. Source: Avinor

The information above was included in AIP Norway on 10 October 2019 (see Figure 14).

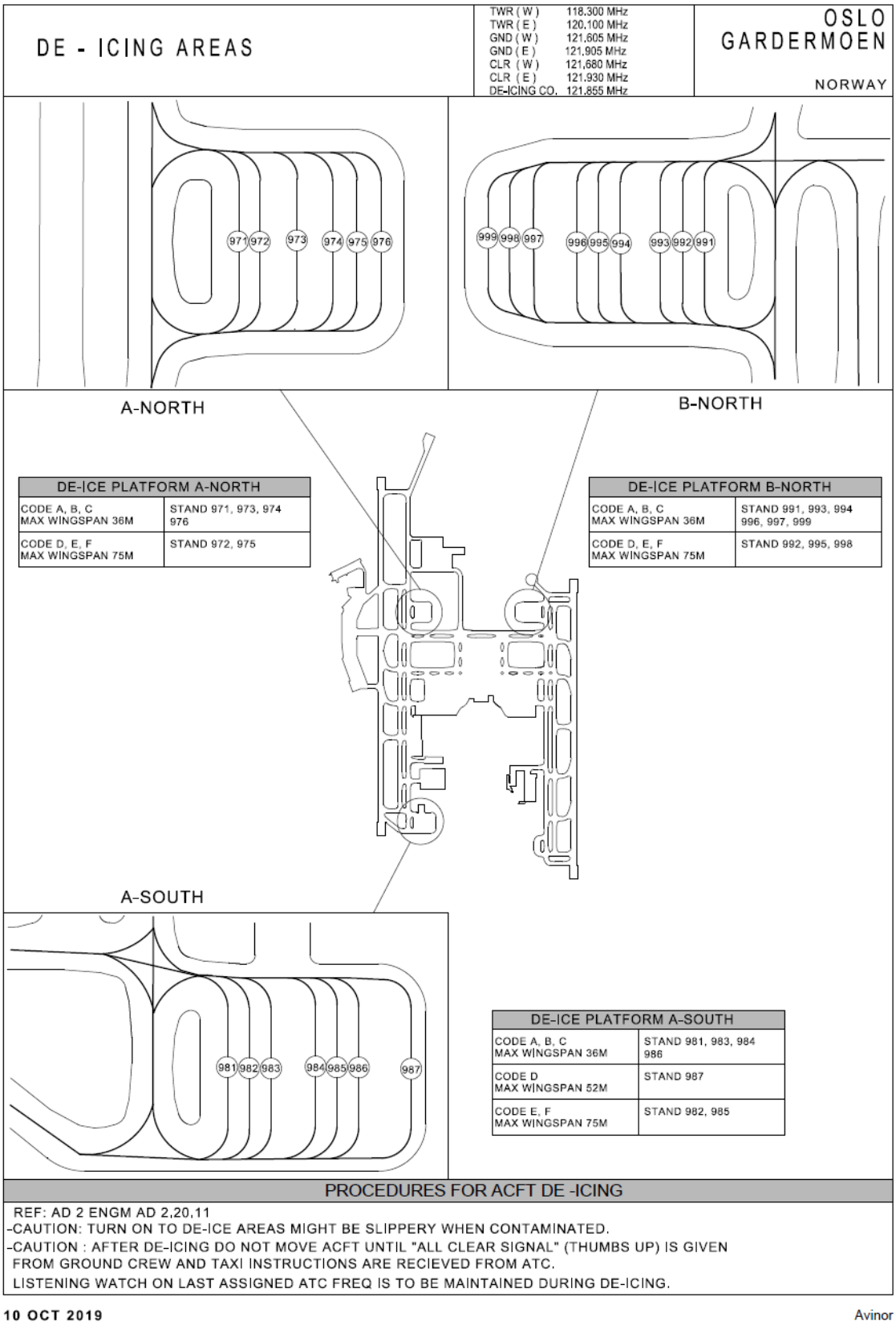

Figure 14: *Revised AIP chart from October 2019 announcing the maximum allowed wingspan at the various de-icing stands. Source: Avinor*

1.18.2.2 *Changes at Avinor Oslo Airport*

In the autumn of 2019, Avinor Oslo Airport marked the guide lines leading up to the de-icing stands with maximum wingspan limitations (see Figure 16). Ground markings were e.g. installed at de-icing stand 991 indicating:

Figure 15: Example of new guide line markings indicating where there are maximum wingspan limitations.

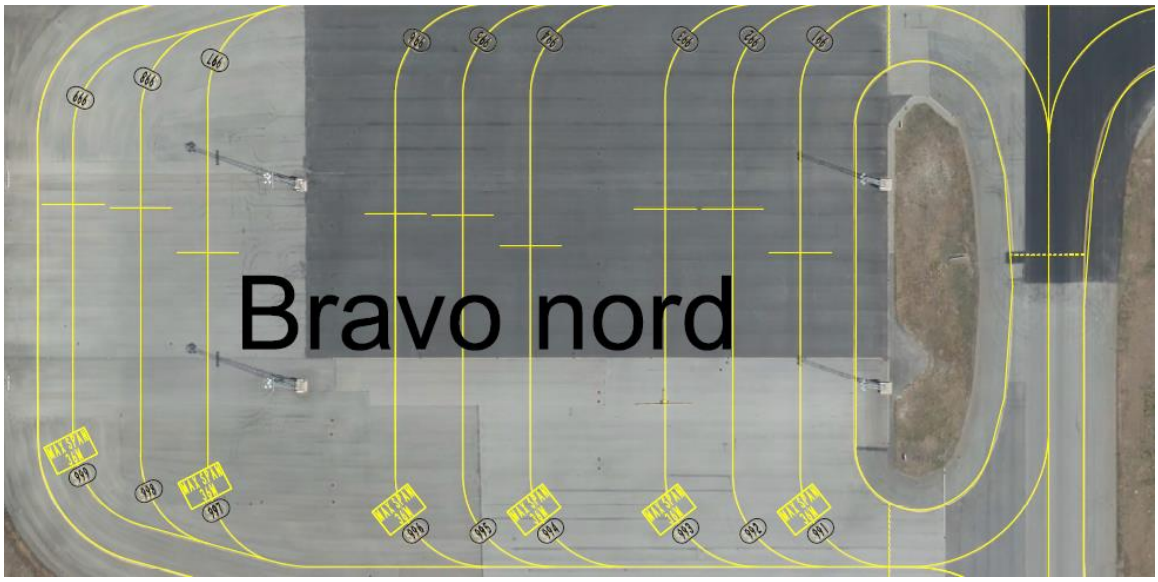

Figure 16: Markings installed in the autumn of 2019 indicating maximum wingspan for a de-icing stand with limitations. Corresponding markings at the other two de-icing platforms. Source: Avinor Oslo Airport

Avinor Oslo Airport had previously granted an exemption for "Alfa South" allowing aircraft with a wingspan of up to 60 meters to use de-icing stand 987. This has now been restricted to 52 meters.

1.18.2.3 *Risk analyses conducted by Avinor Oslo Airport*

After the accident, Avinor Oslo Airport conducted two risk analyses relating to the de-icing areas. The first risk analysis comprised all three de-icing platforms, whereas the last one was dedicated to de-icing platform "Alfa North".

Risk analysis conducted on 26 February 2019:

The purpose of the risk analysis was to identify risks and hazards connected with de-icing of aircraft. The risk analysis revealed 26 undesirable incidents (hazards) related to efficient operations and incidents involving medium risk (yellow hazard area), where measures should be implemented. No hazards with unacceptable risks (red hazard area) were uncovered.

Of these, the Accident Investigation Board would like to draw attention to the following incident:

Collision, where the accident trigger was incorrect choice of de-icing stand. Other contributing factors could include simultaneous presence of aircraft and vehicles or a physical obstacle. Probability- and consequence-reducing barriers that were mentioned included training, procedures, emergency response plan, communication, marking, situation awareness and the use of an escort car. The risk analysis resulted in a list of 23 measures. Some measures have been implemented, whereas others more complex potential measures are being evaluated for follow-up by Avinor Oslo Airport.

1.18.2.4 *Measures - SAS Ground Handling (SGH)*

The day after the accident, SGH decided that for all aircraft larger than code C, there should be a marshaller to guide the aircraft to the correct de-icing stand. This is described in a document that as of January 2020, has been submitted to Avinor for consultative comments.

SGH has also stipulated that there must always be two de-icing coordinators on duty.

De-icing platform "Bravo North" is normally used for southward take-offs. De-icing platform "Alfa North" is also used in the event of high traffic density. In such cases, SGH has stipulated that a minimum of three de-icing coordinators must be on duty.

SGH has increased the number of de-icing staff including a supervisor in front of every aircraft during de-icing.

SGH had until spring 2020 not been able to present work instructions for the de-icing coordinators specifying how de-icing stands are assigned for each aircraft category. SGH has now issued "Coordinator procedure for allocation of de-icing stand at Oslo Airport Gardermoen" (see appendix B).

In March and April 2020 SGH de-icing coordinators tried a solution with OPSView where code D, E and F aircraft has another color marking (red) on the ground radar. This makes it easier to identify aircrafts with wingspan of more than 36 meters.

The lighting on the de-icing platforms is improved.

SGH now has access to video camera No. 1 and 2 which is located at the control tower.

1.18.3 Potential future measures following the accident

1.18.3.1 Avinor Oslo Airport has initiated a new, improved concept for individual control of the leading lights on the de-icing platforms ("follow the greens"). Initially, the concept focuses on control of center line lights at the terminal for taxiways "L-blue, -center and -orange". The computer program will be based on ground radar data combined with previously entered Aerodrome Reference Codes (ICAO) for the relevant aircraft categories. This means the system will detect approaching taxiing aircraft and, depending on their wingspan, ensure that the aircraft can only be directed along lines with sufficient clearance for the relevant aircraft category.

1.18.3.2 Moreover, SGH considers introducing an improved information system to replace the current "Wise" system.

1.18.3.3 Avinor Oslo Airport is also looking into installing information boards with lights, e.g.: “ETH715 stand 992”.

1.18.3.4 The number of CCTV cameras at the airport may also be increased to make sure there is a camera at each de-icing stand. This will make it easier and clearer for the de-icing coordinators to see approaching taxiing aircraft and what takes place around the aircraft during de-icing.

1.18.3.5 As aircraft taxi along the guide lines, experience has shown that it can be challenging to make them come close enough to the de-icing stand. Avinor Oslo Airport is consequently considering the option of establishing stop bars consisting of red lights in the tarmac.

1.18.3.6 SGH has as a result of the ground collision expressed a wish to Avinor Oslo Airport about the following excessive measures:

- Another color marking for code D, E and F aircraft (see section 1.18.2.4).
- Green “Running Rabitt” guide lights on the taxiway.
- Clear “Stop Bar” at the de-icing stand.
- Information board which show assigned de-icing stand (see section 1.18.3.3).
- Access to Menzies Aviation VHF frequency (see section 1.17.5.2).
- Better quality on video cameras during bad visibility.

1.18.4 Other ground collisions

1.18.4.1 In Norway, 46 ground collisions/near-misses occurred between aircraft and other objects during the period 2002-2012[12].

1.18.4.2 The Civil Aviation Authority of Norway has stated that, in the last decade, there were no reports of similar incidents at Norwegian airports.

1.18.4.3 The Accident Investigation Board refers to, among others, our reports relating to three ground collisions and one near-miss:

- SL REP 2013/09 following a collision between two Boeing 737 aircraft at Oslo Airport Gardermoen on 29 March 2012.
- SL REP 2015/16 following a collision between a Boeing 737 aircraft and a de-icing vehicle at Stavanger Airport Sola on 24 November 2014.
- SL REP 2016/04 following a near miss between a Widerøe Dash 8 aircraft and a snow-clearance vehicle at Bodø Airport on 11 February 2015.
- SL REP 2017/09 following a collision between a Sikorsky S-92A helicopter and a truck at Stavanger Airport Sola on 5 July 2016.

[12]See AIBN report SL RAP 2013/09 section 1.18.7.1.

1.18.4.4 Accidents where aircraft wing tips collide with other aircraft or objects on taxiways are fairly common on a global scale. The NTSB issued the following two safety recommendations in September 2012, based on 12 accidents[13]:

> *Require the installation of an anti-collision aid, such as a camera system, on all newly manufactured and newly type-certificated large airplanes and other airplane models where the wingtips are not easily visible from the cockpit to provide a cockpit indication that will help pilots determine wingtip clearance and path during taxi. (A-12-48).*
>
> *Require all existing large airplanes and other airplane models where the wingtips are not easily visible from the cockpit to be retrofitted with an anti-collision aid, such as a camera system, to provide a cockpit indication that will help pilots determine wingtip clearance and path during taxi. (A-12-49).*

1.18.4.5 Both FAA[14] and EASA[15] rejected the safety recommendations from NTSB. The main reason for disallowing the safety recommendations was that so far, no ground collisions caused loss of life or injuries – only material damage.

1.18.4.6 NTSB concluded the follow-up from FAA and EASA classifying both as follows: "CLOSED-UNACCEPTABLE ACTION".

1.18.4.7 On 27 September 2013, the International Federation of Air Line Pilots' Associations (IFALPA) issued "Position Paper 14POS13", which reads:

> *Anti-collision equipment for ground operations*
>
> *In the last 10 years, at least 15 ground collisions involving an aircraft moving under own power colliding with another aircraft have been investigated. In almost all cases damage occurred due to a collision of the wing tip, and in at least one case substantial damage went unnoticed and a damaged aircraft commenced flight. There have been many more accidents in which aircraft collided with ground objects. Taxiing is a critical flight phase. Wing tip clearance is often difficult to assess from the flight deck, and in some aircraft the wing tip itself cannot be seen at all by the flight crew. Additional factors include swept wing growth (during a turn the wing tip describes an arc greater than the normal wingspan), and taxiway layouts that do not guarantee sufficient clearance between aircraft. Accidents can therefore happen in both day time and night time, even when the visibility is very good. In order to reduce the risk of ground collisions, IFALPA believes that all turbine-engined aeroplanes of a maximum certified take-off mass in excess of 5700kg should be fitted with anti-collision equipment for ground operations, and that such equipment should be used in all weather conditions. Means should be provided to alert the flight crew of insufficient obstacle clearance on the ground. There should also be suitable flight crew training on the use of such equipment, and relevant security aspects being taken into account.*

1.18.4.8 In October 2015 the Irish investigation unit AAIU issued a report following a ground collision between two Boing 737 aircraft at Dublin Airport on 7 October 2014.

1.18.4.9 In the report, the AAIU referenced the two NTSB safety recommendations mentioned above (see section 1.18.4.4). The AAIU was of the opinion that ground collisions are a

[13] NTSB Safety Recommendation A-12-48 & A-12-49.
[14] Federal Aviation Administration, USA
[15] European Aviation Safety Agency

potential risk to human life and can cause personal injuries. Among other factors, they referenced the fact that the collision between the two Boeing 737 aircraft in Dublin caused severe damage to the Auxiliary Power Unit (APU) and a fuel leakage that could have ignited. The AAIU considered the Air Navigation Commission (ANC) of the International Civil Aviation Organisation (ICAO) to be the appropriate organization to assess the need for aircraft anti-collision aids on the ground and issued the following safety recommendation:

> *It is recommended that: The International Civil Aviation Organisation (ICAO) should, through the work programme of the ANC, assess the need for the provision of anti-collision aids to help pilots of large public transport aircraft determine wingtip clearance during ground manoeuvring. (IRLD2015016)*

1.18.4.10 Follow-up from ICAO:

> *ICAO responded to the AAIU by letter dated 11 January 2016 advising that:*
>
> *Following considerable analysis of the above safety recommendation and the accident report, it was noted that similar recommendations from the United States National Transportation Board to the Federal Aviation Administration and European Aviation Safety Agency resulted in both these organizations not taking action based on cost benefit analyses.*
>
> *It is further noted that the incorporation of such aircraft equipment (i.e. camera system as anti-collision aid) would result in significant costs and require research in human performance to establish proper training, including analysis of the added task relating to monitoring of extra equipment during taxi operations. Also, retrofitting would most likely not occur due to the high costs involved, which would lead to different procedures depending on whether a particular aircraft in the fleet would be equipped or not with the new anti-collision aid, thereby increasing operational risks.*
>
> ……

1.18.4.11 The AAIU classified the feedback as follows:

> *The AAIU considers the status of this recommendation to be "Not Accepted/Closed".*

1.18.4.12 In the above-mentioned report from Ireland, reference was also made to a report from the British Air Investigation Branch (AAIB) UK relating to a ground collision between two Boeing 737 aircraft at London Airport Stansted on 28 July 2014.

1.18.4.13 Skybrary issued a summary of the report from Ireland which makes reference to other comparable accidents.

1.18.4.14 Skybrary has also published another article on hazards related to wing tip collisions.

1.18.4.15 Many recordings of ground collisions have been posted at YouTube. One video comprises a compilation of various ground collisions that caused significant material damage as well as a risk of fatalities or severe personal injuries.

1.19 Useful or effective investigation techniques

No investigation methods warranting special mention have been used in this investigation.

2. ANALYSIS

2.1 Introduction

2.1.1 The course of events and circumstances of this accident have been established based on the factual information available through interviews with witnesses and technical/electronic sources. So far, similar ground collisions have not caused personal injuries. However, the AIBN concurs with the US and Irish investigation boards that there is a risk potential. In this incident, the outer section of the aircraft's right wing was substantially damaged, but there was no fuel leakage. A fuel leakage could have caused a fire with subsequent and potentially serious injuries.

2.1.2 Below, the Accident Investigation Board will assess the following main factors that were relevant for the accident:

2.2: Allocation of incorrect de-icing stand
2.3: The aircraft's entry into the "Bravo North" de-icing area
2.4: The crew's actions at the de-icing stand
2.5: Indirect communication between de-icing vehicle No. 11 and the pilots on ET-AUP
2.6: Introduction of new technology to be used during taxiing
2.7: New pan-European regulations

2.2 Allocation of incorrect de-icing stand

2.2.1 It was de-icing coordinator No. 2's responsibility to communicate with aircraft crew in connection with the de-icing procedure. Both de-icing coordinator No. 1 and No. 2 knew that de-icing stand 991 was not designed for aircraft as large as the Dreamliner. During de-icing coordinator No. 2's communication with the crew on ETH715, he gave instructions to the crew to use de-icing stand 991 instead of stand 992, as the two de-icing coordinators had agreed. The Accident Investigation Board is of the opinion that the coordinator by a slip-up said 991 instead of 992.

2.2.2 De-icing coordinator No. 2 has explained that his main focus was on reorganizing the order of the aircraft that were approaching de-icing area "Bravo North". The AIBN believes this may have contributed to de-icing coordinator 2's mix-up and allocating wrong de-icing stand.

2.2.3 SGH has stated that aircraft have been assigned an incorrect de-icing stand on previous occasions, or they have taxied to another de-icing stand than the one they were assigned at Gardermoen. However, this has not resulted in collisions between aircraft and other objects. Moreover, SGH has stated that it can be challenging to determine whether aircraft approaching de-icing are, e.g. an Airbus A330/A340 or an Airbus A320/A321, based on the traffic lists. It is equally challenging to determine whether an aircraft is a Boeing 787 or a Boeing 737.

2.2.4 For information about aircraft approaching "Bravo North", the de-icing coordinators must primarily rely on the ground radar in addition to the traffic lists in A-CDM and CCTV cameras – and not look out the window for visual contact. This can make it difficult for the coordinators to continually ensure that all aircraft are directed to a stand approved for their category, particularly on busy days when there is a high demand for de-icing.

2.2.5 It is in line with the prevailing safety thinking that organizations implement measures to prevent human error from contributing to accidents or undesirable incidents. However, the organization had not established sufficient safety barriers to detect any erroneous action. For example, work tasks and responsibilities had not been organized to ensure that the de-icing coordinators functioned as a safety barrier for each other.

2.2.6 As mentioned in section 1.18.2.4, SGH was unable to present work instructions for the de-icing coordinators relating to allocation of de-icing stands for each aircraft category. The AIBN believes that the coordinators' work tasks must be clarified through work instructions that describe specifically how to perform their tasks in order to ensure aviation safety. They should also include instructions related to staffing, coordination and communication. A safety recommendation is issued in this connection. Furthermore, Avinor Oslo Airport should, in consultation with SGH, take a closer look at the de-icing coordinators' work stations and ergonomics, see section 2.2.3.

2.2.7 Moreover, it seems the de-icing coordinators did not have adequate technical aids to ensure correct de-icing stand allocation, based on aircraft category. The type/category of aircraft is registered in the A-CDM de-icing request system. The AIBN is of the opinion that it should be possible to link this information to the de-icing stands that are approved for each aircraft type/category. It should also be technically feasible to ensure that the system disallows allocation of an incorrect de-icing stand.

2.2.8 Currently, the assigned de-icing stand is normally not entered in the data system before after the aircraft has parked. If the data system is to function as a technical barrier to prevent incorrect de-icing stand allocation, the allocation should be entered into the system before the aircraft enters the de-icing area. Moreover, the Accident Investigation Board finds that other technical solutions should be developed that would help ensure the crew taxiing to the correct de-icing stand. During our investigation, the AIBN has received information about several potential solutions, that Avinor Oslo Airport is now assessing. This includes the use of information boards and individual guide lights (see Chapter 1.18.3).

2.2.9 The AIBN believes that technical barriers are more robust than human barriers, such as procedures that all operators must follow. Consequently, a safety recommendation is issued to Avinor Oslo Airport to establish suitable technical solutions to prevent aircraft from being directed to the wrong de-icing stand.

2.3 The aircraft's entry into the “Bravo North” de-icing area

2.3.1 As the ET-AUP turned into the “Bravo North” de-icing area, there were no markings, lights, signage or other technical barriers to indicate to the crew that they had been assigned the wrong de-icing stand. Thus, the crew was unable to stop the aircraft before it hit the light mast to the right.

2.3.2 The crew did not have access to information about which de-icing stands at Gardermoen were approved for a Boeing 787-9. The Accident Investigation Board has noted that Avinor Oslo Airport later on has implemented this information in AIP Norway.

2.3.3 The AIBN's review of corresponding information in AIP Norway for Avinor's other airports, shows a potential for improvement in terms of announcing where there are maximum wingspan limitations at the de-icing platforms. The Accident Investigation Board is of the opinion that information about the type/category of aircraft approved for

each de-icing stand, must be made available in AIP Norway for all airports in Norway. This should apply regardless of whether the de-icing areas are located inside or outside the respective maneuvering areas. All airport operator for Norwegian airports should quality-assure this for all other Norwegian airports (see Appendix C). A safety recommendation is issued in this connection.

2.3.4 Many aircraft categories, including the Boeing 787 Dreamliner, use Electronic Flight Bag (EFB). The information about each airport in the EFB (or on paper charts) comes from AIP. The Accident Investigation Board believes that the EFB should clearly indicate which de-icing stands and taxiways cannot be used by the type of aircraft in question.

2.4 The crew's actions at the de-icing stand 991

2.4.1 The commander saw the light mast and thought that clearance on the right-hand side was marginal. He therefore asked the first officer, who was in the seat to the right, if he could see the distance between the wing tip and the light mast. The first officer could not see the tip of the wing, and, from his position, could therefore not verify that there was sufficient clearance to the light mast.

2.4.2 The commander has stated that the crew did not receive any signal from the ground crews indicating that the aircraft was on collision course with the light mast. The crew may have interpreted this as a tacit confirmation that everything was normal, and that there was sufficient clearance, even though in reality the driver of de-icing vehicle No. 11 acted correctly when he notified the de-icing coordinator via internal radio (PMR), having discovered that the wrong de-icing stand had been assigned.

2.4.3 The crew decided to rely on the given instructions to taxi to de-icing stand 991. The Accident Investigation Board finds it unfortunate that the commander continued taxiing, although at a lower speed, without receiving verification that there was sufficient clearance to the light mast.

2.4.4 In such a situation, the commander could have stopped the aircraft and asked the de-icing coordinator to verify that there was clearance between the wing and the light mast, and that de-icing stand 991 was approved for their category E aircraft.

2.4.5 Some sort of anti-collision aid, or e.g. a wing tip camera, would have given the crew a clear indication that there was insufficient clearance between the wing and the light mast. This is discussed in more detail in Chapter 2.6.

2.5 Indirect communication between de-icing vehicle No. 11 and the pilots on ETH715

2.5.1 De-icing vehicles No. 11 and No. 12 were not equipped with VHF radio. This meant that the driver of de-icing vehicle No. 11 had to use the internal radio (PMR) and ask the de-icing coordinators to stop the aircraft, instead of contacting the ETH715 crew directly on VHF radio.

2.5.2 This indirect communication meant that valuable seconds were lost. Speedier instruction of the aircraft crew to stop taxiing would have helped prevent the collision. It should be considered whether the existing communication solution is sufficient to ensure aviation safety.

2.6 Introduction of new technology to be used during taxiing.

2.6.1 The Accident Investigation Board finds the two above-mentioned safety recommendations from NTSB and the AAIU safety recommendation to be justified, and even more so in 2020 than when they were issued. The AIBN believes that the use of anti-collision aids during taxiing can help improve aviation safety significantly.

2.6.2 Much has happened from 2012 to 2020. Both cameras and other detection systems have been introduced for other means of transport, with good results. Most cockpit crews should therefore be familiar with the principles and use of such equipment. Thus, the concern related to training seems to have been eliminated. To be apprehensive about introducing new equipment because some aircraft would be left without it, claiming that this is a hazard per se, would be a barrier to any change. Furthermore, it has been argued that so far there have been no fatalities associated with this type of ground movements. The Accident Investigation Board believes that in proactive safety work, one should not wait for a fatal accident to occur before implementing measures.

2.6.3 The AIBN concurs with the International Federation of Air Line Pilots' Associations (IFALPA), which in their "Position Paper 14POS13" of 27 September 2013 promotes the introduction of anti-collision aids in all turbine-operated commercial aircraft with a certified take-off mass of more than 5,700 kg, as a contribution to prevent ground collisions (see 1.18.4.7).

2.6.4 The Accident Investigation Board issues a safety recommendation to the EASA to consider a requirement for equipping large aircraft with anti-collision aids for use during taxi.

2.7 New pan-European regulations

2.7.1 As mentioned in section 1.17.6, the Civil Aviation Authority of Norway has so far not issued approvals or conducted oversights and inspections of handling operators ("Apron Service Providers") and ("Apron Management Service Providers").

2.7.2 The airline operator has responsibility to assure that de-icing is conducted according to their contract with the handling operator.

2.7.3 Responsibility and control of movements on de-icing platforms, belongs to the airport operator.

2.7.4 With the new pan-European regulation in force, the Civil Aviation Authority of Norway will conduct oversights and inspections with the handling operators in addition to airport operators.

2.7.5 The Accident Investigation Board believes the new pan-European regulations for handling operators ("Apron Service Providers" and "Apron Management Service Providers") combined with authority oversights and inspections, will have a positive impact on flight safety.

3. CONCLUSIONS

The AIBN's investigation has revealed that the following key factors contributed to the accident:

a) The de-icing coordinator had by a slip-up assigned ET-AUP a different de-icing stand than the one he and his colleague had previously planned.

b) The de-icing coordinators did not have adequate technical aids to ensure that the correct de-icing stand was assigned, based on aircraft category.

c) SGH has been unable to present work instructions for the de-icing coordinators relating to allocation of de-icing stand for each aircraft category. A "Coordinator procedure for allocation of de-icing stand at Oslo Airport Gardermoen" is now taken care of.

d) The crew on ET-AUP did not have access to information about what de-icing stands were authorized for their type of aircraft at Oslo Airport Gardermoen. Information about what de-icing stand can be used by the various aircraft categories was not included in the Aeronautical Information Publication Norway, or in NOTAM.

e) Some type of anti-collision aid, such as a wingtip camera, would have clearly indicated to the crew that there was insufficient clearance between the wing and the light mast, thus preventing a collision.

f) As the ET-AUP turned into the "Bravo North" de-icing area, there were no markings, lights, signage or other technical barriers to indicate to the crew that they had been assigned the wrong de-icing stand. Thus, the crew was unable to stop the aircraft before it hit the light mast to the right.

g) As the aircraft approached the light mast, the commander thought that clearance was marginal. The crew decided to rely on the given instructions to taxi to de-icing stand 991.

4. SAFETY RECOMMENDATIONS

The Accident Investigation Board Norway issues the following safety recommendations:[16]

Safety recommendation SL No. 2020/12T

On 18 December 2018, a Boeing 787-9 operated by Ethiopian Airlines collided with a light mast at a de-icing platform at Oslo Airport Gardermoen. The de-icing coordinator had by a slip-up instructed ETH715 to taxi to a de-icing stand only authorized for aircraft with a much smaller wingspan. Information about what de-icing stands can be used by the various aircraft categories was not included in the AIP Norway, or in NOTAM. As for Gardermoen, this was subsequently ensured through issue of a revised AIP Norway on 10 October 2019.

The Accident Investigation Board Norway recommends that all airport operators for Norwegian airports review and issue information in AIP Norway for all other airports in Norway, stating limitations relating to what de-icing stands/areas the various aircraft categories can use.

Safety recommendation SL No. 2020/13T

On 18 December 2018, a Boeing 787-9 operated by Ethiopian Airlines collided with a light mast at a de-icing platform at Oslo Airport Gardermoen. The de-icing coordinator had by a slip-up instructed the aircraft to taxi to a de-icing stand only authorized for aircraft with a much smaller wingspan.

The Accident Investigation Board Norway recommends that Avinor Oslo Airport, in consultation with the relevant handling operators, find suitable technical solutions for Gardermoen to prevent aircraft from being directed to the wrong de-icing stand.

Safety recommendation SL No. 2020/14T

On 18 December 2018, a Boeing 787-9 operated by Ethiopian Airlines collided with a light mast at a de-icing platform at Oslo Airport Gardermoen. In line with previously issued safety recommendations to FAA, EASA and ICAO, as well as the IFALPA Position Paper and with support from Cockpit Association of Norway (NF), the AIBN believes that anti-collision aids for taxiing would improve aviation safety.

The Accident Investigation Board Norway recommends that EASA consider to require large aircraft to be equipped with anti-collision aids for use during taxi.

The Accident Investigation Board Norway

Lillestrøm, 29 June 2020

[16]The Ministry of Transport forwards safety recommendations to the Norwegian Civil Aviation Authority and/or other involved ministries for evaluation and monitoring, see Section 8 of the Norwegian Regulations regarding public investigations of accidents and incidents in civil aviation.

APPENDICES

Appendix A: Abbreviations

Appendix B: Coordinator procedure for allocation of de-icing stand at Oslo Airport Gardermoen (in Norwegian only)

Appendix C: List of Aerodromes and operators

APPENDIX A – ABBREVIATIONS

AAIB UK	Air Accident Investigation Branch UK
AAIU	Air Accident Investigation Unit Ireland
ACFT	Aircraft
AD	Airport
AIBN	Accident Investigation Board Norway
AIP	Aeronautical Information Publication
ANC	Air Navigation Commission
ATC	Air Traffic Control
ATPL (A)	Air Traffic Pilot License (aeroplane)
BKN	Broken
CCTV	Closed Circuit TV
CPL (A)	Commercial Pilot License (aeroplane)
CVR	Cockpit Voice Recorder
DCL	Datalink Departure Clearance
EASA	European Aviation Safety Agency
EFB	Electronic Flight Bag
ENGM	Oslo Airport Gardermoen
EU	European Union
FAA	Federal Aviation Administration
Ft	Feet
GND	Ground
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFALPA	The International Federation of Air Line Pilots' Associations
IR-ME	Instrument Rating - Multi Engine
Kg	Kilogram

KT	Knots
L	Left
MHz	Mega Hertz
NGS	Nitrogen Generation System
NOTAM	Notice to airmen
NTSB	National Transportation Safety Board
OSL	Avinor Oslo Airport
PMR	Professional mobile radio (internal radio)
Q	Altimeter sub-scale setting to obtain elevation when on the ground QNH
R	Right
REQ	Request
RTF	Radiotelephone
SAS	Scandinavian Airlines System
SGH	SAS Ground Handling
TEMPO	Temporary
UTC	Universal Time Coordinated
VHF	Very High Frequency
WIPS	Wing Ice Protection System

Koordinatorinstruks for tildeling av avisingsstand på OSLO Lufthavn, Gardermoen

- Les av på A-CDM/Tradis (bakkeradar) hvilke(t) fly som har bestilt deicing. Identifisering av flytype skal være positiv. Merk: ICAO aircraft type designator.
- Tildel avvisings-stand i henhold til flytype og deicing-operatør.
- Tildel marshaller for fly med vingespenn over 36 meter (vingespennkategori D - E - F).
- Etabler kontakt med Commander på gjeldende VHF frekvens for info om tildelt stand. For D kategori og større informer om å følge marshallers anvisninger.
- For flytyper i kategori D og større, opprett visuell kontroll med at flyet takser inn på tildelt spor. Dersom marshaller ikke er på plass når flyet er etablert på standens ledelinje, skal det gis melding om «hold your position» inntil marshaller er på plass.

Avising plattformer

Avisingsstand for kategori B, C, D og E

	Track (spor)	Capacity / Aircraft code	Remarks
Alpha North	971	C	
	972	E+ (<75 m)	Replaces simultaneous use of 71 and 73
	973	C	
	974	C	
	975*	E+ (<75 m)	Replaces simultaneous use of 74 and 76
	976	C	
Alpha South	981	C	
	982	E+ (<75 m)	Replaces simultaneous use of 81 and 83
	983	C	
	984	C	
	985*	E+ (<75 m)	Replaces simultaneous use of 84 and 86
	986	C	
	987	D (<52m)	
Bravo North	991	C	
	992	E+ (<75 m)	Replaces simultaneous use of 91 and 93
	993	C	
	994	C	
	995*	E+ (<75 m)	Replaces simultaneous use of 94 and 96
	996	C	
	997	C	
	998	E+ (<75 m)	Replaces simultaneous use of 97 and 99
	999	C	
Bravo South		E	**er p.t. stengt**

***Avisingsstand godkjent for kategori F fly:**

- Alfa Syd: Spor 985
- Alfa Nord: Spor 975
- Bravo Nord: Spor 995
- Bravo Syd. Brukes ikke
- Kode F fly
    - Det skal benyttes Follow Me tjeneste (Avinor) ved taksing inn på, og ut av avisingsplattform.
    - Ved innkjøring til avising plattform Bravo Nord skal det benyttes wingwalker ved innkjøring fra Sierra for å forsikre seg om at det ikke er plassert utstyr i området ved bygg som kan komme i konflikt med flyet.
    - Ved innkjøring til Alpha Nord skal det stenges for trafikk på internvei syd av plattformen.

Note! For kunder av Menzies, be Commander bytte til frekvens 121.630MHz etter parkering.

Inndeling flykategori type (vingespenn) (ICAO-koder)

Kategori B	Kategori C	Kategori D	Kategori E	Kategori F
Fly med vingespenn fra 15 - 24 m	Fly med vingespenn fra 24 - 36 m	Fly med vingespenn fra 36 - 52 m	Fly med vingespenn fra 52 - 65 m	Fly med vingespenn fra 65 - 80 m
CRJ7 D328 E110 ER3/ERD/ER4 F21	AT43/AT44/AT45 AT72/AT73/AT75/ AT46 A318/A319 A320/A20N A321/A21N B736/B737/B738 CRJ9/CRJX BCS1/BCS2 DHC7 DH8A/DH8B/ DH8C/DH8D E290 E170/E75S/E75L E190/E195 F27/F50/F70/F100 SB20 SU95	A30B/A306/A3ST A310 B752/B753 B762/B763/B764 TU204 C-130 C-17	A332/A333 A342/A343/ A345/A346 A359/A35K B744 B772/B77L/ B773/B77W/ B778/B779 B788/B789/ B78X	A338 AN124 AN225 B748 C5

Hvis fly ikke finnes på liste, kontakt Commander for å få bekreftet vingespenn.

Aerodromes and operators (source AIP-Norge AD 1.1 / AD 1.3 / AD 2.2, 23.04.2020)

Aerodrome (not included heliports only)	Location indicator	Operator
Alta airport	ENAT	Avinor
Andøya airport	ENAN	Luftforsvaret
Arendal airport, Gullknapp	ENGK	Arendal lufthavn, Gullknapp AS
Bardufoss airport	ENDU	Avinor
Bergen airport Flesland	ENBR	Avinor
Berlevåg airport	ENBV	Avinor
Bodø airport	ENBO	Avinor
Brønnøysund airport, Brønnøy	ENBN	Avinor
Båtsfjord airport	ENBS	Avinor
Florø airport	ENFL	Avinor
Førde airport, Bringeland	ENBL	Avinor
Hammerfest airport	ENHF	Avinor
Harstad/Narvik airport, Evenes	ENEV	Avinor
Hasvik airport	ENHK	Avinor
Haugesund airport, Karmøy	ENHD	Lufthavndrift As
Honningsvåg airport, Valan	ENHV	Avinor
Hønefoss airport, Eggemoen	ENEG	Eggemoen Utvikling As
Kirkenes airport, Høybuktmoen	ENKR	Avinor
Kristiansand airport, Kjevik	ENCN	Avinor
Kristiansund airport, Kvernberget	ENKB	Avinor
Lakselv airport, Banak	ENNA	Avinor
Leknes airport	ENLK	Avinor
Lillestrøm airport, Kjeller	ENKJ	Kjeller Aero Senter
Mehamn airport	ENMH	Avinor
Mo i Rana airport, Røssvoll	ENRA	Avinor
Molde airport, Årø	ENML	Avinor
Mosjøen airport, Kjærstad	ENMS	Avinor
Moss airport, Rygge	ENRY	Luftforsvaret
Namsos airport	ENNM	Avinor
Notodden airport, Tuven	ENNO	Notodden Lufthavn AS
Ny-Ålesund airport, Hammerrabben	ENAS	Kings Bay As
Oslo airport, Gardermoen	ENGM	Avinor
Røros airport	ENRO	Avinor
Rørvik airport, Ryum	ENRM	Avinor
Røst airport	ENRS	Avinor
Sandane airport, Anda	ENSD	Avinor
Sandefjord airport, Torp	ENTO	Sandefjord Lufthavn As
Sandnessjøen airport, Stokka	ENST	Avinor
Sogndal airport, Haukåsen	ENSG	Avinor
Stavanger airport, Sola	ENZV	Avinor
Stokmarknes airport, Skagen	ENSK	Avinor
Stord airport, Sørstokken	ENSO	Sunnhordland Lufthavn As
Svalbard airport, Longyear	ENSB	Avinor
Sveagruva airport, Svea	ENSA	Store Norske Spitsbergen Gruvekomp. As
Svolvær airport, Helle	ENSH	Avinor
Sørkjosen airport	ENSR	Avinor
Tromsø airport, Langnes	ENTC	Avinor
Trondheim airport, Værnes	ENVA	Avinor
Vadsø airport	ENVD	Avinor
Vardø airport, Svartnes	ENSS	Avinor
Ørland airport	ENOL	Luftforsvaret
Ørsta-Volda airport, Hovden	ENOV	Avinor
Ålesund airport, Vigra	ENAL	Avinor