aibn Accident Investigation Board Norway

Issued December 2010

REPORT SL 2010/18

REPORT ON SERIOUS AIRCRAFT INCIDENT AT OSLO AIRPORT GARDERMOEN 25 FEBRUARY 2010 INVOLVING AIRBUS A320-214 VP-BWM, OPERATED BY AEROFLOT RUSSIAN AIRLINES

Accident Investigation Board Norway • P.O. Box 213, N-2001 Lillestrøm, Norway • Phone: + 47 63 89 63 00 • Fax: + 47 63 89 63 01
www.aibn.no • post@aibn.no

This report has been translated into English and published by the AIBN to facilitate access by international readers.
As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

The Accident Investigation Board has compiled this report for the sole purpose of improving flight safety. The object of any investigation is to identify faults or discrepancies which may endanger flight safety, whether or not these are causal factors in the accident, and to make safety recommendations. It is not the Board's task to apportion blame or liability. Use of this report for any other purpose than for flight safety should be avoided.

Photos: AIBN and Trond Isaksen/OSL

CONTENTS

REPORT ON SERIOUS AIRCRAFT INCIDENT

Aircraft:	Airbus A320-214
Nationality and registration:	Russian, VP-BWM
Owner:	Aeroflot Russian Airlines, Russia
User:	Identical with owner
Crew:	3 pilots: commander, first officer and safety pilot, as well as four cabin crew members, no injuries
Passengers:	60 passengers, no injuries
Place of incident:	Oslo Airport Gardermoen, Norway (ENGM)
Date and time of incident:	Thursday, 25 February 2010 at 1519 hrs.

All hours stated in this report are local time (UTC + 1 hour) unless otherwise specified.

NOTIFICATION OF THE INCIDENT

On Thursday, 25 February 2010 at 1530 hrs. about 10 minutes after the incident had occurred, the officer on duty at the Accident Investigation Board Norway (AIBN) received notification relating to the incident from the chief air traffic controller at Oslo Airport Gardermoen. In accordance with ICAO Annex 13 Aircraft Accident and Incident Investigation, AIBN notified the Russian accident investigation board, the Interstate Aviation Committee (IAC), as well as the accident investigation board in the country of aircraft manufacture, France, about the incident. Both accident investigation boards appointed an accredited representative to assist the AIBN in its investigation as required.

SUMMARY

On Thursday, 25 February at 1519 hours, a serious aircraft incident took place at Oslo Airport Gardermoen (ENGM). Aeroflot flight number AFL212, an Airbus A320 aircraft, made a taxiing mistake and took off from taxiway M instead of runway 01L. There were three pilots, four cabin crew members and sixty passengers onboard. After the incident, the flight continued as planned to Moscow.

The flight crew was not aware that they had taken off from the taxiway until informed of this by the air traffic controller after take-off. Under the prevailing conditions, taxiway M was by chance long enough for the aircraft to take off. The taxiway was at the time of the incident also free of other traffic and obstacles. This prevented a more serious outcome of the incident.

The investigation has uncovered several causes for AFL212's taxiing mistake and take-off from the taxiway. The factors which contributed to the events can be found with the parties involved, i.e. the airline, the control tower and the airport.

The Accident Investigation Board is of the opinion that deficient procedures and insufficient alertness in the cockpit, in combination with insufficient monitoring from the control tower and insufficient signposting in the manoeuvring area, resulted in AFL212 making a taxiing mistake and taking off from taxiway M.

On the basis of the investigation, the Accident Investigation Board has issued a safety recommendation to the airline involved, Aeroflot Russian Airlines. As the airport has already implemented measures to prevent similar incidents, and the Civil Aviation Authority has reopened an earlier safety recommendation from AIBN to Avinor, no further safety recommendations will be issued.

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 VP-BWM, an Airbus A320-214 from Aeroflot Russian Airlines had completed the airline's flight AFL211 from Sheremetyevo International Airport (UUEE) in Moscow, Russia to Oslo Airport Gardermoen (ENGM). The flight lasted just under 2.5 hours. The flight was delayed from Sheremetyevo, and AFL211 arrived at Gardermoen at about 1420 hours, 20 minutes behind schedule. AFL212 landed on runway 01R, and taxied via intersection B6 and taxiway G to parking slot 50 (see page 9, Figure 1). The return flight to Sheremetyevo, flight no. AFL212, was scheduled for departure at 1455 hours. The aircraft was parked at Gate 50 for 43 minutes. The aircrew did not leave the aircraft except to perform a visual external inspection of the aircraft prior to departure.

1.1.2 Pilot flying (PF) was the commander. He was also the instructor for the first officer who was in training. As the first officer (pilot not flying, PNF) was in training, a third crew member, a safety pilot, was present in the cockpit. His task was to assist and monitor the first officer.

1.1.3 Runway 01L was in use for take-offs. The crew used the latest edition of the Jeppesen map of Oslo Airport Gardermoen, dated 6 November 2009. This included a map of the standard taxiing routes and the airport map (See Appendix B). The appendices to the airport map indicated that all entry taxiways to runway 01L were available for intersection take-off.

1.1.4 To save taxiing time by not taxiing all the way down to holding position A1, the crew considered whether they could use the intersection departure A3. Based on the airplane's take-off mass of 61 700 kg, as well as prevailing weather and friction conditions, the crew concluded that the available runway length from A3 was well within the necessary margins.

1.1.5 The first officer, who was responsible for radio communication with air traffic control, contacted the ground frequency at Gardermoen and stated that AFL212 was ready to leave Gate 50. They were cleared to taxi at 1513 hours:

”AFL212 taxi via Golf and November to holding point runway 01L”.

At 1516 hours, just before AFL212 turned left from taxiway G and headed south on taxiway N, AFL212 was instructed to switch to the tower frequency for the western runway, TWR W.

1.1.6 This was a quiet period with little traffic on Gardermoen, as is often the case at this time of day. There were four air traffic controllers and one air traffic controller trainee in the tower cabin. The supervisor position and both tower positions in the west and east were staffed. In addition, training was underway in the merged ground and clearance delivery position.

1.1.7 The air traffic controller in tower position west (TWR W) had started his shift at 1430 hours. Over the last 20 minutes before the incident, he had been responsible for four take-offs on runway 01L. When Aeroflot AFL212 contacted the tower frequency, the aircraft was in the intersection between taxiways G and N. There were neither vehicles nor other airplanes in the manoeuvring area in the west of the airport. AFL212 was the only airplane on air traffic controller TWR W's frequency.

1.1.8 AFL212 acknowledged in their first contact with TWR W that they wanted to use intersection A3. The air traffic controller saw no reason why not, and cleared AFL212 to taxi onward to A3:

At 15:16:55 hours	AFL212	*"TWR, AFL212 good afternoon taxiway November ready for departure from Alpha 3 intersection"*
At 15:17:03 hours	TWR W	*"AFL212 proceed to Alpha 3"*
At 15:17:08 hours	AFL212	*"AFL212 eeh... to Alpha 3"*

1.1.9 The air traffic controller TWR W described how he was surprised that AFL212 requested an intersection take-off, as his experience was that this airline seldom requested this. He figured that the pilot was familiar with Gardermoen, as he did not want to use the full runway length.

1.1.10 AFL212 continued to taxi at normal taxiing speed further southward on taxiway N. The commander drove the aircraft along the centre line of the taxiway, and was the only one of the three in the cockpit directing his main focus out of the window. He had Jeppesen's airport map with an overview of the airport's runway systems in front of him (see Appendix B). The first officer reviewed the checklists for taxiing and initial review of the departure procedures, focusing on instruments and checklists. The safety pilot was focusing on what the first officer was doing. The crew has stated to the Accident Investigation Board that there was a professional and friendly atmosphere in the cockpit, where everyone was focused on his respective tasks.

1.1.11 After giving clearance to AFL212 to taxi to intersection A3, the air traffic controller checked his area for any obstacles to AFL212's take-off. The air traffic controller had good visibility out of his window, and could see his entire area of responsibility on the ground. In addition, he checked the radar image (SDD), as well as his electronic list of incoming traffic. The air traffic controller identified no other conflicting traffic, and as a result he contacted AFL212 and gave the crew take-off clearance for runway 01L. This clearance was given 38 seconds after AFL212 had acknowledged the taxi clearance to A3. The aircraft was then on taxiway N, south of A4 and north of the cargo area (see page 9, Figure 1 and Appendix B). The first officer confirmed receipt of the take-off clearance:

At 15:17:46 hours	TWR W	*"AFL212 runway 01L cleared take-off, zero two zero at six"*
At 15:17:51 hours	AFL212	*"AFL212 aah..cleared for take-off runway 01L"*

1.1.12 Air traffic controller TWR W then initiated a conversation with another air traffic controller. The conversation did not pertain to the ongoing traffic picture. The colleague was behind him to the right, between the supervisor position and the ground position in the tower. The conversation caused the air traffic controller on duty TWR W to turn his back on work position TWR W and the runway.

1.1.13 When the flight crew received the take off clearance, they went through their taxiing checklists. From the time when they received the take-off clearance, they moved their focus from taxiing to the imminent take-off. The commander explained that he expected to receive take-off clearance "on taxiway next to runway", and that he therefore expected that they were on the taxiway next to the runway they had been cleared for. He replaced Jeppesen's airport map of Gardermoen with a standard instrument departure chart for runway 01L when they received the take-off clearance.

1.1.14 The commander, who controlled the aircraft, observed the sign on the right-hand side stating that they were on taxiway N and that intersection A3 was the first on the right. There was nothing indicating that taxiway M was between the taxiway N and holding position A3. First to the right was also taxiway M (See Appendix C, picture 2).

1.1.15 The commander stated in his interview with the Accident Investigation Board that he observed that there was less snow on taxiway M than on taxiway N, and that he interpreted this to mean that he was taxiing onto a "black" runway (see Appendix C, picture 3).

1.1.16 The commander concentrated on keeping the aircraft's nose wheel on the taxiway centreline, and kept his eyes fixed on the centreline in front of the aircraft. He initiated and completed a continuous smooth 180-degree turn from taxiway N to taxiway M. The commander has explained that he, from the time he turned off from taxiway N, was mentally already on "the runway" and, as the take-off clearance had been given, the take-off procedure was initiated.

1.1.17 Playback of data from the ground surveillance monitoring system in the control tower (A-SMGCS) showed that it took 16 seconds from the AFL212 started the turn from taxiway N towards intersection A3 at 15:18:14 hours until it turned past the holding position A3 towards taxiway M in the north direction at 15:18:30 hours.

1.1.18 During the 180-degree turn made by the commander from taxiway N to taxiway M in the northern direction, he did not, according to his own statement, lift his eyes much from the taxiway. As he turned towards M, he turned his head and looked through the right cockpit window to keep the nose wheel on the taxiway centre line. At this time, holding position A3 was to his left. This meant that the commander avoided seeing that out on the left, in the holding position, were lighted signs and yellow runway guard lights flashing on each side, as well as the red and white markings "RWY AHEAD" which were painted on the ground (See Appendix C, picture 3).

1.1.19 Holding position A3 was equipped with a stop bar, which was not lit. The commander stated that he considers it likely that a lit stop bar would have attracted his attention when he turned in towards A3 from taxiway N (See Appendix C, pictures 3, 6 and 7).

1.1.20 The other two pilots did not see the holding position in A3, as they did not pay much attention to what was outside the cockpit windows. The first officer went through his last checklist items, and the safety pilot was observing how the first officer handled his tasks.

1.1.21 At no time was there any doubt among the crew members as to whether they were on the runway or not. In front of them, with good visibility, they could see a long "runway" (See Appendix C, picture 4). The crew said that they could not remember having seen the end of the taxiway, which they thought was runway 01L.

1.1.22 The width of the taxiway, 23 m, compared with the runway's width of 45 m (which is the ICAO standard), did not trigger any sense of something being wrong for the commander. He stated that he had departed from many different airports all over the world, and that runway conditions were not always in accordance with ICAO standards, for example in that all runways are not of the same width. In winter, his experience was that the runway shoulder at some airports could be covered with snow, as could the white runway edge lights. On the day in question, there was daylight and good visibility, so he did not look actively for lit runway edge lights to determine his position.

1.1.23 When AFL212 had completed its 180-degree turn on to taxiway M, the aircraft continued further in a take-off roll in one uninterrupted movement. The commander has explained that he did not notice the green lights embedded in the continuous yellow centre line on taxiway M. The commander had, however, noticed that the markings on the ground were yellow, corresponding to the colour of the runway markings he remembered seeing when landing at runway 01R that same morning. The commander controlled the aircraft, and the first officer observed the speed trend. None of the flight crew noticed anything out of the ordinary about the take-off. As far as the Accident Investigation Board has ascertained, neither did any of the passengers.

1.1.24 The air traffic controller TWR W believed to remember that he had seen the Aeroflot aircraft as it taxied from taxiway N and in towards A3. However, he did not observe that the aircraft continued in a 180-degree turn, so that it ended up facing directly north on taxiway M.

1.1.25 The next time the air traffic controller looked towards the runway, he observed that AFL212 was in a take-off roll northwards on taxiway M, near intersection A4, and at a speed so high that he deemed best not to intervene. Based on the air traffic controller's experience, an Airbus A320 taking off from intersection A3 would normally be in the air before intersection A7, which is identical with the end of taxiway M.

The air traffic controller notified his colleagues in the tower about what was happening at taxiway M. Shortly after take-off, the air traffic controller contacted AFL212:

"AFL212 for your information you departed from a taxiway".

1.1.26 The commander responded, and asked the tower to repeat the message. The air traffic controller repeated the message, and informed the crew that he would write a report, asking the crew to do the same.

1.1.27 The flight crew was appalled when they understood that they had taken off from a taxiway. In conversation with the Accident Investigation Board, the crew stated that they had been very stressed during the onwards flight to Moscow, as they understood what consequences such an incident could be expected to have in the form of reactions from the airline and the Russian aviation authorities. The crew did not discuss the incident before reaching cruising altitude.

1.1.28 The supervisor on duty in the control tower heard that the air traffic controller TWR W informed about Aeroflot's take-off on taxiway M. He looked towards the western runway, and observed the aircraft just after it lifted its nose from the taxiway. He considered this to constitute a serious aircraft incident, and implemented notification as per local procedures.

1.1.29 Playback from several of the airport cameras shows that the aircraft's main wheels had lifted from the ground when it was due south of de-icing platform A-North.

1.1.30 Playback of the aircraft's FDR data shows that the aircraft lifted its main wheels from the surface (lift-off point) at 15:19:07 hours, and that the achieved speed at this time was 149 kt. By applying the FDR data in the form of "start of take-off roll" and “lift-off point” it emerges that the distance used by the aircraft before the main wheels lifted from the ground was 1 245 m. The available taxiway length was 1 652 m (see Chapter 1.10.1.7). This means that 407 m remained to the end of the taxiway.

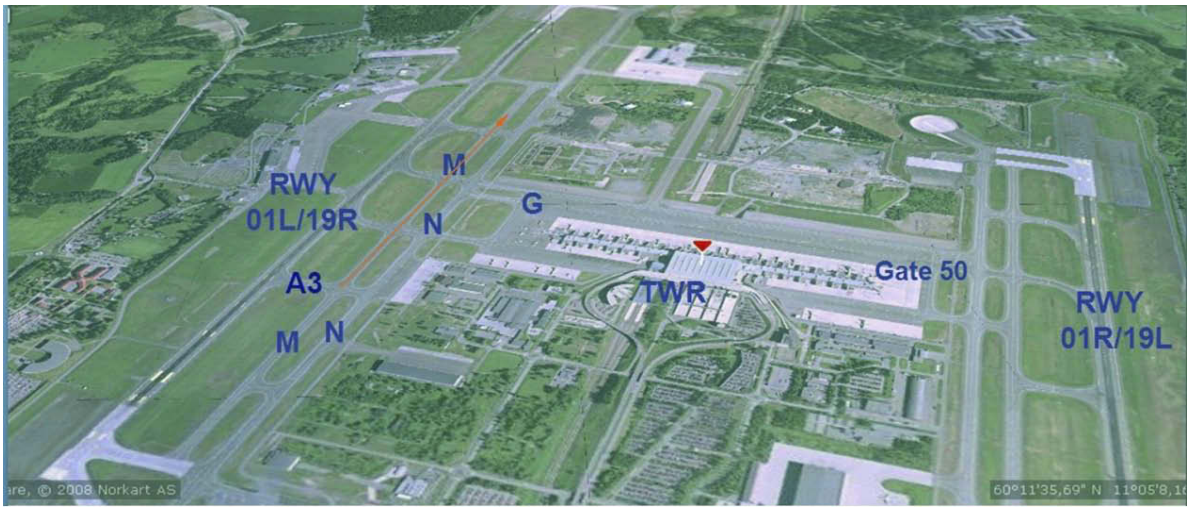


Figure 1: Oslo Airport Gardermoen, (ENGM). The orange line indicates where the aircraft took off northbound on taxiway M, instead of on runway 01L, west of taxiway M.
See also the copy of Jeppesen's airport map in Appendix B.

1.2 Injuries to persons

Table 1: Injuries to persons

Injuries	Crew	Passengers:	Others
Fatalities			
Serious			
None	7 (3 + 4)	60	

1.3 Damage to aircraft

None

1.4 Other damage

None

1.5 Personnel information

1.5.1 Commander

1.5.1.1 The commander, male 38 years old, had been in the employ of Aeroflot Russian Airlines as a pilot since 1993. He had previous flight experience from Tupolevs and Boeing 737s before he began flying Airbus A319/320/321.

1.5.1.2 The commander had a national Airline Transportation Pilot Licence (ATPL(A)) valid until 14 May 2010. He had type rating instructor (TRI) privileges. The commander was furthermore one of the company's CRM (Crew Resource Management) instructors, and he had been a commander for several years. The commander was the first officer's instructor.

1.5.1.3 The commander had flown from Gardermoen four times previously, most recently in December 2009.

Table 2: Flying hours commander

Flying hours	All types	Relevant type
Last 24 hours	8	8
Last 3 days	12	12
Last 30 days	81	81
Last 90 days	145	145
Total	8 231	4 952

1.5.2 The first officer

1.5.2.1 The first officer, male 28 years old, had completed his pilot training in Russia in 2009. He was employed by Aeroflot Russian Airlines in the same year. He was first officer under training, and sat in the right cockpit seat. The first officer had a JAR-FCL Commercial Pilot License (CPL(A)) valid until 7 August 2010.

1.5.2.2 The first officer had not been to Gardermoen before.

Table 3: Flying hours first officer

Flying hours	All types	Relevant type
Last 24 hours	8	8
Last 3 days	Not stated	Not stated
Last 30 days	Not stated	Not stated
Last 90 days	167	167
Total	167	167

1.5.3 Safety pilot (extra crew member)

1.5.3.1 The safety pilot, male 35 years old, sat in the seat in the rear of the cockpit (folding seat), and was tasked with assisting and monitoring the first officer. The presence of a safety pilot in the cockpit during first officer training is standard procedure in the company. The

safety pilot had been an employee of Aeroflot Russian Airlines since 2008, and had a national Airline Transportation Pilot Licence (ATPL(A)) valid until 25 November 2010.

1.5.3.2 The safety pilot had not been to Gardermoen before.

Table 4: Flying hours extra crew member

Flying hours	All types	Relevant type
Last 24 hours	8	8
Last 3 days	19	19
Last 30 days	78	78
Last 90 days	202	202
Total	2 459	639

1.5.4 Flight crew

1.5.4.1 The three crew members stated that they felt well and rested on the day in question. All had had 16 hours of rest before flying from Moscow on the same morning.

1.5.4.2 The crew in question had participated in CRM sessions.

1.5.4.3 When AFL212 landed at Sheremetyevo, Moscow, less than 2.5 hours after take-off from taxiway M at Gardermoen, the crew was met by the company's chief pilot and an investigator from the Russian Civil Aviation Authority. In less than 30 minutes they started routine medical tests and taking blood samples.

1.5.5 The air traffic controller on duty TWR W

1.5.5.1 The air traffic controller in work position TWR W, male 39 years old, was responsible for traffic management on the western runway. When runway 01 is in use, this means mainly departing traffic on 01L, with some landings going to the GA area, west of the western runway.

1.5.5.2 This air traffic controller had started his first shift of the day at 1430 hours, 50 minutes before the incident took place. He had not worked during the three previous days. The air traffic controller has stated that he felt rested on the day in question. He had more than ten years experience as an air traffic controller, he had worked at Gardermoen for many years, and had valid privileges for the service.

1.5.5.3 In consultation with the a representative from the collegue support and the supervisor, the air traffic controller on duty TWR W was replaced by a different air traffic controller following AFL212's departure from taxiway M. Air traffic controller TWR W wrote a report of the incident. According to his own wish and after consultation with the colleague support and the supervisor, the air traffic controller continued his shift in work position GND P from 1700 hours.

1.6 Aircraft information

1.6.1 VP-BWM

1.6.1.1 VP-BWM, an Airbus A320-214 with serial number 2233, was built in 2004 for Aeroflot. The aircraft had flown 22 420 hours in total when the incident took place. The aircraft

type is 37.6 m long and has a wingspan of 34.1 m. The maximum number of passengers is 140.

1.6.1.2 According to the commander's calculations, the relevant take-off mass was 61 700 kg, including 10 000 kg of fuel of the Jet A-1 type. The maximum permitted take-off mass was 75 500 kg.

1.6.1.3 The flight crew has confirmed that the aircraft was fully functional.

1.6.2 Aural Advisory System

1.6.2.1 The aircraft was equipped with Enhanced Ground Proximity Warning System (EGPWS), but without the add-on function Runway Awareness Advisory System (RAAS).

1.6.2.2 RAAS is an ”Aural Advisory System” which provides taxiing aircraft with information about the aircraft’ s position in the manoeuvring area, and sounds an alarm if the aircraft taxies into the wrong area. Aeroflot's nine Airbus A330s had RAAS installed. RAAS was not installed in any of Aeroflot's Airbus A320 aircraft, and the same was the case for the aircraft in question.

1.6.2.3 RAAS uses EGPWS in its airport database to monitor the aircraft's movements at the airport. The system provides information in the form of a speaker voice in the cockpit, which tells the flight crew where they are and sounds an alarm if they taxi into an area they should not be in relation to the take-off runway. An example of a speaker confirmation of a correct line-up: *”On runway 01 left, 2 696 meters remaining”*. The speaker voice can also warn the flight crew with *”On taxiway on taxiway”* if the aircraft is on a taxiway and the speed exceeds 40 kt.

1.6.2.4 The Accident Investigation Board has been informed that Aeroflot's current plans for 2010 do not include installing RAAS in the company's Airbus A320 fleet. It was also stated that the change may be implemented for the company's Airbus A320 fleet if deemed necessary. The cost per aircraft was stated to be USD 20 000, and it was estimated that it would take about one year to install the system on all aircraft.

1.7 Meteorological information

ENGM METAR at 1511 hours: 04005KT 9999 SCT022 BKN026 M10/M12 Q1002 NOSIG

According to a report from eKlima.no., no precipitation was measured on 25 February at Gardermoen. During the two previous days, 1 mm and 0.6 mm precipitation was measured, respectively.

1.8 Aids to navigation

Not applicable.

1.9 Communication

Two-way VHF radio communication between the flight crew on Aeroflot flight no. AFL212 and air traffic control took place without technical problems.

1.10 Aerodrome information

1.10.1 Airport information from AIP Norway, AD ENGM

1.10.1.1 Oslo Airport has two runways (01L/19R and 01R/19L). Runways 01R and 19R are mainly used for landing, and runways 01L and 19L for take-off.

1.10.1.2 The announced runway length for 01L is 3 600 m (TORA/ASDA/TODA), width 45 m, and the surface is asphalt on concrete.

1.10.1.3 The runway is equipped with white edge lights. The markings are in yellow paint (see AIP Norway GEN 1.7, Chapter 7, Item. 5.2.1.4).

1.10.1.4 In accordance with AIP Norway, use of reduced runway length (intersection take-off) is permitted on Gardermoen. For runway 01L, the commander could in addition to using the full length of the runway via A1, use the intermediate positions A2, A3, A4, A5 or A6. AIP Norway ENGM AD 2.13 made a note relating to this:

> *"Inform ATC as soon as possible once transferred to "Gardermoen Tower" if intersection take-off is requested/acceptable."*

1.10.1.5 Upon A3 intersection departure from runway 01L the available runway length is reduced from 3 600 m to 2 696 m. This was signposted in holding position A3 (See Appendix C, picture 3). The intermediate position from A4, A5 and A6 was 2 297 m, 1 928 m and 1 548 m, respectively.

1.10.1.6 Taxiway M is 23 m wide, inside the double yellow taxiway markings. The surface is asphalt. The taxiway shoulders are 11 m wide, e.g. the asphalt surface width is 45 m. (RWY 01L is 45 m wide, inside the runway edge lights. In addition 7,5 m outside the runway edge lights are asphalt surface, e.g. the asphalt surface width is 60 m.)

1.10.1.7 The length of the taxiway is not stated in AIP. Available taxiway length from A3 and northwards is estimated to 1 652 m[1].

1.10.1.8 The taxiways and holding positions to the runways were equipped with markings in the form of yellow paint on asphalt, as well as signs in the form of order, information, direction and position signs, in accordance with BSL E 3-2, Norwegian regulations relating to design of large airports.

1.10.2 Surface conditions

1.10.2.1 SNOWTAM report , SWEN no. 0933 for runway 01L was issued at 0851 hours. Conditions on the runway (F) were assessed at 1/3/3, and the friction figures were estimated at 5/5/5 (H), which means good friction on the runway. SNOWTAM also shows the assessment of taxiway M: "M/349", which states conditions with ice, rime and wheel ruts. The friction for taxiway M was estimated at 5, which means good friction. These took place at 1616 hours, showing numerical values corresponding to good friction.

[1] The distance between the centre lines in A3 and A7 (1 640 m) plus the distance from the centre line in A7 to the taxiway edge to the north (11.5 metres).

1.10.2.2 After the incident with AFL212, Oslo airport decided to perform new brake tests on taxiway M. These took place at 1616 hours, showing numerical values corresponding to good friction.

1.10.2.3 Taxiway M has snow removal priority 1. Snow removal in the area before the incident took place on 23 February at about 1700 hours. Oslo Airport, represented by the Airport Service, the Aerodrome Maintenance department, had logged the following on 24 February 2010, 1525 hours:

> *"completed sign cleaning Mike, November, AN, AS, driven away snow from C1 and A3."*

1.10.3 Status report from the area in question at the time of the incident

1.10.3.1 Following a request from the Supervisor Gardermoen control tower, Oslo airport, represented by the Aerodrome Maintenance department, took pictures of taxiway conditions and signs in the area N-M-A3 (see Appendix C, pictures 2 and 3). They reported the following observations at about 1600 hours:

> *"- signs to the runway were visible on both sides of A3.*
>
> *- The taxiway lights were visible in the curve in towards taxiway M, and further towards runway A3.*
>
> *- The wig-wag lights (runway guardlights) were visible at taxiway M.*
>
> *- The whole area was generally kept well free of snow […]"*

1.10.3.2 An inspection of lights at the manoeuvring area was performed the night before 25 February 2010. The report shows that no errors or deficiencies were reported in connection with the runway or taxiway lighting for the western part of the airport. On taxiway M, ten lamps were reported to be covered by ice near intersections A4 and A6.

1.10.3.3 No errors or irregularities were recorded in the airfield lightning and control system for the western part of the airport in the period between 0100 and 1630 hours on 25 February.

1.10.4 Taxiway and signs lighting

1.10.4.1 The taxiways were equipped with green centreline lights. Gardermoen does not use blue taxiway edge lights for anything other than the taxiways in connection with C1-C3, on the western side of runway 01L/19R.

1.10.4.2 The green taxiway lights are embedded in the yellow centre line on the taxiways. Taxiways N and M did not have distance between the lamps, as N was one of the standard taxiing routes in low-visibility procedures, which taxiway M was not. The taxiway N centreline had little distance between lights (7.5 – 15 m), while M had the same distance between lights as on the runways (30 m between lights on straight sections).

1.10.4.3 All centreline lights on the taxiways at Gardermoen were turned on that afternoon, and light intensity was set at 100%. It was otherwise not common practice to leave the taxiway centreline lights on during the daytime in good visibility and with little ice and snow on the taxiways. It was stated that OSL, represented by the Technical division,

Electro department, had requested the control tower to leave the lights on due to ongoing work.

1.10.4.4 The signs were lit with the same intensity, 100%, as the taxiway lights in the area in question.

1.10.5 Marking of holding position for runway

1.10.5.1 Oslo airport Gardermoen uses cat I and cat II/III holding positions . A few runway entries are equipped with both cat I and cat II/III holding positions, respectively 90 metres and 120 metres from the runway centreline. Most holding positions, like runway entry A3, have only cat II/III holding positions. All cat II/III holding positions for the runways were equipped with stop bars (8 red lamps embedded in the holding position, throwing light in the direction from the runway). A lit stop bar must never be crossed. The air traffic controller extinguishes the bar before the aircraft (or vehicle) can pass. See also the pictures in Appendix C.

1.10.5.2 All holding positions are equipped with runway guardlights (elevated yellow lights on each side of the holding position, emitting light in an alternating pattern). The runway guardlights for a runway entry are always on. At the time in question, the brightness of the runway guardlights in A3 was set at 100%.

1.10.5.3 It is not a requirement (see 1.10.9) that the stop bar should be turned on during good visibility, as was the case during the day in question. The stop bar in holding position A3 was therefore not turned on.

1.10.5.4 The A3 holding position was equipped with intersection take-off signs, as recommended by ICAO Annex 14 to indicate take off runway available (TORA), 2 696 m (see Appendix C).

1.10.5.5 All holding positions had red and white “RWY AHEAD” markings. From the pictures taken the same day, the painted field appeared to be worn. It was also partially covered by snow. (See Appendix C, picture 3).

1.10.6 The Accident Investigation Board's inspection

1.10.6.1 On 9 March 2010, 12 days after the incident, two accident investigators from the AIBN inspected the area at Oslo Airport. The AIBN investigators used a vehicle with a lift in order to observe the area from the same height as the crew in the cockpit of an Airbus A320, i.e. approx. 4 m over the ground. The accident investigators visited the areas taxiway N-M-A3, as well as the corresponding area on the east side of S-T-B6, to assess the visual aids available to the flight crew in the form of markings, signs and lighting. It was furthermore observed that the ”RWY AHEAD” markings on the ground in holding position A3 were worn, but more visible from 4 metres up than on the ground.

1.10.7 Operational information about special circumstances

1.10.7.1 Issued ATIS and NOTAM notifications described no special circumstances of importance to the incident.

1.10.7.2 The flight crew had, in the form of their Jeppesen airport maps, information corresponding to AIP AD 2 ENGM 2-10 *”Aerodrome Hot spot chart”* (see Appendix B).

The list of ”hot spots” included fire factors at the airport, designated HS1– HS4. None of them affected the planned taxiing route from gate 50, via taxiways G and N, over taxiway M and to intersection A3. However, there were comments to both intersections A1 and A2.

1.10.8 Runway marking colours

1.10.8.1 In Norway, yellow is used to mark both runways and taxiways. This deviates from the international standard, which is white on runways and yellow on taxiways. The matter is set out in AIP Norway GEN 1.7 -15, Chapter 7, Differences between Norwegian provisions/practices and the provisions/practices contained in Annex 14, Volume 1 – Aerodromes:

> *”English, 5.2.1.4 Runway markings shall be yellow.”*

1.10.8.2 AIBN has previously, in a report on an approach in poor visibility to runway 35 at Bergen Airport Flesland, pointed out that Norway uses yellow runway markings (SL RAP 2005/48):

> *“Norway is the only country in the world using yellow runway markings. AIBN has not seen any scientific evidence supporting the Norwegian policy of using yellow runway markings. CAA-N should consider evaluating the requirement for adhering to ICAO standard white runway surface markings in Norway. (SL recommendation no. 53/2005)”*.

In connection with the safety recommendation, the Civil Aviation Authority sent a letter on 28 November 2005 to most aircraft and airport operators in Norway, as well as to a number of Norwegian aviation organisations. The Norwegian Civil Aviation Authority requested opinions on whether Norway should continue to use yellow runway markings or change them to white, as the international standard requires.

In its letter of 5 April 2006, , addressed to the respondents to the above-mentioned letter with a copy to the AIBN, the Norwegian Civil Aviation Authority stated that the opinions received were to a large extent unanimous:

> *”The airport operators and the Norwegian Air Traffic Controller Association stated that most importance must be attached to the opinions of the users, i.e. the opinions of those operating the flights. The airlines unanimously recommend continued use of yellow markings on runways. The Association of Norwegian Airlines stated that the issue has been processed in the Flight-Operational Committee, where the unanimous opinion was that yellow is easier seen, and therefore also better from a safety perspective. The Armed Forces, represented by the Flight-Operative Investigatorate, stated that yellow or white made little difference, but considered there to be advantages in adhering to the international standard. Avinor and the Norwegian Air Traffic Controller Association recommend carrying out a risk assessment to form the basis for a decision. […]”*

Furthermore, the Norwegian Civil Aviation Authority wrote that:

> *[…] there is small chance of the conclusion of a risk assessment deviating from the unanimous recommendation of the flight-operational community.”*

The Norwegian Civil Aviation Authority concluded that Norway would continue to use yellow markings on runways.

1.10.8.3 The European Organisation for the Safety of Air Navigation (Eurocontrol) has established an information portal "Preventing runway incursion", which can be accessed via : http://bluskyservices.brinkster.net/rsa/. The portal contains information about what runway incursion is, as well as how to avoid it. In several sections, it is stressed that anyone driving or taxiing on the manoeuvring area must remember that the runway markings are white and the taxiway markings yellow.

1.10.9 Use of stop bars on ENGM

1.10.9.1 ICAO Annex 2 Rules of the Air: 3.2.2.7.3 *"An aircraft taxiing on the manoeuvring area shall stop and hold at all lighted stop bars and may proceed further when the lights are switched off"*.

ICAO Annex 14 Aerodromes: 5.3.19.13 Note 1. *"— A stop bar is switched on to indicate that traffic stop and switched off to indicate that traffic proceed."*

1.10.9.2 The following is a note to AIP Norge ENGM AD 2.9:

> *"Stop bars at CAT III HLDG points may be in OPR during all visibility conditions and shall under no circumstances be crossed when illuminated."*

1.10.9.3 Requirements related to use of stop bars were described in "Low-visibility instructions - Gardermoen control tower", document no. OSL-AS-BL-OI-008-E20, from which Item 1.4 is quoted here:

"In visibility conditions 2, 3 and 4, CAT. II/III holding positions with stop bars must be used. The brightness must be adapted to the light conditions."

The four visibility conditions were defined in Items 0.1 – 0.4 of the low visibility instructions, and had been translated into Norwegian from ICAO doc 9830, A-SMGCS manual. From that document, we quote only from visibility condition 1, corresponding to visibility conditions at the time of the incident:

> *"Visibility condition 1: Visibility is sufficient for the pilot to taxi and avoid collision with other traffic on taxiways and at intersections by visual reference, andfor ATC to control all traffic on the basis of visual surveillance."*

1.10.9.4 As "*visibility condition 1"* prevailed at the time of the incident, requirements for use of stop bars did not apply.

1.10.9.5 At the time of the incident, there were no lit stop bars between the main terminal and the western and eastern runway. The stop bars for holding positions C1, C2 and C3 for runways at the GA terminal were, however, were lit, as they always were, regardless of visibility conditions (see Appendix C, picture 1).

1.10.9.6 For several years, Gardermoen control tower had considered using stop bars around the clock. Several risk assessments had been carried out with a view to increased use of stop bars. The assessments concluded that using stop bars in the direction from the main terminal round the clock was not recommended, as the air traffic controllers' user interface was not good enough and because the system issued too many false alarms.

1.10.9.7 *In August 2008, the International Federation of Air Traffic Controllers' Associations International (IFATCA) published the report "Survey report Stopbars" . IFATCA, an*

organisation representing about 50 000 air traffic controllers in 133 countries, took the initiative to map how stop bars are used in various countries. There was agreement that the use of stop bars can be an important element in the work to prevent runway incursions. The report provides a description of how stop bars are used at 39 airports on five continents, and, as expected, the report uncovered that the use of stop bars differed between airports. On the basis of this report, Gardermoen control tower decided to await further decisions as to how to use already implemented stop bars.

1.10.10 Local Runway Safety Team (LRST)

To strengthen runway safety at Avinor's airports, each airport has established a Local Runway Safety Team (LRST). This group reports to and advises the airport manager about issues concerning runway safety.

The concept for LRST has been implemented in accordance with the recommendations in ICAO doc 9870 “Manual for the prevention of runway incursion” and “The European action plan for the Prevention of Runway Incursions (EAPRI)”.

LRST's responsibility and tasks include

- obtaining, analysing and disseminating information relating to runway safety.
- evaluate and provide input for signposting, marking and lighting.

update the hotspot map to reflect the risk situation for the airport's runway safety.

1.10.10.1 LRST at Oslo Airport has, since being established in 2005, been active and submitted several reports to the airport management and held several runway safety campaigns aimed at pilots and drivers. In December 2007, LRST submitted a report to the airport manager relating to signs in the manoeuvre area. The focus of the report was that signs and markings at OSL should, insofar as possible, adhere to/be in accordance with ICAO standards, and in accordance with the instructions and clearances in daily use in the traffic management at the airport. Many of the proposals in the report resulted in changes to signs and markings.

Some of the changes related to the use of intersection take-off were implemented, e.g. introduction of intersection take-off signs indicating take-off runway available (TORA) when using the most frequently used holding positions, including A3. Such signs are assumed to increase pilot vigilance as regards which take-off distance is available from the position in question.

Another proposed change was to change the sign ” N A 3 ->” to ”N M -> A 3->” (see Appendix C, picture 5). This change was not given priority in 2008, as OSL, in cooperation with LRST, assumed that most of the flights used the full runway rather than an intermediate take-off position. OSL reviewed the sign plan again in 2009, but no decision was made to change the signs in area N – M – A3.

1.10.11 Use of intersection take-off

1.10.11.1 *Oslo Airport Gardermoen*

The following is quoted from AIP AD 2 ENGM 2-11 Standard taxi routes departures:

"Departures from intersection may be available on request. Sequence is not normally altered unless desirable to expedite traffic or to accommodate CTOT."

The air traffic controller on duty TWR W told the Accident Investigation Board that he was surprised when AFL212 requested a take-off from intersection A3. Aeroflot had operated from Gardermoen for several years, with several departures every week. His experience was as hat Aeroflot seldom requested intersection take-off.

The supervisor on duty said he had experienced Aeroflot using both intersection and full runway length take-off. He also stated that intersection take-off was becoming more and more common at Gardermoen. Some Scandinavian airlines use intersection take-off in an estimated 90% of their departures, while other companies are more restrictive. For foreign companies, the use of intersection take-off varies more. Some companies often request using a shorter runway, while others mainly use the full runway length.

1.10.11.2 *Flight crew*

The commander told the Accident Investigation Board that Aeroflot did not have a specific company policy concerning the use of intersection take-off. If weight and performance calculations so permitted, the commander considered intersection take-offs advantageous, as they could save both taxiing time and aviation fuel. However, the fact that the flight was about 20 minutes delayed on the day in question was not decisive for the choice made by the aircrew. The commander stated that they would most likely have chosen an intersection take-off even if they had been on schedule. With substantially increased weight and/or poorer visibility/weather conditions, however, they would have chosen to use the full runway length.

The commander had flown from Gardermoen four times, most recently in December 2009. In December 2009, he flew together with a different pilot, who was the commander, and intersection A3 was used for departure.

1.10.12 Phraseology for taxi instructions

ICAO Doc 9432 (Manual of Radiotelephony) states in paragraph 4.4.1 that:

> *"Taxi instructions issued by a controller will always contain a clearance limit, which is the point at which the aircraft must stop until further permission to proceed is given. For departing aircraft, the clearance limit will normally be the taxi-holding point of the runway in use, but it may be any other position on the aerodrome depending on the prevailing traffic circumstances".*

This is also in line with the content of paragraph 12.3.4.7 (Taxi Procedures) of the ICAO PANS ATM (Doc 4444). As described in ICAO Annex 10 Vol II, 5.1.1.1:

> *"ICAO standardised phraseology shall be used in all situations for which it has been specified […]".*

The Norwegian regulations for radio communication, called BSL G 5-1, are mainly translated parts from ICAO Annex 10, Volume II, chapter 5. In BSL G 5-1, Attachment 1, paragraph 1.5 it is stated that the word "proceed" shall be used for vehicles at the maneuvering area, while the word "taxi" shall be used for aircrafts. During the

communication between the controller and the flight crew, the word “proceed” was used, see chapter 1.1.8.

1.10.13 Guidelines and practice for issuing take-off clearances

1.10.13.1 *Current guidelines and instructions*

ICAO doc 4444, “Procedures for air navigation services, rules of the air and air traffic services”, Chapter 7.6.2 “Designated positions of aircraft in the aerodrome traffic and taxi circuits” was directly translated in to Norwegian in RFL 1[2].
The following is quoted from RFL 1 Chapter 7, Item and Figure 5.2.1 (AIBN's emphasis):

> *”The following positions of aircraft in the traffic and taxi circuits are the positions where the aircraft normally receive control tower clearances.* ***Aircraft should be watched closely as they approach these positions (see Figure 5.2.1) so that proper clearances may be issued without delay.*** *Where practicable, all clearances should be issued without waiting for the aircraft to initiate the call.*
>
> *Position 1. Aircraft initiate call to taxi for departing flight.*
>
> *Position 2. If there is conflicting traffic, the departing aircraft will be held at this point. Engine run up will normally be performed here.*
>
> ***Position 3. Take-off clearance is issued here, if not practicable at position 2.***
>
> *Position 4. Clearance to land is issued here as practicable.*
>
> *Position 5. Clearance to taxi to parking area is issued here to landing aircraft.*
>
> *Position 6. Parking information issued here if necessary.*
>
> *Note: Fig. 5.2.1 shows a system where landing rounds include left turns, i.e. left downwind leg and left base turn.*

[2] RFL 1 The Norwegian ”Instructions for conducting air traffic control” contains general procedures for conducting air traffic control and complement the provisions in BSL F 1 (”Air traffic rules”) and ICAO Annex 11. The instructions which have been prepared by Avinor are predominantly a translation of ICAO DOC 4444 – PANS ATM, processed and adapted to Norwegian conditions.

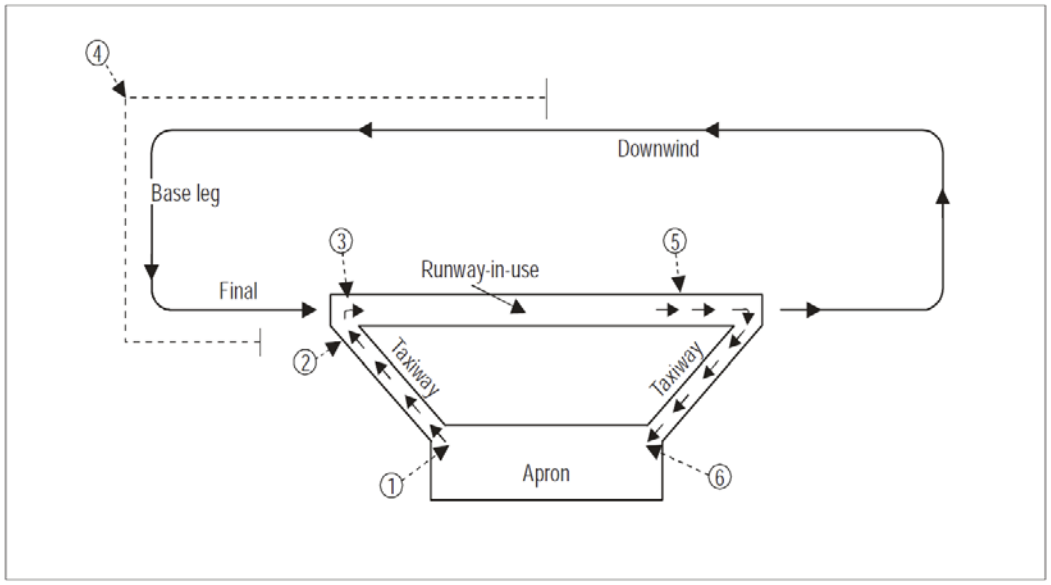


Figure 2: RFL 1 Chapter 7, Item. & Fig. 5.2.1 (from ICAO doc 4444 (PANS-ATM))

1.10.13.2 *Practice for issuing take-off clearance*

In Avinor's internal magazine ”Pri 1” no. 02/2010, it is stated that Avinor has gathered experiences from airports in Norway showing that the phraseologies ”Taxi to holding point” or ”Line up and wait” are not always included before issuing take-off clearance. In the magazine mentioned above, Avinor's Air Navigation Services department called upon air traffic controllers to indicate clearance limits in steps by using the phraseologies ”Taxi to holding point” before ”Line up and wait”, followed by ”Cleared for take-off”.

The Accident Investigation Board has been informed that the air traffic control in Russia almost always gives ”Line up and wait”, verifies that the aircraft is in the right place, and then gives ”cleared for take-off”. The flight crew on AFL212 stated that they mainly, both in Russia and abroad, were used to receive clearances divided into ”line up and wait” and then ”take-off clearance”. In their opinion, it was in any case more common to receive the take-off clearance on the taxiway nearest the runway, i.e. taxiway M in this case.

In the case in question, take-off clearance was issued for runway 01L when the aircraft was on taxiway N, directly south of intersection A4. The onward taxiing route from there was south on taxiway N, turn to the right, cross taxiway M and proceed straight ahead to holding position A3. The air traffic controller on duty TWR W has told the Accident Investigation Board that it was not uncommon for the control tower to issue take-off clearance to aircraft at that point in the taxiing route if the air traffic controller had assured himself that the take-off would not come into conflict with other traffic. The supervisor on duty confirmed this.

The taxiway nearest the runway, M (for 01L/19R) and T (for 01R/19L) was used rarely, e.g. for flights with not imminent slot times or for large aircraft that taxi slowly, and for towed aircraft.

In accordance with AIP AD 2 ENGM 2-11 ”Standard taxi routes departures”, departing traffic at Gardermoen taxi via N on the western side (01L/19R) and S on the eastern side (01R/19L). This means that the taxiway nearest the runway (i.e. M on the western side,

and T on the eastern side) must be crossed to get on to the runway if intersection take-off is used. This also appears from the airport map, see Appendix B.

1.11 Flight recorders

The aircraft was equipped with a flight data recorder (FDR) and a cockpit voice recorder (CVR). The relevant voice recordings had been deleted during the flight, as the duration of the recording is 120 minutes, less than the flight time to Moscow. The FDR data were downloaded and were useful for the Accident Investigation Board's investigation.

1.12 Wreckage and impact information

Not applicable

1.13 Medical and pathological information

Routine medical tests including blood samples of the flight crew were taken shortly after landing in Moscow. The tests gave no positive results.

1.14 Fire

Not applicable

1.15 Survival aspects

Not applicable

1.16 Tests and research

None

1.17 Organisational and management information

1.17.1 Aeroflot Russian Airlines

1.17.1.1 Aeroflot is Russia's largest airline, with Sheremetyevo airport in Moscow as its home base. According to www.aeroflot.ru, the airline had regular flights to 95 destinations in 48 countries at the time of the incident. Aeroflot had 118 aircraft in its fleet. Of these 73 were of the Airbus type, nine A330s, 16 A321s, 33 A320s and 15 A319s, respectively.

1.17.1.2 Aeroflot has a CRM (Crew Resource Management) program, with two annual mandatory sessions.

1.17.1.3 Aeroflot's SOP (Standard Operative Procedures)

- for taxiing: contained nothing specific to indicate that the commander and first officer together should verify that they were taxiing correctly in accordance with the cleared taxiing route.

- for departure (pre take-off): likewise contained nothing to indicate that the commander and first officer together should verify that the line-up was correct in accordance with the cleared runway and available take-off run/holding position and compass heading.

1.17.2 Avinor AS

Avinor AS operates 46 airports in Norway, of which 12 in cooperation with the Armed Forces. The activities also include Air Navigation Services – ANS[3]. Avinor was established as a limited company, wholly owned by the Norwegian state, on 1 January 2003. The ownership is managed by the Ministry of Transport and Communications.

Avinor is responsible for air navigation services in Norwegian airspace, including dedicated parts of the airspace above the North Atlantic. Avinor operates air traffic control services at 21 controlled airports, including Norway's main airport Oslo Airport, Gardermoen.

1.17.3 Oslo lufthavn AS

Oslo lufthavn AS is a wholly-owned subsidiary of Avinor AS, and has its own chief executive. OSL is charged with the task of operating the main airport at Gardermoen. According to www.osl.no, Oslo Airport had 18.1 million passengers in 2009.

OSL is responsible for all infrastructure, airport services and technical services (including electro services and communication, navigation and surveillance services) which were relevant for the incident on 25 February 2010.

1.18 Additional information

1.18.1 Three earlier related incidents at Oslo Airport

1.18.1.1 *Attempt at take-off from taxiway M at intersection A3 on 23 October 2005 with Boeing 737-800, TC-APH, operated by Pegasus Airlines.*

The incident took place in darkness at 2210 hours.

The southern part of runway 01L was not in use at the time, and A1 and A2 were therefore closed. When taxiing southward on taxiway N, the crew received take-off clearance for runway 01L via intersection A3. The commander taxied from taxiway N on to taxiway M, misinterpreted the markings on the taxiway and initiated take-off from taxiway M. The air traffic controller discovered the wrong manoeuvre and prevented the aircraft from taking off from the taxiway.

The Accident Investigation Board investigated the case and on 26 July 2006 issued Air traffic incident report at Oslo Airport Gardermoen on 23 October 2005 with Boeing 737-800, TC-APH (SL RAP 20/2006).AIBN issued two safety recommendations (see Chapter 1.18.2.1).

1.18.1.2 *Line-up for take-off on taxiway M at intersection A3 on 5 June 2008 with Airbus A318, operated by Air France.*

The incident took place in daylight in early morning at 0530 hours.

[3] Air Navigation Services - ANS is a general term for air traffic management - ATM, meteorology – MET and communication, navigation and surveillance - CNS.

Avinor, represented by Gardermoen control tower, received an email from an Air France commander stating that he had almost made a taxiing mistake at intersection A3. An aircraft incident was avoided as the commander (pilot flying) was warned by his first officer, who knew that you had to cross taxiway M to get to holding position A3. Quote from the email:

> "*The pilots seemed to be confused about signals and ground markings. No light to clearly identify runway 01L from taxiway M. I would like to raise this event just for safety concern to check marking or identify hot spot around this holding point."*

The incident was not formally recorded in Avinor's or OSL's reporting systems. The Norwegian Civil Aviation Authority and AIBN were accordingly not informed about the incident. The information emerged in connection with the incident on 25 February 2010.

1.18.1.3 *Unintended turn in the direction of taxiway M at intersection A3 on 26 August 2009 with Boeing 777, operated by Thai Airways.*

The incident took place in daylight at 1300 hours.

Thai Airways received a take-off clearance for runway 01L via intersection A3 as the aircraft was taxiing in towards A3 from taxiway N. The aircraft turned north on taxiway M, which was observed by the air traffic controller. The flight crew has explained that they had no intention of taking off from taxiway M, but that they made a taxiing mistake due to having directed their attention away from the taxi procedure and towards the procedure for calculating take-off weight.

The incident was recorded in accordance with local regulations, and OSL was in contact with the airline.

1.18.2 Special measures following the earlier incidents

1.18.2.1 *Follow-up of safety recommendations issued in SL RAP 20/2006*

AIBN issued two safety recommendations to Avinor and OSL respectively in SL RAP 20/2006, which relates to Pegasus Airlines' attempt to take off from taxiway M on 23 October 2005:

> *" At airports where taxiways run parallel to the runway, there is a risk that air crews become confused and try to use a taxiway for take-off. The AIBN recommends that Avinor considers implementing a procedure where take-off clearance is not issued before the air traffic controller has verified that the aircraft has passed a point where the only remaining possibility for departure is on the intended runway."* ***(SL recommendation 31/2006)***
>
> *At Oslo Airport Gardermoen, the brightness of the runway guardlights,"wig-wags", are adjusted together with the taxiway centreline lights. This results in the wig-wags being turned down in good weather conditions in darkness, and they partly lose their eye-catching characteristics. AIBN recommends that OSL installs separate brightness regulators for runway guardlights****. (SL recommendation 32/2006)****"*

SL safety recommendation 32/2006 was adopted and closed, and the following reasoning given in the Civil Aviation Authority's letter to the Ministry of Transport and Communications dated 24 June 2008:

> *"The Norwegian Civil Aviation Authority has received confirmation from area director LHT, Oslo Airport, that stop bars and wig-wag lights have been disconnected from the taxiway light control and are now controlled from separate circuits for both runway systems. The Norwegian Civil Aviation Authority deems these measures to fulfil the intention of the recommendation"*

In a letter to Avinor dated 18 October 2007, the Norwegian Civil Aviation Authority requested feedback on Avinor's plans in connection with SL recommendation 31/2006. At the time, 15 months had passed since SL RAP 20/2006 had been published. Avinor's feedback was referred to in the Civil Aviation Authority's letter to the Ministry of Transport and Communications, dated 17 February 2009:

> *"Avinor has processed the recommendation and concluded that it would currently not be practical to introduce such a procedure. In a letter to the Norwegian Civil Aviation Authority of 29 February 2008, Avinor states: "There will always be a consideration as to whether the establishment of a new procedure will actually contribute to improve safety, against whether the procedure may increase the work load for operative personnel and thus constitute a risk factor. We believe the incident on Gardermoen can be considered to be a stand-alone case, as there seems to be no trend of such "situations/ incidents". The Norwegian Civil Aviation Authority predominantly agrees with Avinor. This is a stand-alone case and the Norwegian Civil Aviation Authority is of the opinion that the recommendation should not be complied with. SL recommendation 31/2006 is hereby closed."*

1.18.2.2 *Changes to "Aerodrome hot spot chart"*

ICAO defines "hot spot" as follows:

> *"a location on an aerodrome movement area with a history or potential risk of collision or runway incursion, and where heightened attention by pilots and drivers is necessary".*

On the basis of the three mentioned incidents where Pegasus Airlines (2005), Air France (2008) and Thai Airways (2009) had made taxiing mistakes in the area N – M – A3, the Local Runway Safety Team at Oslo Airport proposed marking A3 as a new hot spot area in AIP Norge AD 2 ENGM 2-10, "Aerodrome Hot spot chart".

There were already four runway incursion hot spots identified as HS1-HS4 in this chart. OSL reported an additional hot spot no. 5 in January 2010. HS5 reads as follows:

> *"When departure from intersection A3 RWY 01L is planned, confirm lining up on the runway. Runway confusion experienced between taxiway M and RWY 01L."*

The new "Aerodrome Hot spot chart" with HS5 was published on 3 June 2010.

1.18.3 Measures after the incident on 25 February 2010

1.18.3.1 *Internal Avinor/OSL measures*

a) The chief air traffic controller at Gardermoen control tower issued a reminder to the air traffic controllers relating to provisions for issuing take-off clearance in the form of a bulletin in the tower elevator. The bulletin was based on the text and figure from RFL 1, Chapter 7, Item & Fig. 5.2.1 (see this report's Chapter 1.10.13). The following text was added:

"If take-off clearance is given to an aircraft before Point 2 in the figure, it is especially important to monitor the flight to ensure that it is carried out in accordance with the clearance given."

b) OSL initiated an internal investigation of the serious aircraft incident. The internal investigation group consisted of two representatives from OSL and an air traffic controller from a different unit than Gardermoen control tower. The report from the investigation team to the chief executive of OSL was completed on 12 March 2010.

The report recommended that OSL should review the sign plan again, with emphasis on areas where taxiing mistakes might occur, including A3/M. Furthermore, local air traffic controllers were advised to familiarise themselves better with the manoeuvring area by inspecting it personally, with special emphasis on areas where taxiing mistakes have occurred. Avinor was furthermore advised to consider safety recommendation no. SL 31/2006 from AIBN report 20/2006 again.

In cooperation with the airport's Local Runway Safety Team, OSL reviewed the sign plan again, focusing on signs relevant for taxiing south on taxiway N to holding position A3 for runway 01L. As a result of the review, a temporary position sign was erected on taxiway M which would enable pilots to identify their position should they taxi on to the taxiway. The temporary sign was replaced with a lit sign in the summer of 2010. A direction sign to M was also inserted in the row of signs referring to A3 from taxiway N (see Appendix C, picture 5).

1.18.3.2 *Measures implemented on the initiative of the Norwegian Civil Aviation Authority*

a) Notam ENGM-0042/10

On request from the Norwegian Civil Aviation Authority, Gardermoen control tower issued a Notam on 10 April 2010:

"WHEN DEPARTURE FROM INTERSECTION A3 RWY01L IS PLANNED, CONFIRM LINING UP ON THE RWY. RWY CONFUSION EXPERIENCED BTN TWY MIKE AND RWY01L"

b) The Norwegian Civil Aviation Authority reopened AIBN safety recommendation 31/2006

In a letter to the Ministry of Transport and Communications of 12 March 2010, the Norwegian Civil Aviation Authority wrote the following:

"The Norwegian Civil Aviation Authority refers to an incident on Gardermoen on 25 February 2010 where Aeroflot took off from TWY M. Following a review of the

incident and discussions with the local management at OSL and Gardermoen control tower, the Air Navigation Services department is of the opinion that AIBN Safety recommendation SL 2006/31 should be reopened.

The Civil Aviation Authority's assessment is based on the incident which occurred on 25 February 2010. In addition, the Norwegian Civil Aviation Authority has learned that notifications of concern have been submitted regarding the possibility of misunderstanding the conditions concerning TWY M and RWY 01L from a different airline, cf. incident with Air France on 5 June 2008. The Norwegian Civil Aviation Authority is concerned with avoiding such incidents, and will therefore ask Avinor to review and make a decision concerning the safety recommendation again. […] SL recommendation 31/2006 is hereby reopened."

1.18.3.3 *Internal Aeroflot measures*

On 4 March 2010, one week after AFL212 departed from taxiway M at Oslo airport Gardermoen, the Director of Aeroflot Flight Ops sent a notice to all Airbus pilots in the company. The notice requested Aeroflot crew to use this Airbus procedure to avoid taxi mistakes and runway incursions. Flight crews were asked to note the following text from "Flight Operation Briefing Notes (Airbus), Standard Operating Procedures, VII.13 Taxi to active runway":

"The taxi phase should be considered as a critical phase of flight and be carefully briefed. Using the airport chart, perform a review of the expected taxi routes with special attention to "hot spots" (i.e. intersections where the risk of confusion and the resulting risk of taxiway or runway incursion may exist).

Plan the execution of checks and actions to be performed during taxi in order to prevent distraction by cockpit duties when approaching hot spots.

Pay particular attention to temporary situations such as work in progress, other unusual activity and recent changes in airport layout.

When taxi instructions are received from ATC, PF and PNF should refer again to the airport diagram to verbally agree on the assigned runway and taxiway route, including instructions to hold short of or cross an intersection runway.

Be aware that the expectations established during the takeoff briefing can be significantly altered with a different and unexpected taxi clearance (i.e. be prepared to follow the clearance or instructions you actually received, and not the one you expected to receive).

As applicable, discuss the low-visibility taxi procedures and routes (if published) and the characteristics of the airport surface movement guidance and control system (SMGCS)."

1.18.3.4 *External Aeroflot measures*

Aeroflot Russian Airlines provided enhanced learning for other airlines by presentation of the incident at the IATA Incident Review Meeting in May 2010 (see chapter 1.18.8).

1.18.4 Examples of take-off accidents as a result of taxiing mistakes

AIBN has found no published reports relating to accidents as a result of take-off from taxiways. However, several reports have been published relating to accidents as a result of runway incursion or confusion during take-off from runways.

1.18.4.1 The accident in Taipei in October 2000 where Singapore Airlines' flight no. SQ006 with a B747-400 took off on a closed runway instead of on the parallel runway it was cleared to take off from. After a 1000 m take-off roll, the aircraft collided with a construction structure on the runway. 83 of the 179 people onboard died.

1.18.4.2 The accident in Milan, Linate in October 2001, where Scandinavian Airlines' flight no. 686, an MD-87 collided with a Cessna Citation II Business jet. The SAS aircraft was in a take-off roll on the correct departure runway. Just before the SAS aircraft reached rotation speed, it collided with the Cessna which had taxied on to the runway by mistake. 118 people died, i.e. everyone onboard as well as four people in a hangar which was hit.

1.18.4.3 The accident in Lexington, Kentucky in August 2006, where Comair's flight no. 191, a Bombardier CRJ-100 crashed during take-off from the wrong runway. The Comair aircraft had been given take-off clearance for RWY 22, but the flight crew taxied to the shorter runway RWY 26 by mistake and took off. The runway was not long enough, and the Comair aircraft crashed during take-off. Of 47 passengers and 3 flight crew onboard the two aircraft, 49 died and one person was seriously injured.

On the basis of the report on the accident, the US National Transportation Safety Board (NTSB) issued several safety recommendations to the US Federal Aviation Administration. The recommendations included the following:

"Require that all 14 Code of Federal Regulations Part 91K, 121, and 135 operators

- *establish procedures requiring all crewmembers on the flight deck to positively confirm and cross-check the airplane' s location at the assigned departure runway before crossing the hold short line for takeoff. […] (A-07-44)*

- *install on their aircraft cockpit moving map displays or an automatic system that alerts pilots when a takeoff is attempted on a taxiway or a runway other than the one intended (A-07-45)"*

According to NTSB's overview of recommendations as of February 2010, safety recommendation A-07-45 was still open, while the others had been complied with.

Recommendation A-07-45 is on NTSB's "*Most wanted list, a list of critical changes needed to reduce transportation accidents and save lives"*. In connection with A-07-45, FAA has announced that it will provide financial support to the implementation of "Electronic flight bag, which includes "Moving map display" or "Aural runway alerting system".

1.18.5 Various evaluations of the benefit of cockpit information systems

1.18.5.1 Eurocontrol (European Organisation for the Safety of Air Navigation) has assessed to what extent cockpit-installed systems such as "Airport moving map displays" and "Runway awareness and advisory systems" can contribute to reduce the number of

runway incursions. Eurocontrol concluded that few aircraft will have such systems installed anytime soon, and that the installation of such systems would reduce the number of runway incursions by 6-10% (Source: www.skybrary.aero). Eurocontrol's assessments concerned runway incursions. There are, however, many similar characteristics in causal connections for runway incursion and take-off from the wrong runway/taxiway.

1.18.5.2 Investigations conducted in the US in connection with take-off from the wrong runway at US airports concluded that cockpit information systems as referred to above, are considered to be of major significance for ensuring that aircraft take off from the correct runway.

As a result of the Comair accident, the Federal Aviation Administration (FAA) Aviation Safety Information Analysis and Sharing center (ASIAS) initiated an investigation based upon several different US databases to ascertain map which factors had contributed to aircraft taking off from the wrong runway (see Report from FAA ASIA "Wrong runway departures" issued in July 2007). The report claims that cockpit systems play an important role as safety barriers to prevent aircraft from taking off from runways other than the one they are cleared for:

"A class 2 electronic flight bag (EFB) with the own-ship position displayed on a surface electronic map for ground operation provides pilots with an invaluable tool — an immediate orientation of the airplane position on the airport surface. It has been identified as the most effective mitigation to prevent wrong runway and runway incursion events. […]

Own-ship moving map display – own-ship and/or an aural advisory system combine to form a very powerful mitigation strategy. A combination of own-ship moving map display – own-ship and an aural advisory system would produce a combined risk elimination of nearly 60 percent while offering a path for flight decks to migrate toward own-ship moving map – directed path, which has a risk reduction greater than 80-percent. This solution also would offer risk reductions for runway incursions and other safety initiatives."

1.18.5.3 The FAA ASIAS report "Wrong Runway Departures" mentions Cleveland, Ohio as the US airport with the most instances of aircraft taking off from the wrong runway. Major improvements of the airport infrastructure were undertaken to reduce risk. In addition, procedures for the air traffic control and individual airlines were amended (AIBN's emphasis)*:*

> *"ATC conducted tower controller briefings following each airplane departing on the wrong runway. From these briefings, two basic policies were implemented. First, airplanes departing runway 24L or runway 24C are issued a TIPH clearance (Taxi into position and hold). Secondly, the* ***ATC tower controller visually verifies the airplane is on the correct runway before issuing a takeoff clearance.*** *[…]"*
>
> *"[…] Likewise, the pilot community began to adjust their procedures to reduce the threat of a departure on the wrong runway. […] The air carrier also implemented a heading check for departures from runway 24L. Finally,* ***the air carrier eliminated its taxi checklist to maximise the heads-up time during the taxi for both the pilot taxiing and the pilot monitoring the taxi****. At this air carrier, after push back from the gate, the engines are started and the after-start checklist is completed. Part of the*

after-start checklist involves completely configuring the airplane for departure and is completed before the taxi begins.

The cooperative effort and use of a combination of safety enhancements to improve the overall safety proved to be successful in Cleveland and can be a useful method for other airport communities to adopt."

1.18.6 Active check of runway prior to take-off

Another airline which the Accident Investigation Board has conferred with states that they, in their procedures, have an active check when lining up on the take-off runway. The procedure contains a check that they are on the correct runway, on the correct intersection, and in the correct compass heading:

Pilot Flying (PF): *"RWY 01L, A3 INT, compasses checked"*
Pilot Not Flying (PNF[4]): *"Checked"*

1.18.7 Serious aircraft incident at Amsterdam Airport Schiphol on 10 February 2010

The Dutch Safety Board (DSB) has opened a full investigation in to a serious aircraft incident at Amsterdam Airport Schiphol on 10 February 2010. PH-BDP, a Boeing 737-306 from the Dutch airline KLM took off from a taxiway. The incident took place in the evening, in darkness. The investigation has not been concluded pr. November 2010. The following information relating to the ongoing investigation has been published on the Dutch Safety Boards 's website:

"The crew took off from taxiway B instead of runway 36C. This taxiway is located parallel to runway 36C. The remainder of the take-off was uneventful."

The following additional information can be added:

"The aircraft was standing on the de-icing platform and had been de-iced. The crew was instructed to taxi south via taxiway Alfa for runway 36C

The captain was PF, the co-pilot PNF. For both pilots Amsterdam Airport Schiphol was their home base

While taxiing south on Alfa, the taxi plan changed as it was communicated between ATC and crew to depart from intersection W8

Both taxiway Alfa and taxiway Bravo are parallel to runway 36C

To enter runway 36C via W8 from taxiway Alfa, taxiway Bravo has to be crossed in a western direction"

1.18.8 Enhanced learning by sharing experience

The IATA (International Air Transport Association) Incident Review Meetings (IRM) is held twice a year. The aim is to discuss actual accidents and serious incidents, to learn

[4] Pilot Not Flying (PNF) is also mentioned as Pilot Monitoring (PM)

from them, and to propose mitigations that can prevent reoccurrences. Recommendations are then given to IATA Safety Group (SG)[5].

The IRM meeeting was held in Montreal at IATA headquarters on 4-5 May 2010. The meeting was well attended by airlines, manufacturers and other safety organizations. 76 participants from 54 airlines and organizations attended the meeting.

”Runway incursion/confusion” was one of the subjects being covered at the meeting. During this session, two commanders from the airlines KLM and Aeroflot Russian Airlines held a presentation in common of the taxiway take-offs happened in respectively The Netherlands and Norway in February 2010. The presentations provided useful knowledge for individual airlines. Among many recommendations given to IATA SG after the IRM meeting were:

> *“IATA support for installation of systems such as RAAS […].*
>
> *”Airlines should consider the concept of positive runway identification before any takeoffs or landings […].”*

1.19 Useful or effective investigation techniques

No methods used in this investigation warrant special mention.

2. ANALYSIS

2.1 Introduction

2.1.1 The causes of this serious aircraft incident on 25 February 2010 at Oslo Airport Gardermoen cannot be related to one specific factor. There was a combination of several factors which resulted in Aeroflot flight no. AFL212 making a taxiing mistake and taking off from taxiway M. AIBN is of the opinion that contributing factors can be found with the organisations involved, i.e. the airline, the control tower and the airport.

2.1.2 Section 1.18.4 in this report mentions relevant take-off accidents from this decade which were the result of taxiing mistakes. The Accident Investigation Board believes that Aeroflot's taxiing mistake on Gardermoen could have had serious consequences, if the taxiway had not been free of other traffic (as in the Linate accident) or free of obstacles during take-off (as in the Taipei accident). Likewise, it could have had serious consequences if the available taxiway length had not been sufficient to enable the aircraft to take off (as in the Lexington accident).

The further analysis reviews the factors AIBN believes contributed to AFL212's taxiing mistake on the day, as well as factors which the AIBN believes contributed to the taxiing mistake not being discovered in time to stop AFL212's take-off from the taxiway.

The sections below will discuss relevant information and barriers:

---

[5] ”The IATA Safety Group (SG) monitors aviation safety problems being experienced and identified by airlines, and develops strategies to continuously improve safety. The IATA SG comprises airline safety managers and industry experts. The Safety Group meets twice annually.” Source http://www.iata.org/workgroups/Pages/sacwg.aspx

- which were used
- which were available, but were not fully used
- which were unavailable

In its analysis, the Accident Investigation Board has applied Eurocontrol - Systemic Occurrence Analysis Methodology, SOAM [6] to identify factors which we believe contributed to AFL212 making a taxiing mistake and carrying out a take-off from a taxiway (see the form in Appendix D).

2.2 Evaluation of the information used

2.2.1 The flight crew's decision to use intermediate take-off position

AIP and Jeppesen's airport map announced that all entries to runway 01L were available for intersection take-off. It was common procedure in the airline for the commander to request intersection take-off, if flight-operational conditions (such as take-off mass, runway conditions, temperature and winds) made it possible, and other considerations (such as shorter taxiing distance and less fuel consumption) made it practical.

The flight crew had checked in the standard manner that the aircraft's take-off mass and prevailing weather and friction conditions were well within the necessary margins for a take-off from intersection A3, where the available runway length would be 2 696 m (see Chapter 1.1.4). The Accident Investigation Board is of the opinion that the flight crew's decision to request take-off from intersection A3 was prudent.

In the first contact on the tower frequency, Aeroflot stated that they were ready for a take off from intersection A3. The Accident Investigation Board therefore believes that the time when the flight crew requested departure from intersection A3 was in accordance with applicable guidelines given in AIP Norge ENGM AD 2.13.

2.2.2 Expectation of and guidelines for when take-off clearance should be given

The guidelines for issuing take-off clearances are practiced differently around the world. This reduces predictability for pilots, which is unfortunate. Based upon the commander's experience, it is common in Russia to receive ”line up and wait” before take-off clearance is received. Outside of Russia, it was the commander's experience that the phrase ”line up and wait” is not always used, but that take-off clearance is most often received on the taxiway closest to the runway.

The guidelines for when an air traffic controller will issue the take-off clearance are set out in ICAO doc 4444, Chapter 7.6, Item 7.6.2, and in a corresponding Norwegian translation in RFL 1, Chapter 7, Item and Figure 5.2.1. ICAO's guidelines apply to all member states to the extent that the individual country has not published relevant appendices or exceptions in their national AIP. Beyond this, the air traffic control had no guidelines for issuing take-off clearance in the local regulations.

[6] SOAM - Systemic Occurrence Analysis Methodology - A “Reason” - based organisational methodology for analysing incidents and accidents, SOAM is a process for conducting a systemic analysis of data collected during an ATM safety occurrence investigation, and for summarising and reporting this information using a structured framework and standard terminology”. (source: http://www.eurocontrol.int/esp/public/news/SOAM.html)

In Figure 5.2.1 mentioned above (see Figure 2 in Chapter 1.10.13.1 of this report), a taxiway has been drawn leading in to the runway. Other parallel taxiways adjacent to each other are not indicated in the figure. The Accident Investigation Board is of the opinion that this generic figure is not unambiguous in its explanation of when a take-off clearance will be given in a more complex runway system, such as at Oslo Airport, where there are parallel taxiways.

Position 2 in Figure 5.2.1 is described as follows in the text: *"If there is conflicting traffic, the departing aircraft will be held at this point."* The Accident Investigation Board therefore considers that position 2 is the holding position for runway, or near this. The preconditions for holding an aircraft are, according to the text, *"if there is conflicting traffic"*. Accordingly, the guidelines in ICAO doc 4444/RFL I can be interpreted to mean that the principle "line-up and wait before take-off clearance" must not necessarily be complied with if there is no other conflicting traffic.

There was no other conflicting traffic in the situation in question. AFL212 was the only aircraft in the western runway system (see Appendix C, picture 1). No other landings or take-offs were scheduled, nor were there any vehicles in the western runway system. It is not uncommon at Oslo Airport for take-off clearance to be given at an earlier time, as long as the traffic situation permits. Nor had any signals been given by the air traffic control's management services indicating that the air traffic controllers should issue take-off clearances at a later point in the taxiing route. The Accident Investigation Board has therefore concluded that the time for issuing the take-off clearance for Aeroflot flight no. AFL212 was not in violation of applicable guidelines and practice at Oslo Airport Gardermoen.

The introductory text in RFL 1 (Chapter 7Item and Fig. 5.2.1) focuses on monitoring of aircraft and efficient issuing of clearances:

> *"[…] Aircraft should be watched closely as they approach these positions so that proper clearances may be issued without delay […]"*.

The Accident Investigation Board interprets this to mean that it is desirable with a continuous movement from taxiing to take-off, without stopping the aircraft, if the traffic situation so permits. The text in RFL 1 also emphasises that the air traffic controller must monitor the aircraft carefully when they approach these positions.

Chapter 1.1.8 in this report refers important parts of the communication between the tower and the flight crew. The controller used the phrase "*AFL212 proceed to Alpha 3"*. Such a clearance is not in line with standard ICAO phraseology, as described in chapter 1.10.12. The word "proceed" shall be used for vehicles at the maneuvering area, while the word "taxi" shall be used for aircrafts, e.g."*AFL212 Taxi to holding point A3"*.

Consider AFL212s answer: *"AFL212 eeh….to Alpha 3"*, it is likely to think that the received taxi instruction was not fully understood in cockpit. AIBN would like to emphasize that nonstandard phraseology should be avoided, because it can contribute to ambiguous interpretations.

In the incident in question, the phraseology *"Taxi to holding point"* was not used correctly, according to the ICAO standards. *"Line –up and wait*" was not used. *"Cleared for take-off"* was used, well in advance of the aircraft arriving at the runway.

”Line-up and wait” would to a greater extent required the air traffic controller to monitor that the aircraft had assumed the correct position before giving take-off clearance. That being said, the Accident Investigation Board wishes to point out that step-by-step clearances also have unfortunate side effects. From a flight-operational point of view, maintaining a continuous taxiing movement from gate to take-off is desirable. A complete stop during taxiing is not advantageous as regards traffic flow and fuel economy. As it is not always possible for the air traffic controller to monitor an aircraft throughout the taxiing route, the next clearance cannot always be given without delay. A three-part clearance can accordingly result in the aircraft coming to a complete stop, even if there is no conflicting traffic. See also Chapter 2.3.3.

The Accident Investigation Board believes there are two acceptable options:

- A step-by-step clearance, i.e. using ”Taxi to holding point” and ”Line-up and wait” before ”Cleared for take-off”

- take-off clearance before ”Line-up” is reached, but the flight must then be visually monitored

2.2.3 The controller's assumption that the commander was familiar with Gardermoen

Air traffic controller TWR W has explained that he was surprised at AFL212’ s request for intersection take-off, as the airline's flights to and from Gardermoen five times a week seldom requested this. As a result of the request for intersection take-off, the air traffic controller assumed that the flight crew was familiar with Gardermoen. In the Accident Investigation Board's opinion, the fact that the air traffic controller considered the request surprising and atypical for the airline warranted extra care in the monitoring of the flight.

2.2.4 Use of visual information

2.2.4.1 Signs towards holding point A3

The Accident Investigation Board is of the opinion that the signposting on taxiway N towards holding point A3 (see Chapter 1.1.14) was insufficient as a visual aid and contributed to the commander's taxiing mistake. This is discussed further in Chapter 2.4. The Accident Investigation Board furthermore believes that the commander had visual aids available along the further taxiing route which could have prevented the taxiing mistake had they been sufficiently used. This is discussed further in Chapter 2.4.

2.2.4.2 Snow conditions on taxiway M

The commander observed that there was less snow on taxiway M than on taxiway N, and, according to his own statement, interpreted this to mean that he was taxiing onto a runway.

Based on the available documentation, it cannot be confirmed whether there actually was less snow on taxiway M than on taxiway N at the time of the incident. The Accident Investigation Board believes the commander's assumption had an impact on the chain of events, as it contributed to the misunderstanding of their location. However, the Accident Investigation Board believes that a taxiway free of snow should not be interpreted as a runway.

2.2.4.3 Yellow taxiway and runway markings

The other source of information applied by the commander to confirm that they were on the runway was the taxiway markings he saw on taxiway M. The commander expected yellow runway markings and erroneously interpreted the yellow taxiway markings as a confirmation of being on the runway.

The Accident Investigation Board would like to point out that foreign aviation organisations frequenting Norwegian airports were not asked to state whether white or yellow runway markings were preferable (see Chapter 1.10.8.2).

Had the ICAO standard for runway markings been applied in Norway, the yellow markings would have indicated that they were on a taxiway and not on a runway, as the commander mistakenly believed. However, there were several other visual characteristics that the commander did not see that indicated that they were taxiing onto a taxiway, see Chapter 2.3. The Accident Investigation Board therefore believes that the commander's misunderstandings related to the yellow taxiway markings should not be given more emphasis than the other contributing factors to AFL212 taking off from taxiway M on that day.

2.3 Assessment of available information which was not fully utilised

2.3.1 The flight crew's check of taxiing route before departure

The Accident Investigation Board is of the opinion that the airport map (see Appendix B) clearly shows that the taxiing route from gate 50 to runway 01L via taxiways G and N crosses taxiway M for all other runway entries than A1. The flight crew accordingly had sufficient information about the taxiing route, and the relative locations of the taxiways.

2.3.2 Removal of airport map when the take-off clearance had been received

Replacing the airport map with the standard instrument departure chart when receiving the take-off clearance is asserted to be in line with the airline's procedures (see Chapter 1.1.12).

On the basis of conversations with the flight crew, the Accident Investigation Board considers it probable that the procedures are based on the expectation that the line-up clearance is issued before take-off clearance. If so, the flight crew would normally receive the take-off clearance on the runway. This corresponded to the commander's experience of where the aircraft usually was when the take-off clearance was received: on the runway or not further from the runway than the taxiway next to the runway. However, receiving the take-off clearance does not necessarily mean that you are on the taxiway nearest the runway.

The Accident Investigation Board assumes that the airport map was replaced due to an expectation on part of the commander that he would have no further use for it. At this time, he had followed the taxi clearance as given, via taxiways G and N, where the next and last point in the taxi clearance was holding point A3. The last point in the taxi clearance would then be to turn right on to the runway, a manoeuvre which did not necessarily necessitate the use of a map.

2.3.3 The air traffic controller's monitoring of the aircraft after giving take-off clearance

It is known that it can be harder for air traffic controllers to maintain concentration during periods with little traffic than during periods with more traffic. It is also natural that conversations between colleagues take place in a control room, and that attention is turned away from the window or screen as was the case here. That being said, the Accident Investigation Board is of the opinion that conversations between colleagues must take place in a manner which does not distract the focus from the primary duty of exercising air traffic control in a work situation.

In addition to exercising air traffic control and giving traffic information, the air traffic controller is responsible for coordinating traffic internally with other working positions, and externally with neighbouring air traffic control units. The air traffic controller is also tasked with checking flight plan data, etc. The total number of duties may entail that the air traffic controller cannot always keep his eyes fixed on events outside the window or on the monitoring screens in the working position.

The air traffic controller TWR W was not busy with other duties at the time which would have prevented him from monitoring AFL212's taxiing. He had therefore, as the Accident Investigation Board sees it, ample opportunity to monitor the aircraft's taxiing and take-off. The incident could accordingly have been avoided if the air traffic controller had monitored the aircraft, observed the taxiing mistake and stopped the departure before the take-off roll.

The Accident Investigation Board is of the opinion that the air traffic controller made a good judgment when he decided not to intervene when he saw the aircraft in a take-off roll on taxiway M. The decision not to stop the aircraft was made very quickly, and the air traffic controller has explained that the decision was based on relevant facts, such as the already high velocity, potential delays in braking resulting from language barriers, that the taxiway was free of obstacles and that aircraft taking off from intersection A3 in his experience generally become airborne before passing intersection A7.

From the tower, it is difficult to assess the aircraft's velocity, and if the velocity had been high enough, there was definitely a chance of the flight crew not managing to stop in time. The air traffic controller's assessment that language barriers could have resulted in the flight crew not immediately responding to the air traffic controller's instruction to interrupt the take-off was relevant in relation to the use of the remaining taxiway length.

The Accident Investigation Board believes that the air traffic controller made a good evaluation when he decided not to intervene. The risk of the aircraft continuing beyond the taxiway length in an interrupted departure was greater than the risk of the aircraft not managing to complete the take-off.

2.3.4 Confirmation bias

Mistakes occur when passive and active actions do not create the anticipated result. An explanation for why people make wrong decisions can be limitations in the human capacity for information processing. ”Confirmation bias” is about how people can be selective in their use of available information: Observations that support a perception are recorded, while observations which do not support the perception are not actively sought

and therefore easily overlooked. If the perception was wrong from the beginning, the phenomenon results in the retention or reinforcement of the misconception.

The Accident Investigation Board considers it probable that the ”Confirmation bias” phenomenon was a factor in the incident in question, where the commander made a taxiing mistake and took off from taxiway M.

The Accident Investigation Board also considers it probable that the following information supported the commander's perception of being on the taxiway next to the runway and to have taxied onto the runway:

- AFL212 received the take-off clearance while on taxiway N, due south of A4. The commander was used to receive take-off clearance in steps or on the taxiway nearest to the runway.
- The commander observed less snow on taxiway M than on taxiway N.
- The commander expected and saw yellow runway markings on taxiway M and perceived this to be confirmation that he saw yellow runway markings.

As described above, ”Confirmation bias” is about looking for and observing information which supports own expectations, and not actively looking for information which disproves the expectations. The available information which could have disproved the commander's perception of where the aircraft was includes Jeppesen's airport map of Oslo Airport Gardermoen, showing two parallel taxiways adjacent to the runway.

Below is a description of the available information in the form of visual characteristics along the taxiing route, which could in addition have disproved the commander's assumptions, but which was not noticed sufficiently by the crew.

2.3.4.1 Taxiway lights

The Accident Investigation Board considers it likely that the green embedded taxiway lights were visible, both on taxiway N and taxiway M. Runways do not have green centreline lights, so their presence was an indication that taxiway M was not a runway. Full-strength centreline lighting in daylight is uncommon. If the centreline lighting had been noticed, this could have contributed to disprove the commander's perception of taxiway M as runway 01L.

2.3.4.2 Holding position A3

Furthermore, the Accident Investigation Board believes that the sign postings up to holding position A3 from taxiway N were insufficient, but that the holding position A3 itself was well marked. However, this was not noticed, as no crew members looked in that direction (see Chapter 1.1.17).

Although the ”RWY AHEAD” markings on the ground were worn, the red and white paint on the ground was probably visible from the cockpit.

In addition to the green centreline lights, signs and marking of the holding position and flashing runway guardlights, there were also other characteristics indicating that they were on a taxiway and not a runway.

2.3.4.3 Runway characteristics

The commander has stated that he had experienced varying conditions around the world as regards runways and taxiways. The Accident Investigation Board believes it probable that the commander, in what the board assumes to have been a ”Confirmation bias” mode, perceived the difference between the conditions on taxiways N and M to confirm that one was a runway and the other a taxiway.

2.3.4.4 The long flat stretch he saw in front of him when he had taxied 180 degrees from taxiway N to taxiway M did not have white runway edge lights. However, the runway, west of taxiway M, had lit white runway edge lights, which were in all probability clearly visible. The taxiway was also 23 m wide, which is half the width of the runway, 45 m. As mentioned in chapter 1.10.1, full asphalt width, including the shoulders width for TWY M is 45 m. Full asphalt width for RWY 01L, including the shoulders is 60 m.

In light of the fact that the commander had previously observed that taxiway M was better cleared of snow than taxiway N, and that he had interpreted this to mean that taxiway M was a runway, the Accident Investigation Board believes that it was not logical to conclude that 10 m on each side of the runway was covered with snow. Snow and contaminated taxiways and runways can be a problem in regard to the pilots' opportunity to determine their position, but the Accident Investigation Board believes that the real conditions at the time of the incident must be considered to have been good.

2.3.5 Use of more pairs of eyes

Another source of information, which the Accident Investigation Board believes was not sufficiently used, was the crew members' opportunity to confer with each other. The commander did not ask for confirmation that he had taxied correctly, and the two other members of the flight crew did not ask if he had. Neither did the pilots have such a check set in their SOP. It is the impression of the Accident Investigation Board that the two would have corrected the commander if they had discovered any deviation from the scheduled taxiing route. It was unfortunate that the first officer and safety pilot paid little attention to looking out of the cockpit windows, as more pairs of eyes would have reduced the risk of a taxiing mistake.

Playback of data from the ground monitoring system used in the control tower shows that it took 16 seconds from AFL212 started the turn from taxiway N towards intersection A3 until it turned past the intersection A3 and headed north on taxiway M. The Accident Investigation Board considers it likely that the first officer and safety pilot, who were not busy controlling the aircraft nose wheel along the centre line, would have discovered that the holding position A3 was straight ahead if they had paid attention out of the windows during these seconds.

2.3.6 Notification of A3 as a new “Hot spot”, without signs towards A3 being improved

With the new ”hot spot”-notification for intersection A3, which Oslo Airport, with input from LRST, reported to Avinor's AIP announcement service in January 2010, there were notifications for six out of eleven entries to runway 01L/19R.

The Accident Investigation Board is of the opinion that notifications to pilots in the form of ”hot spots” for areas where there have been repeated cases of taxiing mistakes must be in addition to, and not instead of improved signposting in the relevant area.

The Accident Investigation Board is under the impression that the Eurocontrol's Local Runway Safety Team's (LRST) concept seems to be working well for Avinor's airports, and that LRST has genuine influence on issues which influence runway safety.

It is furthermore the Accident Investigation Board's opinion that the relevant LRST at Oslo Airport cooperates well with the airport management in prioritising how signposting and markings should be improved.

Changes to the signposting of intersection A3 were not given priority in 2007, because LRST and the airport assumed that the full runway was mainly used. This practice changed, in that several airlines used intersection take-off to a greater extent. There were also known cases of taxiing mistakes near intersection A3. On this basis, the Accident Investigation Board believes that the airport's review of the sign plan in 2009 should have resulted in improved signposting to avoid taxiing mistakes at A3.

2.4 Evaluation of information which was not available

2.4.1 Intersection A3 was not defined as a ”hot spot”

The flight crew had reviewed the airport maps over Oslo Airport when they were at the gate prior to departure. For intersection A3, the following ”hot spot” for intersection A3 was published in AIP Norge AD 2 ENGM 2-10, ”Aerodrome Hot spotlight chart”, 3 June 2010:

> *”When departure from intersection A3 RWY 01L is planned, confirm lining up on the runway. Runway confusion experienced between taxiway M and RWY 01L.”*

The Accident Investigation Board is of the opinion that the above-mentioned notification in the form of a ”hot spot” for intersection A3 in the airport map could have contributed to make the flight crew more conscious of the risk of taxiing mistake in the area if it had been published before the incident.

2.4.2 Stop bar in A3 was not lit

The stop bar in A3 was not lit in line with the air traffic control's routines, as it was daylight and visibility was good. The commander stated that he deemed it likely that a lit stop bar would have attracted his attention when he turned in towards A3 from taxiway N.

The stop bar, with the eight red lamps, is embedded in the ground and most visible at dusk and in the dark (see Appendix C, pictures 3, 6 and 7). The four flashing yellow runway guardlights were on. These lamps are eye-catching also in daylight as they stick well up from the ground and flash in turn, two and two on each side of the holding position.

As it was daylight and the commander did not notice the eye-catching runway guardlights, the Accident Investigation Board assumes that it is likely that he would have failed to register a lit stop bar.

2.4.3 Signposting for taxiway M

The Accident Investigation Board is of the opinion that the commander did not receive sufficient help from the airport's signs to discover that there was a taxiway M between taxiway N, which the aircraft was on, and holding point A3.

In conversation with the commander, it emerged that he had observed the direction sign in question to ”A3” on taxiway N. If the sign had contained a reference to ”M” in addition to ”A3”, the Accident Investigation Board believes that the commander would probably have reassessed his views on the onward taxiing route. Likewise, the Accident Investigation Board believes that a position sign ”M” on taxiway M would have contributed to make the flight crew discover their taxiing mistake.

After the incident on 25 February 2010, Oslo Airport decided to add a direction sign ”M” to the existing sign on taxiway N, as well as a position sign ”M” on taxiway M (see Appendix C, picture 5).

As the airport has implemented the necessary changes to the signs in the area after the incident, the Accident Investigation Board will not issue a safety recommendation relating to this.

2.4.4 The controller did not have a procedure for when to issue a take-off clearance.

There were several factors which could have prevented the departure in question from taxiway M, including the air traffic controller waiting to issue a take-off clearance for AFL212 until after the aircraft had passed a point where the only remaining possible take-off was from runway 01L/19R. The Accident Investigation Board therefore supports the Civil Aviation Authority's decision that Avinor should review and take a position on safety recommendation SL 31/2006 anew (see Chapter 1.18.3.2).

2.4.5 The flight crew had no procedure for actively checking runway prior to take-off

2.4.5.1 During the incident in question, the other flight crew members were not paying attention to the commander's taxiing and positioning prior to take-off.

In current commercial pilot training (multi-crew) and CRM training, great emphasis is placed on crew cooperation and communication. The commander involved in the incident was also a CRM instructor, which should warrant him focusing on involving the first officer, who was his student.

The Accident Investigation Board believes that one of the factors that could have prevented the serious aircraft incident would have been more flight crew members paying attention out of the windows. The board presumes that a comment or question from the first officer related to the commander's manoeuvring would have been sufficient to snap the commander out of his ”confirmation bias” mode, see Chapter 2.3.4.

The first officer was, according to his own statement, mainly busy with checklists for taxiing and initial review of the take-off procedures, and gave this as the reason for not looking out of the windows to any significant extent. It is unfortunate if the SOP includes many checklists and briefings just prior to line-up and take-off. The airlines should deliberately try and schedule as many check-points to the Before taxi check-list, so that

the Before take-off check-list is as short as possible, without leaving out important check-points. In this way, both pilots can focus on taxiing and the imminent take-off.

2.4.5.2 There were no items in Aeroflot' s SOP and correspondent check-lists which warranted that the PF and the PNF should verify together that they had taxied correctly, and that they were on the correct runway before the take-off procedure was implemented.

As earlier mentioned the Director of Aeroflot Flight Ops sent a notice to all Airbus pilots in the company about the importance of following effective briefings during taxi phase (see chapter 1.18.3.3). The AIBNs opinion is that this information was suitable for the propose. However, AIBN cannot see that corresponding check-list entries are present in the documentation received.

The Accident Investigation Board believes that a check-list as mentioned in Chapter 1.18.6, would have increased the flight crew's attention to where the aircraft was, and accordingly reduced the risk of taking off from the wrong position. The Accident Investigation Board therefore recommends that the airline changes its SOP and correspondent check-list entries, with the purpose of ensuring that the flight crew verify that they are on the correct intersection, on the runway they have been cleared for, and on the correct compass heading, before implementing the take-off procedure.

2.4.6 <u>The flight crew did not have an aural advisory system</u>

US investigations under the auspices of the FAA have concluded that cockpit systems in the form of aural advisory system and/or airport moving map display can play a vital role as an extra safety barrier to prevent departure other than the runway the aircraft is intended to take off from. (see Chapter 1.18.5.2).

A moving map display provides the flight crew in a taxiing aircraft with information about the aircraft' s position in the manoeuvring area if they confer actively with the display to confirm their position. As the flight crew assumed that they were on the runway, and since they lacked a procedure to actively check the aircraft's position, the Accident Investigation Board does not consider it certain that the flight crew would have conferred with a moving map display in this case.

However, the Accident Investigation Board assumes that the flight crew would have heard an aural advisory system in the form of a speaker voice in the cockpit which warned them "*On taxiway on taxiway*", and that they would accordingly have interrupted the take-off. The warning would have been issued when the velocity exceeded 40 kt, and it is unproblematic to interrupt a take-off at such a low velocity.

An aural advisory system would have functioned as an extra barrier which would, in all probability, have discovered and warned of the taxiing mistake, a mistake that neither the flight crew nor the air traffic controller registered. For aviation safety purposes, it would be beneficial if all aircraft were equipped with such warning systems. The Accident Investigation Board has considered making a safety recommendation to Aeroflot Russian Airlines to install an aural advisory system for its Airbus A320 fleet. However, it is not a requirement, nor common, to have an aural advisory system available in the cockpit. The Accident Investigation Board therefore believes that it would not be right to recommend that only one airline should install such a technological barrier, and refers to the fact that the corresponding recommendation in the USA remains open (see Chapter 1.18.4.3). The

Accident Investigation Board therefore chooses in this report to limit itself to issuing an operative safety recommendation which is assumed to take effect earlier in the chain of events, see Chapter 4.

3. CONCLUSIONS

In this investigation, the AIBN believes that it has uncovered that there were multiple causes for AFL212 taxing mistake and take-off from the taxiway. The factors which contributed to the events can be found with the organisations involved, i.e. the airline, the control tower and the airport.

3.1 Investigation results

a) The crew members had valid certificates and privileges for the aircraft type. They were rested, and the atmosphere in the cockpit prior to the incident was good.

b) The air traffic controller had valid authorisation papers for the service, and was rested. The control tower was normally staffed. The incident took place during a quiet time of day with little traffic.

c) Radio communication between the control tower and the flight crew was normal, however the phraseology used for one taxi instruction was not in line with the ICAO standards.

d) The use of intersection take-off at Gardermoen was common if conditions were suitable.

e) The commander expected that take-off clearance was given when the aircraft was no further away than on the taxiway nearest the runway. When the take-off clearance was given, he did not check whether the expectations were in line with realities.

f) The air traffic control's procedure did not require issuing take-off clearance only when the air traffic controller had established that the airplane had passed a point where the only remaining possibility for take-off was on the relevant runway.

g) The time at which the air traffic controller issued the take-off clearance was not in violation of current practice and guidelines. If the traffic conditions so allowed, it was common to leave out the clearance ”line up and wait” and issuing "cleared for take-off" well in advance.

h) After several earlier taxiing mistakes in the area N-M-A3, the airport had initiated a change in the airport map, in the form of a new hot spot which would warn against taxiing mistakes when using intersection A3, but the airport did not improve the signs in the area. Nor had changes to the airport map been realised at the time of the incident.

i) It did not emerge from the signs on taxiway N for intersection A3 that taxiway M was between taxiway N and holding position in A3. The missing direction signs to ”M” contributed to the commander's taxiing mistake.

j) The signs on taxiway M did not have a position sign ”M”, which could have contributed to making the flight crew understand that they were not on the runway.

k) The air traffic controller did not monitor the aircraft's taxiing mistake and start of the take-off, contributing to the take-off from the taxiway not being discovered in time.

l) The flight crew did not notice that they had made a taxiing mistake. Aeroflot Russian Airlines had no procedures documented in current SOP that required the crew to confirm their location before take-off.

m) There was no requirement for an aural advisory system in cockpit. Such a system would have functioned as an extra safety net for the flight crew in the event of other barriers failing.

n) The misjudgements uncovered in the investigation were not discovered by the procedures in force in the control tower and in the cockpit.

o) The flight crew did not discover that they had taken off from the taxiway until informed of this by the air traffic controller after take-off.

p) Under the prevailing conditions, taxiway M was by chance long enough for the aircraft to take off. The taxiway was at the time of the incident also free of other traffic and obstacles. These factors prevented a more serious outcome of the incident.

3.2 Significant investigation results

The Accident Investigation Board is of the opinion that deficient procedures and insufficient alertness in the cockpit, in combination with insufficient monitoring from the control tower and insufficient signposting in the manoeuvring area, resulted in AFL212 making a taxiing mistake and taking off from taxiway M.

4. SAFETY RECOMMENDATIONS

The investigation of this serious aircraft incident has identified areas where the Accident Investigation Board sees a need for issuing safety recommendations to improve air safety[7].

The Accident Investigation Board issues one safety recommendation in this report. An additional safety recommendation would have been made to Avinor had the Norwegian Civil Aviation Authority not already reopened AIBN's safety recommendation no. SL 31/2006, which advised Avinor:

> *”[…] considers implementing a procedure where take-off clearance is not issued before the air traffic controller has verified that the aircraft has passed a point where the only remaining possibility for departure is on the intended runway.”* ***(SL recommendation 31/2006)***

[7] The Ministry of Transport and Communications ensures that safety recommendations are put before aviation authorities and/or other relevant ministries for assessment and follow-up, cf. Section 17 of the Regulations relating to public investigation of air traffic accidents and incidents in civil aviation.

Likewise, the Accident Investigation Board would have issued a safety recommendation to Oslo Airport to improve the signs in the relevant area, had the airport not already done so in cooperation with the airport's Local Runway Safety Team (LRST). LRST at the individual airport is already tasked with reviewing signs and other markings of taxiways, to verify that the design is of such a nature that it prevents incorrect taxiing to the runway. AIBN will therefore not make safety recommendation relating to this.

Safety recommendation SL no. 2010/12T

There is a risk of flight crews using taxiways instead of runways for take-off. The risk is highest at airports with taxiways running parallel to runways. Aeroflot Russian Airlines had no procedures documented in current SOP to confirm their location before takeoff.

The AIBN recommends that Aeroflot Russian Airlines changes its SOP (Standard Operation Procedures) with corresponding check-list, so that the commander and first officer together verify that they are on the correct intersection, on the runway they have been cleared for, and on the correct compass heading, before implementing the take-off procedure.

The Accident Investigation Board of Norway

Lillestrøm, 9. December 2010

REFERENCES

No special references

APPENDICES

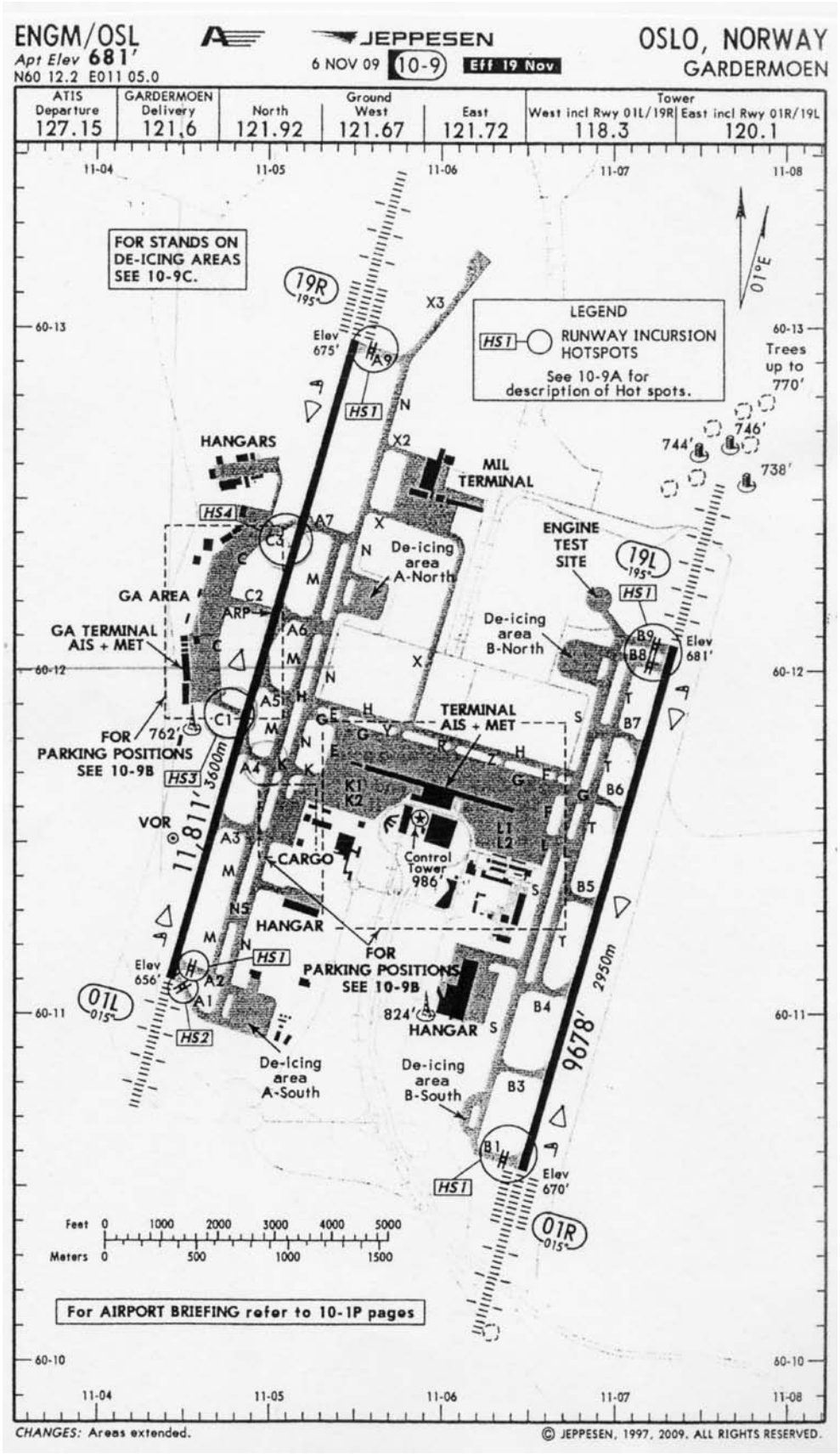
Appendix A:	Relevant abbreviations
Appendix B:	Jeppesen, airport map of Oslo Airport Gardermoen (ENGM)
Appendix C:	Pictures
Appendix D:	SOAM chart

APPENDIX A Relevant abbreviations

AIBN	Accident Investigation Board Norway
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
A-SMGCS	Advanced Surface Movement Guidance and Control System
ASDA	Accelerate-Stop Distance Available
ASIAS	Aviation Safety Information Analysis and Sharing center (FAA org.)
ATIS	Automatic Terminal Information Service
ATPL(A)	Airline Transport Pilot License (Aircraft)
BSL	Provisions for civil aviation
CPL(A)	Commercial Pilot License (Aircraft)
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
CTOT	Calculated Takeoff Time
DSB	Dutch Safety Board
EFB	Electronic Flight Bag
EGPWS	Enhanced Ground Proximity Warning System
Eurocontrol	European Organisation for the Safety of Air Navigation
FAA	Federal Aviation Administration
FDR	Flight Data Recorder
GA	General Aviation
GND	Ground
GND-P	Ground Planner
IATA	International Air Transport Association

ICAO	International Civil Aviation Organisation
LRST	Local Runway Safety Team
METAR	Routine weather observation for air traffic
NOTAM	Notice to airmen
NTSB	National Transportation Safety Board
PF	Pilot Flying
PNF	Pilot not Flying
RAAS	Runway Awareness and Advisory System
RFL	Rules for air traffic control
RWY	Runway
SDD	Situation Data Display (radar image)
AIBN	Accident Investigation Board Norway
SOAM	Systemic Occurrence Analysis Methodology (Eurocontrol)
SOP	Standard Operation Procedures
TGA	Take-Off/Go-Around
TODA	Takeoff Distance Available
TORA	Takeoff Runway Available
TWR	Tower
TWY	Taxiway
UTC	Coordinated Universal Time

APPENDIX B



Copy of the flight crew's Jeppesen map of Oslo Airport Gardermoen

APPENDIX C **Pictures**

Picture 1

The figure shows a section of the ground monitoring system at Gardermoen (A-SMGCS). The intersection A3 – M – N is marked with a blue dotted ring. The aircraft (gray shadow) with blue label ”AFL212” can be seen south of de-icing platform A-North. The aircraft's main wheels had at that time left the ground. The picture shows that there were no other aircraft or vehicles nearby. The picture also shows that all taxiway lighting had been turned on, and that the stop bars were only lit in holding positions C1, C2 and C3.

Picture 2

The picture was taken at ground level about one hour after the incident. The black field on the picture is taxiway M, and the piece of asphalt between taxiway N and M. (Taxiway N is not shown, only snow-covered field on the taxiway shoulder). The sign in front is on the right side of taxiway N, and shows that A3 is the first exit to the right. The sign gives no information about taxiway M being between N and A3. Photo: OSL

Picture 3

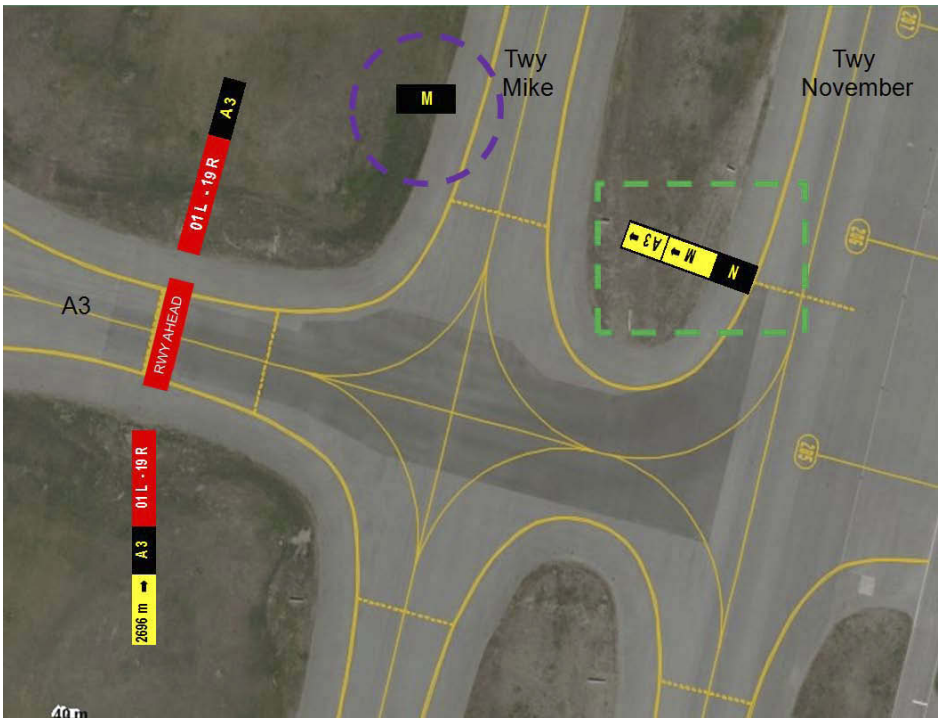
The picture has been taken at ground level about 1 hour after the incident, and shows the area towards to holding point in A3. “RWY AHEAD” can only be glimpsed in the holding position. The picture shows the left intersection take-off sign in A3,which indicates the take-off runway available (TORA) of 2 696 m. The green taxiway lights can be glimpsed, as can the flashing runway guardlights. The stop bar is not lit. Photo: OSL

Picture 4

The picture was taken during the Accident Investigation Board's inspection at Gardermoen on 9 March 2010, and shows taxiway M looking northwards from A3. The picture was taken from a height of 4 m above the ground (Airbus A320 cockpit height above ground). There was a thin layer of snow on the taxiway on 25 February, but the commander saw the yellow taxiway markings. Photo: AIBN.

Picture 5

The picture shows the two sign changes in intersection A3-M-N which Oslo airport carried out as a result of AFL212's take-off from taxiway M. There is a new position sign 25 metres north of the holding position (mauve circle mark), as well as changed signs on taxiway N (green square mark). Others signs in the intersection for other taxiway directions are not shown.



Picture 6

The picture was not taken in connection with the incident, but illustrates how the stop bars, ”RWY AHEAD” marking and runway guardlights look from a cockpit.

Photo: LRST ENGM

Picture 7

The picture was not taken in connection with the incident, but illustrates how stop bars and runway guardlights look when it is darker than it was at the time of the incident.

Photo: LRST ENGM

Appendix D Eurocontrol Systemic Occurrence analysis methodology (SOAM). "SOAM is a process for conducting a systemic analysis of data collected during an ATM safety occurrence investigation, and for summarising and reporting this information using a structured framework and standard terminology". The form shows the AIBN's SOAM analysis.