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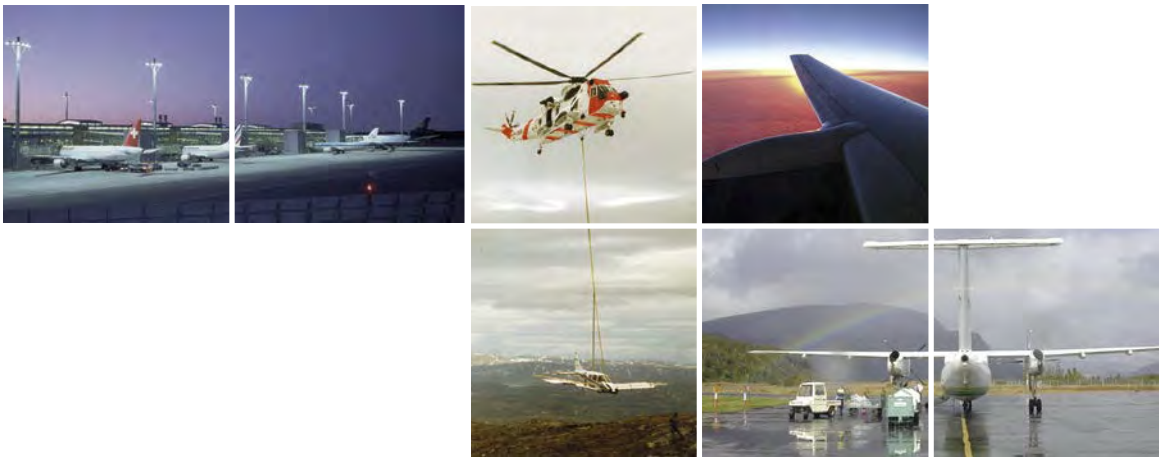

REPORT ON SERIOUS INCIDENT AT OSLO AIRPORT GARDERMOEN ON 31 OCTOBER 2012, AIRCRAFT PROXIMITY (AIRPROX) BETWEEN LN-DYC (NAX741) AND LN-NOM (NAX740), BOTH OPERATED BY NORWEGIAN AIR SHUTTLE ASA

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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.

Photos: AIBN and Trond Isaksen/OSL

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AIR ACCIDENT REPORT

Type of aircraft:	1. Boeing 737-800 2. Boeing 737-800
Nationality and registration:	1. Norwegian, LN-NOM (NAX740) 2. Norwegian, LN-DYC (NAX741)
Persons on board:	1. Two pilots, cabin crew of four and 90 passengers. 2. Two pilots, cabin crew of four and 130 passengers..
Operator:	Both Norwegian Air Shuttle ASA
Accident site:	Oslo Airport Gardermoen
Accident time:	Wednesday 31 October 2012, at time 0735

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

NOTIFICATION

The Accident Investigation Board Norway (AIBN) recieved notificaion of the incident on 1 November 2012, the day after the incident occurred.

SUMMARY

On 31 October 2012, an aircraft proximity (AIRPROX) situation occurred between two aircraft from Norwegian Air Shuttle during a simultaneous missed approach (NAX741) and departure (NAX740) at Oslo Airport. There was a strong tailwind on final. The AIBN believes that the flight crew on NAX741 had unrealistic expectations regarding the possibility of being stabilized no later than at 1000 ft Above Field Elevation (AFE). The decision to initiate a missed approach procedure was taken at a late stage. The expectations of the final controller and tower controller, that the speed for the landing aircraft would be reduced sufficiently during the approach, were not met. The missed approach of NAX741 came into conflict with the simultaneous departure of NAX740.

Visibility conditions were such that the tower controller could not maintain visual separation between the two aircraft. Both were climbing, one after the other. The tower air traffic controller instructed NAX741 to divert west. A confusion of call signs occurred and led to NAX740 executing the clearance given to NAX741. The minimum horizontal distance between the aircraft was approximately 0.2 NM (370 m) whereas the vertical separation was 500 ft (152 m). It is the AIBN's view that the situation contained a real danger of collision, but once it was a fact, the situation awareness and sound assessments of the flight crews and tower controller prevented a further escalation of the conflict.

The AIBN considers established and practiced procedures to be conductive to recognizing situations and averting them before they become critical. Data from the Cockpit Voice Recorder (CVR) was not secured. CVR data is important to understand the sequence of events, and the AIBN therefore sees it as unfortunate when CVR data is not secured. The AIBN does not promote any new safety recommendation in this report, but refers to a previously issued safety recommendation (SL No 2012/06T), which has not been closed out.

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 Background information

1.1.1.1 The incident occurred on one of the first winter days of the season, and Oslo Airport Gardermoen and Air Traffic Control were making preparations to handle snowfall and snow clearance starting from the early morning. Weather conditions were such that all aircraft needed to be deiced. Deicing platform 01L has the largest capacity, and over-all conditions favored runway 01L as takeoff runway.

1.1.1.2 The Control Tower primarily wished to implement segregated runway use with 01L for takeoff and 01R for landing. Because it was snowing it became necessary to close the western (01L/19R) and eastern (01R/19L) runways alternately during snow clearance. They remained closed for app. 15 minutes each time. The western runway had reopened at app. time 0710 after snow clearance. The snow clearance train had been relocated to the eastern runway, and the airport services duty supervisor informed that they were ready.

1.1.1.3 Supervisor Gardermoen Control Tower contacted Oslo Air Traffic Control Center using Approach Planner and set the time for 15 minutes' closing of the eastern runway. They set up three landings on 01L during the time 01R was closed and agreed that the distance between successive landings should be 8 NM. The Supervisor informed the departure runway tower controller about this. However, this tower controller was scheduled to have a break at time 0730, and a colleague had consequently taken over his position.

1.1.1.4 The colleague had, since the start of his watch one hour earlier, been working in the Clearance Delivery position. In handing over his position the departing tower controller briefed the arriving tower controller on traffic controlled by him. He was told that there was a strong tailwind on final and that three landings had been agreed with 8 NM distance on the takeoff runway during the time when the eastern runway would be closed.

1.1.2 Approaching aircraft with call sign NAX741

1.1.2.1 A Boeing 737-800 from Norwegian Air Shuttle (Norwegian) with call sign NAX741 departed from Trondheim Airport Værnes (ENVA) bound for Oslo Airport Gardermoen (ENGM). Estimated time of arrival (ETA) was at time 0735.

1.1.2.2 Before descent from cruising altitude the air crew accessed Automatic Terminal Information Service (ATIS) "arrival" for Gardermoen. The broadcast included information that runway 01R was in use and that there was a tailwind on final down to an altitude of 2 000 feet. Surface wind was from 020º at four knots.

1.1.2.3 After descent was initiated, NAX741 was cleared to follow BELGU 1L; see Appendix B. Shortly after passing BELGU, the crew was given a direct route to ABUBA, which was the last point on BELGU 1L. The direct route was shorter, and consequently the need arose to increase the rate of descent.

1.1.2.4 At time 0716, when the aircraft passed FL 220, the crew was notified by Oslo Approach that the landing runway was switched to 01L because 01R was going to be closed for snow clearance. The route that was plotted in the Flight Management Computer (FMC)

was for runway 01R. With a switch to runway 01L the distance to landing was further reduced, and NAX741 was higher up than required by an optimum descent profile. The Commander and the First Officer (F/O) concluded that they could manage well even with the tailwind on final, so long as they were not vectored too tightly onto ILS runway 01L.

1.1.2.5 At time 0728 the Sector TMA Director asked the NAX741 air crew to reduce their speed to 220 kt, and the flight was passed on to the final controller on frequency 128,900 MHz. NAX741 was told to continue on the same heading and descend to 6 000 ft. One minute later, when the aircraft was 8 NM north of ABUBA (see Appendix B), vectoring towards the final approach was initiated. The final controller noticed that NAX741 came in somewhat high. In the course of the next couple of minutes NAX741 received the following clearances, which the crew confirmed:

Norshuttle 741 turn left heading 120 descend to 5 000 feet
Norshuttle 741 descend to 4 000 feet left heading 100
Norshuttle 741 left heading 040 cleared ILS zero one left

1.1.2.6 NAX741 was established on localizer to runway 01L at a distance of 9.5 NM from runway threshold. The altitude was 4 900 feet and ground speed 260 kt. Indicated airspeed (IAS) in the cockpit was 220 kt. According to the FDR data the wind on altitude at this time was from 208 degrees at 30 knots.

1.1.2.7 The NAX741 Commander has explained that they had not applied airbrakes during their descent or during the final approach stage because he considered the effect to be small and it would have led to vibrations in the aircraft, which would have increased further when they set flaps.

1.1.2.8 Flaps 1 were set just before they were established on localizer. The aircraft was then above the glide path. Landing gear was selected down when the aircraft was 7 NM out at 4 000 ft. The ground speed and wind direction/speed were approximately unchanged. Indicated airspeed was reduced to 215 kt. The Commander has explained that it was difficult to get down to the glide path and at the same time reduce the speed because of the strong tailwind. The crew nevertheless chose to continue the approach, hoping that the tailwind would decrease.

1.1.2.9 NAX741 was transferred from Sector TMA Final to Gardermoen control tower, on tower frequency 118,300 MHz, when the aircraft was app. 6 NM from the runway threshold with a ground speed of 250 kt. Indicated Airspeed (IAS) in the cockpit was 212 kt [1]. When the final controller transferred NAX741 to Gardermoen control tower, the crew was instructed to reduce the speed to 180 kt or less. The speed reduction was given in consideration of the distance to the preceding landing on the eastern runway 01R (NAX271); see situation image in Appendix C.

1.1.2.10 NAX741 tried to call up Gardermoen Control Tower 22 seconds later, but selected the wrong frequency and came through to Oslo Approach on frequency 118,475 MHz. They were made aware of this, and NAX741 first checked in on the tower frequency at time 07:33:43.

[1] According to AIP ENGM AD 2.22 subsection 2c, the recommended indicated airspeed is 160 kts at 4 NM, unless Air Traffic Control has instructed differently.

1.1.2.11 Playback of radar data shows that NAX741 was app. 3.7 NM from the runway threshold at an altitude of 2 100 ft and with a ground speed of 250 kt when they spoke with the tower controller for the first time.

1.1.2.12 Immediately after the tower controller answered NAX741, he gave takeoff clearance (departure clearance) to NAX740, which was ready in takeoff position on the runway. The crew of NAX741 did not catch that the other aircraft was cleared for takeoff.

1.1.2.13 The crew of NAX741 had set flaps 5 at 6 NM and flaps 15 were selected just before they established visual contact with the runway. Then the distance to the threshold was app. 1 NM and the altitude 1 300 ft (700 ft above runway elevation and 400 ft above the glide path altitude). Indicated airspeed in the cockpit was 191 kt.

1.1.2.14 NAX741 came out from the clouds and the crew established visual contact with the runway app. 700 ft underneath them. They then became convinced that the approach flight was not stabilized and that it therefore must be aborted. The Commander instructed the F/O that they must abort and at time 07:34:30 called out on the tower frequency:

Norshuttle 741, going around

1.1.2.15 The tower controller confirmed, saying:

Norshuttle 741, roger, going around, that's copied, and departing traffic below essential traffic

1.1.2.16 The NAX741 crew increased the engine power and the aircraft started to climb. The track they used was in accordance with standard procedure for missed approach, as published in AIP AD2 ENGM, i.e. straight forwards along the extended runway centerline.

1.1.2.17 App. 15 seconds later NAX741 passed above runway threshold 01L with a ground speed of 190 kt. The other aircraft, NAX740, had just taken off and was at an altitude of 700 ft north of runway exit A5 with a ground speed of 154 kt. Distance measurements using the traffic surveillance system showed that the horizontal distance between the two aircraft was then 1727 m.

1.1.2.18 At the same time the tower controller called them up again, saying:

Norshuttle 741, when able, left turn heading 270

1.1.2.19 NAX741 responded to the call-up, saying:

[..illegible..] heading 270 Norshuttle 741

1.1.2.20 The crew of NAX741 did not, however, hear that NAX740 also responded to the call (see subsection 1.1.3.10).

1.1.2.21 Right before NAX741 again flew into the cloud cover, the Commander caught a glimpse of a couple of flashes in front of the aircraft, which he perceived as strobe light, without being able to see or understand what the source was. They continued their flight straight forwards to execute the missed approach as planned. App. 15 seconds after NAX741 had responded affirmatively to the tower controller's instructions to turn to heading 270 degrees when they were ready, NAX741 started turning towards the required heading; see Appendix D.

1.1.2.22 Both aircraft used GPS synchronized clocks. Correlation of the FDR data from the two aircraft revealed that the minimum horizontal distance between them occurred at time 07:35:28, when NAX740 had passed 1 300 ft and NAX741 1 800 ft. The minimum radar vertical separation was app. 500 ft with a minimum horizontal distance of app. 0.2 NM[2]. See animation images in Appendix D.

1.1.2.23 When the NAX741 crew started the left turn, they received a TA warning from TCAS [3] and they observed that the symbol on the screen (the yellow dot) was practically on top of their own position. The conflicting traffic alert was given without altitude indication, and the Commander has explained that it was only then that he understood that there was an aircraft taking off just ahead of them. The stress impact reached extra high levels since they were in instrument meteorological conditions (IMC) and could not see the other aircraft. The Commander has explained that he perceived the traffic he saw on the TCAS display as being very close and at an altitude lower than his own aircraft. He says he thought that "he's going to hit us straight in the belly".

1.1.2.24 He noticed that the other flight also turned west and therefore added more engine power and changed his turn from left to right. About at the same time that the NAX741 Commander had started his last change of heading, northbound, he was instructed by the tower to turn right, heading 360 degrees, i.e. the same action he had himself just executed.

1.1.2.25 Satisfactory separation between the two aircraft was attained shortly after, and NAX741 was transferred from the tower controller to Oslo Approach for new vectoring for approach and landing on runway.

1.1.3 Departing flight with call sign NAX740

1.1.3.1 Departing flight NAX740 was a Boeing 737-800 from Norwegian bound for Trondheim Airport Værnes (ENVA).

1.1.3.2 When NAX741 was establishing its approach to runway 01L, the runway had just been reopened after snow clearance, and the tower controller had just taken over the working position (see subsection 1.1.1.3). He saw that there were many aircraft on the deicing platform and in holding, ready for takeoff on runway 01L (see overview image from traffic surveillance system in Appendix C). He gave the first aircraft, NAX522, clearance for takeoff. At the same time he could see on his radar screen that NAX741 was on its way in to establish on localizer, app. 10 NM out. The tower controller has explained that he reckoned 8 NM distance between successive landings to be sufficient time to take a takeoff before the landing.

1.1.3.3 The tower controller has further explained that he noticed that NAX741 was maintaining a ground speed of about 230-250 kt. His experience said that the speed would be reduced on the way in and that he therefore could take in the next aircraft for takeoff. The tower controller gave NAX740 clearance for line-up at time 07:32:51.

1.1.3.4 To make certain that the departure would be clear of the runway before the arrival of the approach, the tower controller followed up with the following announcement:

[2] The slant range was 352 m (0.19 NM), the vertical separation was 152 m (500 ft), i.e. the distance between the aircraft projected down onto the line was consequently 317 m (0.17 NM). This is rounded up to 0.2 NM.
[3] Traffic Alert and Collision Avoidance system (TCAS), Traffic Alert (TA)

And Norshuttle 740 if you need a run-up, start your run-up immediately and then stand by for immediate departure

1.1.3.5 Through the approach window in the ground radar image the tower controller further noticed that NAX741 was still maintaining good speed on its way in towards runway 01L. He waited for the approach to check in on the frequency, which NAX741 did, but only at the time when NAX740 started run-up in holding position.

1.1.3.6 NAX740 received takeoff clearance at time 07:33:50. Playback of the FDR shows that NAX740 started its run five seconds later. The aircraft spent 34 seconds on the runway and was airborne at time 07:34:29.

1.1.3.7 The aircraft that was about to land did not reduce its speed considerably, as the tower controller had expected. When the departure started moving, NAX741 was barely 2 NM from the runway threshold with a ground speed of app. 220 kt. The tower controller has explained that he was thinking that a violation of minimum runway separation might occur in this situation. At app. 1 NM final he saw the strobe lights of NAX741 at app. 1 000 ft above the ground, practically at the cloud base. At the same time he heard NAX741 report that they were aborting their approach.

1.1.3.8 Right after this, NAX740 took off from the runway, and the crew heard NAX741 reporting their go-around. They also heard that NAX741 received traffic information about them (see subsection 1.1.2.15).

1.1.3.9 NAX740 continued their flight straight ahead. 14 seconds later they were 700 ft above the ground, when they heard the next radio call-up from the tower controller:

Norshuttle741, when able left turn heading 270

1.1.3.10 NAX740 misread this, believing that this call was for them. They did not hear that NAX741 also answered, at the same time that they responded:

Roger, left turn heading 270 Norshuttle740

1.1.3.11 The tower controller heard the response from NAX740, and understood that the call signs had been confused in such a way that the NAX740 crew had perceived the instruction for NAX741 as theirs. NAX740 didn’t get any read-back to the fact that they had responded mistakenly to the instruction that was meant for NAX741.

1.1.3.12 The tower controller called up Oslo Approach on the hotline (direct phone line). They confirmed that they saw what was happening on the radar and traffic surveillance screens.

1.1.3.13 NAX740 immediately initiated a left turn to 270 degrees (at time 07:34:55). Right after this the crew received a TCAS TA warning of conflicting traffic with altitude indication 400 feet above own aircraft. The NAX740 crew reduced their rate of climb to improve the vertical separation relative to the other aircraft, which they understood was above them.

1.1.3.14 The cloud base was at app. 1 000 ft, and the tower controller no longer had visual contact with the two aircraft. On the radar image he could see that the departure, NAX740, had initiated a left turn. He called up NAX740 (at time 07:35:06) and gave traffic information:

NAX740 essential traffic above on missed approach turning left shortly

1.1.3.15 The NAX740 crew answered:

Yes we are decreasing (.. illegible ..) NAX740 we are turning now

1.1.3.16 NAX740 was established on heading 270 degrees at time 07:35:40 and maintained this heading westbound for 1 minute and 10 seconds, until the aircraft was vectored northbound for destination Værnes.

1.1.3.17 The conflict between the two flights had been resolved, and the tower controller had transferred both flights to the next frequency, Oslo Approach, by time 0737. The tower controller was then relieved in his work position by a colleague and offered colleague support.

1.2 Injuries to persons

None.

1.3 Damage to aircraft

None.

1.4 Other damage

None.

1.5 Personnel information

1.5.1 The aircraft crews

1.5.1.1 *Commander NAX740*

The Commander held an ATPL (A) Airline Transport Pilot License with type rating for Boeing 737, and had been working in the company since 2006. The Commander declared that he had felt rested. He knew the airport well.

Table 1: Flying experience Commander NAX740

Flying Experience	All types	On type
Last 24 hours	-	8
Last 3 days	-	8
Last 30 days	-	65
Last 90 days	-	172
Total	10 147	5 038

1.5.1.2 *First Officer NAX740*

The First Officer held an ATPL (A) Airline Transport Pilot License with type rating for Boeing 737, and had been working in the company since 2011.

Table 2: Flying experience First Officer NAX740

Flying Experience	All types	On type
Last 24 hours	-	2
Last 3 days	-	4
Last 30 days	-	45

Last 90 days	-	178
Total	9 950	6 350

1.5.1.3 *Commander NAX741*

The Commander held an ATPL (A) Airline Transport Pilot License with type rating for Boeing 737, and had been working in the company since 2004. The Commander declared that he had felt rested. He knew the airport well.

Table 1: Flying experience Commander NAX741

Flying Experience	All types	On type
Last 24 hours	-	4
Last 3 days	-	13
Last 30 days	-	33
Last 90 days	-	87
Total	9 500	4 401

1.5.1.4 *First Officer NAX741*

The First Officer held a CPL (A) Commercial Pilot License with type rating for Boeing 737, and had been working in the company since 2011.

Table 2: Flying experience First Officer NAX741

Flying Experience	All types	On type
Last 24 hours	-	1
Last 3 days	-	1
Last 30 days	-	82
Last 90 days	-	196
Total	1 641	1 391

1.5.2 Air traffic control staff on duty

1.5.2.1 Gardermoen control tower had air traffic controllers on duty in the following work positions: Supervisor (SUP), Tower position West and East (TWR-W and TWR-E), Ground (GND), Clearance Delivery (CLR) and Ground Departure Sequencer West (DEP SEQ W). On duty in the tower was also a separate Ground Extra (GND X) air traffic controller for handling UHF ground communications, especially with airport services, which were taking care of winter maintenance.

1.5.2.2 Oslo Air Traffic Control Center (Oslo ATCC) at Røyken had air traffic controllers on duty in the following approach positions: TMA Final, TMA Director and TMA-West (TMA-West and East positions combined). The next position, ordinarily that of TMA-East, was occupied by the air traffic controller who was acting as instructor to the air traffic controller occupying the TMA Final position. The work position to the right of TMA Final was not in use when the incident occurred, but was occupied at the start of the watch.

1.5.2.3 The operative leadership at Oslo Air Traffic Control Center has informed that they have no instructions defining where instructors should be seated when they are working in position with candidates. Instructors are advised to sit up close to their candidates when they are just starting up, but they should pull away to the neighboring position when the

candidate has gathered some experience. In this way instructors can use their own measuring tools, maps, etc. to see the situations independently instead of through the candidate's use of tools and maps. If the neighboring position cannot be used, it is an alternative to use a work position two to three seats away. The possibility to override communications is available in all positions, allowing the instructor to go out on the relevant frequency and interrupt if necessary.

1.5.3 Air traffic control

1.5.3.1 *Tower controller (TWR-W)*

The tower controller was certified and authorized with the rating required to perform air traffic control services at Oslo Airport Gardermoen. The air traffic controller was certified for the first time in 1990 and had been working at Gardermoen for many years.

The number of service hours was within the limitations of the regulations in force. The air traffic controller had had two days off and since then worked a daytime watch in the tower the day before. On the day of the occurrence the controller had come to work at time 06 and worked in the Clearance delivery (CLR) position from time 0630 to 0730, and has declared to have felt rested. The controller took over the western tower position (TWR-W) at time 0730, four minutes before the incident occurred.

1.5.3.2 *Supervisor Gardermoen Tower (SUP)*

The supervisor was certified and authorized with the rating required to perform air traffic control services at Oslo Airport Gardermoen. The supervisor was certified as an air traffic controller for the first time in 1993, and authorized as a supervisor at Gardermoen in 2005.

The number of service hours was within the limitations of the regulations in force. The supervisor (SUP) was on watch from time 0630, and has declared to have felt rested.

1.5.3.3 *Final Sequencer air traffic controller - Oslo Approach*

The Final controller was certified and authorized with the required rating to perform this form of air traffic control services at Oslo Air Traffic Control Center. The controller was certified for the first time in 2003, and had been working as an Approach controller at Oslo Air Traffic Control Center since 2010.

The Final controller was on retraining after leave of absence, and was therefore supported by a colleague performing the role of instructor. The instructor was consequently the on-duty controller. The instructor was following events on a separate radar screen and had communications equipment set on the Final frequency, with the possibility to override. The instructor was authorized as an air traffic controller for the first time in 2002 and as an instructor at Oslo Approach in 2010.

The number of service hours for instructor and candidate were within the limitations of the regulations in force. They had started their watches at time 0600 and 0700, respectively. Both declared they had felt rested.

1.6 Aircraft information

1.6.1 No technical irregularities have been reported concerning the involved aircraft.

1.6.2 Both aircraft were equipped with the anti-collision system TCAS II (Traffic Alert and Collision Avoidance System). TCAS is independent of ground-based systems and functions through communication between transponders onboard different aircraft.

1.6.3 TCAS II warns pilots of other aircraft nearby, which may represent a danger (Traffic Advisory, TA), and gives instructions for vertical avoidance maneuvers (Resolution Advisory, RA) if they come too close to each other. The pilots' navigation display also provides visual indication of nearby traffic which does not represent any danger (Proximate traffic).

1.6.4 TCAS generates Traffic Advisory (TA) or Resolution Advisory (RA) warnings only if certain requirements are fulfilled. Among the parameters taken into consideration are the given aircraft's own altitude, the altitude of the other aircraft, and the corresponding speeds and headings.

1.6.5 Both NAX740 and NAX741 received TCAS TA warnings in the given incident. Both aircraft were then in clouds, and the crews could not establish visual contact with the other aircraft. Both aircraft received TCAS TA warnings after starting a left turn.

- NAX740, the departure, received a TCAS TA with altitude indication showing that the other aircraft was 400 ft above own aircraft. As a consequence of the warning the crew reduced the rate of climb.

- NAX741, the approach, received a TCAS TA without altitude indication, but the yellow symbol on the screen (yellow dot) was practically on top of own position.

- Correlation of FDR data from the two aircraft showed that the minimum horizontal distance between them was found when NAX470 had passed 1 300 ft and NAX741 1 800 ft (see subsection 1.1.2.22).

1.7 Meteorological information

1.7.1 ATIS (Automatic Terminal Information Service) "Arrival" for Gardermoen, at time 0720. The text *"Tailwind on final to 2 000 ft"* was also included in the next ATIS broadcast at time 0750. At that time the cloud base had also gone down from 1 400 ft to 1 200 ft.

> *ENGM ARR ATIS R 0620ZD-ATISARR_RWY01R_EXP_ILS_APCHTRL_FL090 TAILWIND ON FINAL TO 2000 FEETRSCD_RWY01R_BA444 BATIME0605 8 MMS DRY SNOW SANDED ICE MESSAGE NBR 2 VALIDWIND 020/4KTS VIS 4800M FBL_SN CLD SCT 1400FT OVC 1700FTTMS4 DPMS5 QNH_993HPATEMPO VIS2500M FBL_SN BR CLD BKN800FTCONFIRM ATIS R*

1.7.2 The Flight Safety Committee of the Norwegian Airline Pilots Association in a public hearing comment stated that ATIS is often received on data link/ACARS, and that data link ATIS for Gardermoen contains MET reports for both runways, unlike the practice for other European airports with several runways. Data link ATIS for Gardermoen thereby gives an excessively complex and long printout, in which essential information such as tailwind may be difficult to discover.

1.8 Aids to navigation

No reported irregularities.

1.9 Communications

No reported irregularities; communications of normal good legibility.

1.10 Aerodrome information

1.10.1 Relevant flight operative procedures

1.10.1.1 The declared runway length (TORA – Take-Off Runway Available) for runway 01L is 3 600 m. The airport's elevation above sea level is 681 ft (AD ELEV).

1.10.1.2 The first leg of the outbound flight procedure from runway 01L and the missed approach procedure for runway 01L both initially follow magnetic heading 014°, i.e. straight ahead along the extended runway centerline.

1.10.1.3 The departure procedures describe that the radio frequency is to be switched to Oslo Approach upon instructions from the Gardermoen tower controller.

1.10.2 Relevant air traffic control systems

1.10.2.1 Approach controllers have the radar image (SDD) as their primary tool of visual supervision. Tower controllers have an overview of the runway and primarily follow the flights visually through the windows. The tower controller also has a radar image, which i.a. is used to see to it that separation between departures and approaches and between successive departures are in accordance with the set minima. In addition to the radar image the air traffic controllers at Gardermoen Control Tower and Oslo Approach have a data display from the traffic surveillance system (A-SMGCS), using combined sensor technology to provide a good image of the traffic on and around the airport; see Appendix C. The system is mainly a tool meant for the control tower when the visibility conditions are such that the air traffic controllers cannot follow the traffic visually by looking out through the window.

1.10.2.2 The radar system has the alarm function STCA (Short Term Conflict Alert), which issues a warning if the specified separation minima are about to be breached. The alarm function is, however, active only if at least one of the aircraft in a conflict is above 5 500 ft. STCA therefore had no practical application in this incident.

1.10.2.3 The traffic surveillance system (SMGCS) has several alarm functions, such as e.g. Runway Incursion Monitoring (RIM). The alarm function shall provide the air traffic controller with warnings in the form of audio and a change of color in the track labels for objects involved in a runway incursion conflict. Data playback shows that the RIM alarm function worked in accordance with system specifications in the given incident[4]. The

[4] Playback from the traffic surveillance system shows RIM warning at time 07:34:25, when the horizontal distance between NAX741 and NAX740 was measured to be app. 2 300 m (app. 1.2 NM). After this the RIM alarm was activated at time 07:34.44, when the horizontal distance was reduced to app. 1 750 m (app. 0.9 NM). NAX740 received departure clearance at time 07:33:50, i.e. before the RIM warning. NAX741 reported go-around 40 seconds later, at time 07:34:30.

RIM alarm had no practical application in this incident, given that the parameter settings are adapted for simultaneous occurrence of objects on the runway.

1.11 Flight recorders

1.11.1.1 The aircraft were equipped with Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR). FDR data were downloaded from both aircraft, and proved to be useful in the AIBN's investigation.

1.11.1.2 The recording time for CVR is limited. Existing regulations allow aircraft to have CVR storage time of only 30 minutes. CVR data was not secured from any of the aircraft and therefore overwritten by the time the AIBN received information about the incident. Commission Regulation (EC) No 859/2008 of 20 August 2008, EU-OPS L 254/9, states the following in the section on crew responsibilities, subsection (f):

> *10 (ii) not permit a cockpit voice recorder to be disabled of switched of during flight unless he/she believes that the recorded data, which otherwise would be erased automatically, should be preserved for incident or accident investigation nor permit recorded data to be manually erased during or after flight in the event of an accident or an incident subject to mandatory reporting.*

1.12 Wreckage and impact information

Not relevant.

1.13 Medical and pathological information

Not relevant.

1.14 Fire

Not relevant.

1.15 Survival aspects

Not relevant.

1.16 Tests and research

None.

1.17 Organizational and management information

1.17.1 Norwegian Air Shuttle ASA

According to the airline's web site, www.norwegian.no, Norwegian is, as of October 2013, the next largest airline in Scandinavia, with a fleet consisting of 80 aircraft. They have 68 Boeing 737-800's, 10 Boeing 737-300's and two Boeing 787-8 Dreamliners.

1.17.2 Operative procedures

1.17.2.1 Criteria for stabilized approach and execution of missed approach are described in Norwegian's Operations Manual[5]. In an excerpt from this manual some of the relevant criteria are mentioned:

- Deviation from localizer and glide path shall not exceed a deflection of one "dot".
- Landing gear down and flaps set to landing configuration (30 - 40 degrees).
- Maximum deviation in flight speed Vref + 15 kt.
- Maximum sink rate of 1 500 ft/min.
- Positive engine power above idle.
- Landing checklist completed.
- Approach should be stabilized before the aircraft reaches height 1 000 ft Above field elevation (AFE). The above mentioned parameters will during initial approach be indicators of whether it will be possible to attain a stabilized approach by 1 000 ft AFE.

1.17.3 Missed approach and pilot training

1.17.3.1 Norwegian's Operations Manual [6] describes the airline's procedures for when a missed approach shall be executed:

> *A missed approach shall be executed whenever the PF is unable to comply with established procedures or in a situation where continued approach for landing is not advisable.*

1.17.3.2 Aviation authority regulations on training and skill tests for pilots, cf. EU-OPS 1.965, require that the semiannual Operator Proficiency Check (OPC) include execution of at least one missed approach.

1.17.3.3 Norwegian has stated that their pilots execute at least two missed approaches at each OPC in a flight simulator every six months.

1.17.4 Avinor AS

Avinor is a limited company wholly owned by the state, which operates 46 airports in Norway, of which 12 in cooperation with the armed forces. Operations also include Air Navigation Services – ANS. Avinor exercises air navigation services in Norwegian

[5] Part A (Operations Manual A) inter alia subsection 8.4.1.13
[6] Part A (OM A) inter alia subsection 8.4.6 and Part B (OM B) subsection 2.11.1

airspace, including dedicated parts of the airspace over the North Atlantic. Oslo lufthavn AS is a wholly-owned subsidiary, which owns and operates Norway's main airport, Oslo Airport at Gardermoen.

1.17.5 Missed approach and training for air traffic controllers

1.17.5.1 Air Traffic Controllers in Avinor practice missed approach during the institutional air traffic controller training, which is carried out in accordance with Eurocontrol CCC (Common Core Content) specifications.

1.17.5.2 During annual maintenance training and/or periodic professional updates (Periodisk Faglig Oppdatering, PFO), missed approach in which the air traffic controller must additionally handle other traffic may be covered within "extraordinary situations", but this is not specifically required.

1.17.5.3 The use of tower simulator as a part of tower air traffic controller training or in connection with PFO, was not a government requirement at the time of the incident. The government regulation (forskrift) of 11 November 2003 No. 1345 (BSL G 2-1) on the establishing, organizing and operation of air navigation services, Article 19 (1), describes requirements for maintenance training for air traffic controllers. In EU Regulation 805/2011, which was adopted into Norwegian law on 2 July 2013, it is required that tower simulator training shall be a part of the maintenance training for tower controllers.

1.17.5.4 The air traffic controllers affiliated with Gardermoen control tower did, however, have tower simulator training as part of their annual PFO, and have had this for many years.

1.17.6 Relevant regulations

1.17.6.1 Government regulation (forskrift) of 1 July 2011, No. 732 on air traffic management (BSL G 8-1) implements two ICAO documents in Norway with affiliated Norwegian special provisions: ICAO doc 4444 (PANS-ATM) Procedures for Air Navigation Services - Air Traffic Management) and ICAO doc 7030 (Regional Supplementary Procedures).

1.17.6.2 ICAO doc 4444, Art 8.9.3.6, relevant for Oslo Approach:

> *Aircraft vectored for final approach should be given a heading or a series of headings calculated to close with the final approach track. The final approach vector should enable the aircraft to be established in level flight on the final approach track prior to intercepting the specified or nominal glide path if an MLS, ILS or radar approach is to be made, and should provide an intercept angle with the final approach track of 45 degrees or less.*

1.17.6.3 ICAO doc 4444 Art 4.6.3.6, relevant for Oslo Approach:

> *Only minor speed adjustments not exceeding plus/minus 40 km/h (20 kt) IAS should be used for aircraft on intermediate and final approach.*

1.17.6.4 Gardermoen control zone is ATS airspace class D. Here IFR flights shall be separated from other IFR flights, cf. AIP Norway ENR 1.4.

1.17.6.5 *Before missed approach – Runway separation between landing and departure*

Minimum required separation between a landing and a departure on the same runway is described in ICAO doc 4444 subsection 7.10.1:

> *[…] a landing aircraft will not normally be permitted to cross the runway threshold on its final approach until the preceding departing aircraft has crossed the end of the runway-in-use, or has started a turn, or until all preceding landing aircraft are clear of the runway-in-use […].*

1.17.6.6 *After missed approach – Radar separation between go-around and departure*

The air traffic controller must take into consideration that an approach might for different reasons need to be discontinued. Previously Norwegian regulations contained a special provision allowing radar to be used as a tool to separate a missed approach from a simultaneous departure. ICAO doc 4444 (PANS-ATM) does not describe whether radar may be used as a tool for separating a missed approach from a departure. Neither is this included in the Norwegian special provisions.

The AIBN is familiar with the fact that the absence of this special provision has been discussed locally at Gardermoen control tower, centrally in the Avinor Flight Safety Division and within the Norwegian Civil Aviation Authority. The involved parties have in cooperation arrived at the conclusion that ICAO doc 4444 can be interpreted such that a missed approach may be regarded as a departure, since the same outbound flight path is used for the first leg (see subsection 1.17.8.1).

Since a missed approach can be considered to be a departure, radar separation may be used if the air traffic controller cannot visually supervise the flights. Requirements for radar separation may, in accordance with ICAO doc 4444 subsection 6.1, be reduced if:

> *Adequate separation can be provided by the aerodrome controller when each aircraft is contiguously visible to this controller; or*
>
> *Each aircraft is contiguously visible to flight crews of the other aircraft concerned and pilots thereof report that they can maintain their own separation; or*
>
> *In the case of one aircraft following another, the flight crew of succeeding aircraft reports that the other aircraft is in sight and separation can be maintained".*

Due to the cloud cover, none of the three above-mentioned criteria were fulfilled. The separation minima that were in force after NAX741 had initiated missed approach were therefore 3 NM radar separation horizontally[7] or 1 000 ft vertically.

1.17.7 Cooperation agreement between Gardermoen Tower and Oslo ATCC

1.17.7.1 Gardermoen Control Tower (ENGM) and Oslo Air Traffic Control Center (ENOS) have a cooperation agreement which regulates how the coordination of traffic between the units shall be carried out: Letter of agreement (LOA) ENGM-ENOS[8]. The local

[7] AIP Norway ENR 1.6.-3 describes radar separation minima in the following way: The horizontal radar separation minimum is 5 NM unless a greater minimum is prescribed (depending on equipment in use of when wake turbulence is likely to exist). In special cases, Avinor may approve a separation minimum of 3 NM.

[8] Letter of agreement (LOA) from April 2011, which is included among Management Documents for both units, Gardermoen Tower: GM-H-L001-KOOR-01, and Oslo ATCC: OS-H-L001-KOOR-07.

guidelines, as they were implemented at the time of the incident, refer to the provisions in the LOA for coordination of traffic.

1.17.7.2 According to LOA subsection D.1.6 - 1.7, separation between aircraft shall be established and maintained in the following way:

- between arrivals (Oslo APP establishes and Gardermoen maintains separation).
- between departures (Gardermoen establishes and Oslo APP maintains separation).
- between departure and arrival, including arrival which discontinued the approach (Gardermoen establishes and Oslo APP maintains separation).

1.17.7.3 LOA subsection D.1.9 specifies further:

> *When using radar separation, distance and speed shall be such that required radar separation is maintained after transfer of radar control. However, the accepting unit shall, if necessary, take action to ensure that separation is maintained.*

1.17.7.4 Oslo Airport, with its two parallel runways, is operated using one out of three different runway modes, cf. LOA subsection A 1.9:

> *Mixed Parallel Operations (MPO) – Simultaneous approaches and departures on parallel instrument runways where radar separation is prescribed.*
>
> *Segregated Parallel Operations (SPO) - Simultaneous operations on parallel instrument runways in which one runway is used exclusively for arrivals/landing aircraft and the other runway is used exclusively for departures.*
>
> *Single Runway Operations (SRO) – Mixed operations when only one runway is in use.*

1.17.7.5 LOA subsection D 2.4 addresses the question of who makes decisions in the coordination between the units under given circumstances. For single flights the air traffic controller in the relevant work position is responsible for decision-making. In all other cases coordination responsibility lies with the supervisor:

> *[...] Change of runway mode: Supervisor TWR - Supervisor Oslo ATCC.*
>
> *Snow clearance/closing of runway/landings on departure runway: Supervisor TWR - Supervisor Oslo ATCC.*
>
> *Spacing on final: Supervisor TWR - Supervisor Oslo ATCC.*
>
> *Change of runway for landing for single flights: TWR E/W - Oslo APP Planner.*

1.17.7.6 LOA subsection D 3.3 gives an opening for accepting landings on the departure runway during the time when the landing runway is closed for snow clearance:

> *When the main landing RWY is closed due to snow clearance, Supervisor Gardermoen TWR shall, in cooperation with Supervisor Oslo ATCC, assess inbound and outbound traffic load to determine if the main departure RWY should be used for landing. The appropriate landing interval shall be specified.*

1.17.7.7 LOA subsection D 3.3, however, sets no guidelines concerning the number of landings. Neither is there mention of any prerequisites that must be present for it to be acceptable to allow landings on the departure runway, e.g. whether the “Departure sequencer”

position is manned or not. Nor is there any description of whether it is required to consult with the on-duty tower controller.

1.17.8 Local go-around procedures at Gardermoen control tower

1.17.8.1 The local procedure at the time of the incident, ENGM TWR Part 7 (GM-H-L001-CTR-TMA02), addresses missed approaches in subsection 2.3. Selected quotes:

> *[…]Standard procedure for missed approach, as published in AIP AD2 ENGM [9], shall be followed so long as there are no traffic-related or safety-related reasons to deviate from this (subsection 2.3.1.1).*
>
> *[…] Aircraft executing missed approach shall remain on the TWR radio frequency until the aircraft is established on missed approach procedure and a turn away from parallel runway is confirmed visually or using radar. Radio communications are to be transferred to the relevant TMA sector when clear of own traffic. (subsection 2.3.1.3).*
>
> *[…] A missed approach may deviate from the provisions of Regulations on Noise Prevention for Oslo Airport Gardermoen, ref. these regulations, Art 5 (subsection 2.3.3.4).*

1.17.8.2 In subsection 2.3.3 it is written that the procedures for radar navigation management of aircraft that are executing missed approach provide separation from departing aircraft on the parallel runway. The procedures also provide separation from aircraft that are executing missed approach to the parallel runway. Separation from simultaneous departure on the same runway is, however, not mentioned.

1.17.9 Practice at Gardermoen control tower - landings on departure runway

1.17.9.1 Previously the practice at Gardermoen control tower was that the tower controller for the departure runway decided whether landings could be accepted on the departure runway during the app. 15 minutes when the landing runway was closed for snow clearance. With the introduction of the cooperation agreement between Gardermoen Control Tower and Oslo ATCC, the decision-making responsibility was essentially transferred from the tower controller to the supervisor (see subsection 1.17.7.5).

1.17.9.2 App. 10 air traffic controllers had the supervisor checkout at Gardermoen Control Tower. This group did not have a uniform perception of how many landings could be accepted on the departure runway when the landing runway was closed for snow clearance for 15 minutes. Some were more restrictive than others in accepting landings on the departure runway. How many landings they accepted varied from none to three, depending on which supervisor was on duty that day. Practice also varied concerning how to consult with the departure runway tower controller.

1.17.9.3 In the case of the incident in question, the duty supervisor's assessment was that the number of personnel on watch in the control tower and the conditions in general indicated that three landings on the departure runway was acceptable. The supervisor based this conclusion on several factors, e.g. the fact that the tower controller had relief since the "Departure sequencer" position was manned. The "Departure Sequencer" coordinated the

[9] The first leg of the outbound flight procedure for runway 01L and the procedure for missed approach for runway 01L both follow magnetic heading 014 ° (up to 5 000 ft for missed approach).

traffic in and out of the deicing platform, and the tower controller's responsibilities were consequently limited to the runway. 8 NM spacing was agreed for successive landings in order to provide space for a departure between two landings.

1.18 Additional information

1.18.1 Call sign confusion

1.18.1.1 As described in subsection 1.1.2.18, the clearance given by the tower air traffic controller to NAX741: *"Norshuttle 741, when able left turn heading 270"*, was misunderstood by NAX740, as if the clearance was for them. The result was that both aircraft executed a left turn towards the west.

1.18.1.2 Worldwide the problem of call sign confusion has led to many incidents and much work has therefore been put into preventing this from happening. Reference is i.a. made to a summary of documents in Skybrary: http://www.skybrary.aero/index.php/Call-sign_Confusion.

1.18.1.3 AIBN has obtained an overview from the Norwegian Civil Aviation Authority of reported incidents in recent years in which call sign confusion has been a contributing factor. The overview reveals a substantial number of incidents. The Norwegian Civil Aviation Authority has worked actively on this topic and has, among other things, published an Aeronautical Information Circular, AIC-N 01/11. It deals with guidelines for reducing the risk of call sign confusion. The guidelines are targeted towards airlines and flight deck crews as well as the air traffic control service.

1.18.1.4 Norwegian Air Shuttle has converted to alpha-numeric call signs (a mixture of numbers and letters) on many of their scheduled routes in order to minimize the risk of confusion. After the incident at Gardermoen, Norwegian went even further in changing call signs for a number of their routes, among them NAX741, which from now on has the call sign "Norshuttle 1YE" in order not to be confused with NAX740, which still has the call sign "Norshuttle 740".

1.18.2 Related serious air traffic incidents at Gardermoen

1.18.2.1 Due to non-stabilized approach a Boeing 757-200, with call sign Icelandair 315, was forced to discontinue its approach to runway 01L. The incident occurred on 22 January 2002 and was close to becoming an accident. Only luck kept the margins on the safe side, cf. the AIBN report SL 2003/07.

1.18.2.2 Icelandair 315 initiated this missed approach at a very late stage and not in accordance with company procedures.

1.18.2.3 The ensuing loss of control caused the aircraft to perform a series of extreme maneuvers bobbing up and down. At one point the aircraft was as low down as 321 ft radar height. The 75 passengers onboard experienced the intermittent positive and negative g-forces as most frightening and unpleasant. Loose objects were thrown around both in the cabin and on the flight deck, but there were no injuries to persons. The aircraft was in the clouds when this was going on (IMC – instrument meteorological conditions). The air crew managed to regain control and returned for landing on runway 01L.

1.18.2.4 Another related incident involving simultaneous landing and departure on runway 01L occurred at Gardermoen on 8 March 2000. Three aircraft were involved in the incident, which was very close to becoming an accident; see the AIBN report SL 06/2001.

1.18.3 Relevant reported air traffic incidents at Gardermoen in 2012

1.18.3.1 The AIBN has obtained an overview of reported cases of breach of runway separation minima registered at Gardermoen control tower in 2012. Seven incidents were registered in which the distance between two aircraft was reduced to less than prescribed but where vertical or horizontal separation was quickly reestablished, so the situation did not develop into a serious aircraft incident.

1.18.3.2 Five out of the seven cases were limited to the distance between a landing and the departure ahead of it becoming less than a full runway length. The situations had essentially arisen because the departure spent more time than expected on the runway at the same time as the landing was quicker than the air traffic controller had made provisions for. Two out of the seven cases involved a missed approach in which the tower controller had instructed the Commander[10] to deviate from published procedure for missed approach in order to attain the necessary separation from a simultaneous departure. In one out of the two mentioned cases there was call sign confusion leading to the wrong aircraft responding to an instruction to change heading.

1.18.4 Related air traffic incident, Bergen Airport Flesland, 4 October 2011

1.18.4.1 In an air traffic incident at Bergen Airport Flesland, an aircraft proximity (AIRPROX) situation occurred between two commercial aircraft in a complex situation. Also in this case the aircraft had a higher than normal speed on final. See the AIBN report, SL 2012/08.

1.18.4.2 A Boeing 737-800 with call sign NAX31M discontinued its approach to runway 17 just before landing because the crew considered it unlikely that NAX18Z, a Boeing 737-300, which had received departure clearance and which they could see was standing still in take-off position on the runway, would be clear of the runway before they would be landing. NAX31M initiated a missed approach at app. 500 ft and climbed according to procedure.

1.18.4.3 NAX18Z at the same time took off, which the crew of NAX31M did not take notice of. The two aircraft followed approximately the same track. Visibility was good. The aircraft were climbing one after the other and with a relative speed difference of 10-15 kt, which meant that it would take time for the arrival to catch up with the departure. There was no real risk of collision present in this incident the way it actually developed. The minimum distance between the aircraft was 0.5 NM horizontally and 400 ft vertically. NAX31M executed evasive maneuvering by immediately turning right when they caught sight of the departure ahead of them.

1.18.4.4 The AIBN in the report SL RAP 2012/08 promoted three safety recommendations to Avinor. Two out of the three safety recommendations were still open as of October 2013, including safety recommendation SL No. 2012/06T. It is quoted in its entirety below,

[10] Deviating instructions in the form of heading directions westbound or eastbound, depending on which runway was in use, as well as an altitude limitation.

because the AIBN considers the circumstances to be relevant also for the incident of our interest at Gardermoen on 31 October 2012:

> *Safety recommendation SL No. 2012/06T*
>
> *In the incident in question at Bergen Airport Flesland, an aircraft proximity (AIRPROX) situation occurred between two aircraft during a missed approach. At the time of the incident Flesland ATC had not documented local guidelines for traffic management during a missed approach, an omission that was attended to after this incident.*
>
> *Accident Investigation Board Norway recommends that Avinor assess whether other air traffic control units that bear responsibility for control tower and/or approach control have satisfactory local guidelines for handling traffic management during a missed approach.*

1.18.5 Follow-up of safety recommendation SL No. 2012/06T in Avinor

1.18.5.1 Safety recommendation SL No. 2012/06T was issued in October 2012. Avinor informed the Norwegian Civil Aviation Authority in March 2013 that they had initiated work to assess standardization of local procedures relative to missed approach. This work i.a. addressed the following issues:

- How to ensure separation between departures and possible missed approaches.
- Whether to establish a rule against issuing departure clearance after an arrival has passed a specific point on the final.

1.18.5.2 Avinor wanted the issues to be resolved centrally before possibly giving the units instructions to draw up local guidelines. Before establishing national guidelines Avinor further wanted to take into consideration the work that was done on a European level. Towards this goal Avinor participated at the Eurocontrols Go-around Safety Forum in Brussels on 18 June 2013. However, what they brought back with them from their participation there did not provide any definite answers.

1.18.5.3 Avinor has assessed the need for as well as the possibility of standardizing procedures for units other than Flesland, which had already implemented operative procedures regarding missed approach, ref. SL RAP 2012/08. Avinor's assessment was that only very few elements were suitable for standardized solutions. The need for regulation of this issue also varied between the units. For units where the questions raised were similar to those at Flesland, Avinor/ATM considered using the operative procedures that had been introduced at that unit as a basis for possible standardized procedures.

1.18.5.4 *Guidelines to ensure runway and radar separation during go-around*

The AIBN report on the air traffic incident at Flesland on 4 October 2011, SL RAP 2012/08, in subsection 1.18.2.3 describes that:

> *For planning in connection with runway separation the local regulations at Flesland included figures with recommended time consumption for landings and for departures from different holding positions. Some examples were given for different types of aircraft. It was emphasized that variations linked to different circumstances that influenced the performance of aircraft must be assessed.*

Flesland had introduced time estimates for how far from the threshold an aircraft must be to allow a departure to be taken before a landing. The unit's operative leadership a few days after the incident informed local air traffic controllers that:

> *There should be at least 2 minutes between arriving aircraft if there is going to be a departure in between.*
> *Departing aircraft should have started TKOF roll no later than when arriving aircraft is 1 minute from THR […].*

The AIBN is aware that the operative management at Gardermoen control tower also has assessed whether establishing a point on the final could help air traffic controllers to achieve both runway separation and radar separation when conditions are such that flights cannot be supervised visually. This point on the final might be used as a cutoff limit for departures, which would be required to have commenced take-off roll by the time the arrival is at this point at a certain number of NM from the runway threshold. The air traffic controller must, however, take into consideration the aircraft's performance as well as different circumstances that influence this, which makes it difficult to fix such a point.

The Norwegian Airline Pilots Association's Flight Safety Committee has submitted the following public hearing comment concerning the possible establishment of such a point on the final:

> *High tail-/headwind would make it very unpractical with any fixed point on the final, after the passing of which departure clearance cannot be given. Flesland's time-related recommendations seem more sensible, but could add to controller workload […].*

1.18.5.5 *Guidelines for alternative traffic management during go-around*

Flesland ATC had, after the incident at the unit on 4 October 2011, produced «Traffic management during go-around». The procedure provided the local controllers with guidelines for standard measures during a missed approach, as well as a list of preferred alternatives in case standard procedure for missed approach could not be followed. See Appendix E in report from air traffic incident at Flesland, SL RAP 2012/08. We quote from the procedure:

> *The way the unit's system for traffic management is constructed, there does not exist one single fixed solution for how to handle any or all missed approaches. This is due to such factors as different constellations of aircraft, performance, weather conditions, distance between aircraft going around and preceding departing aircraft, etc. All the variable factors affect which solution will function the best in a given situation. The above guidelines are therefore meant as an incentive to increase awareness about which possibilities are available as well as which factors to think through and/or base ones choice of solution on.*

1.18.6 International focus on go-around challenges

1.18.6.1 Missed approach (go-around) is a part of normal operation. Investigations carried out internationally[11], however, show that:

- "*1-3 go-arounds for every 1000 approaches*"
- "*Only 3 % of pilots follow the airline policy of initiating a go-around in case of experiencing an unstabilised approach*"

1.18.6.2 Pilots consequently very rarely experience an actual go-around other than in a simulator. Those who fly short routes will typically have a go-around once or twice a year, whereas long route pilots will have a go-around every two or three years. The investigations further indicate that flight crews generally have a high threshold against going around, since only three out of 100 non-stabilized approaches result in a go-around.

1.18.6.3 An approach is most commonly aborted because the criteria for stabilized approach are not fulfilled (see subsection 1.17.2.1), and the pilot therefore chooses to abort. Then in the next case if necessary visual references are not observed at Decision Altitude/Height (DA/H) or Minimum Descent Altitude/Height (MDA/H), or because ATC gives instructions for the flight to go around.

1.18.6.4 Most accidents in commercial aviation over the last 10 years have happened during approach or landing. Investigations have shown that very many of the landing accidents[12] were initiated due to pilots choosing to land even though an after-the-fact analysis of flight data showed that the approach was not stabilized.

1.18.6.5 Leading aviation actors place a strong focus on how to solve the problem of non-stabilized approaches. The primary focus is on how to avoid non-stabilized approaches, next that pilots to a greater extent must choose to initiate go-around rather than landing if the criteria for stabilized approach are not met. Going around is considered to be less of a risk than continuing a non-stabilized approach followed by a landing.

1.18.6.6 The Norwegian Airline Pilots Association's Flight Safety Committee has given the AIBN the following public hearing comment regarding the pilot's dilemma upon receiving instructions for tighter vectoring than set down in the published procedure:

> *There is much focus on saving both time, distance and fuel in the competition-exposed branch of aviation. In parallel with the inclination of the majority of the corps of pilots to accept requests, this will have as a result that all initiatives from controllers that imply improvement in the above-mentioned factors will be accepted […] It is often difficult to calculate the correct profile, as pilots rarely get track mileage information from ATC. If vectored on the inside of the published*

[11] The investigations referred to here were presented at "Go-around Safety Forum" in Brussels on 19 June 2013. The forum was organized by Eurocontrol in cooperation with Flight Safety Foundation (FSF) and European Regions Association (ERA). Approximately 230 professionals attended, including participants from Avinor, the Norwegian Civil Aviation Authority, Norwegian Air Shuttle and AIBN. All the presentations from the Go-around Safety Forum can be found here: http://www.skybrary.aero/bookshelf/books/2322.pdf. A toolkit for ATC has also been produced (January 2013): http://www.skybrary.aero/index.php/Solutions:Stabilised_Approach_Awareness_Toolkit_for_ATC

[12] For statistics on runway excursion accidents 2010-2013, see: http://www.nlr-atsi.nl/services/runway-safety/runway-excursions/. Reference is also made to the European Action Plan for the Prevention of Runway Excursions: http://www.skybrary.aero/index.php/European_Action_Plan_for_the_Prevention_of_Runway_Excursions_(EAPPRE)

procedure they will end up too high up; therefore it is important to receive this information as early as possible.

1.18.6.7 Risk-filled situations that may arise during go-around are mainly loss of control and maneuvering problems. This risk increases the later the decision to go around is taken. The go-around may also come into conflict with other traffic, where risk of collision and of wingtip vortices is essential.

1.18.6.8 The French national accident investigation bureau (Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile, BEA) has carried out a major study of "Aeroplane State Awareness during Go-Around". The study i.a. contains an analysis of common factors contributing to loss of control during three approach/go-around accidents in 2009 and 2010. BEA suggests strategies that may prevent future occurrences and submits several recommendations to the EASA. The study can be found here: http://www.bea.aero/etudes/asaga/asaga.php.

1.18.6.9 Air traffic control can, with well-functioning procedures and sound dispositions on the part of air traffic controllers, offer favorable conditions for a safe execution of an uninterrupted approach.

1.19 Useful or effective investigation techniques

During this investigation no techniques have been used that qualify for special mention.

2. ANALYSIS

2.1 Introduction

2.1.1 The traffic picture around an airport is dramatic and requires constant interpretation on the part of both pilots and air traffic controllers. Traffic management must be conducted in a safe manner and at the same time remain efficient. Safety considerations demand that all actors constantly plan their actions with sufficient margins. In planning efficient traffic management there are inherent expectations as to what other actors are going to do, expectations which do not always prove to be correct and which create a need for adjustment of own plans. Maintaining the balance between safety and efficiency also requires that good procedures are established for the different actors, so that a set of minimum safety margins are always upheld independently of individual assessments and expectations.

2.1.2 The NAX741 crew, final controller and tower controller's expectation that the ground speed would be reduced considerably during approach, was not fulfilled. The approach was not stabilized, and the ensuing missed approach resulted in a conflict with the simultaneous departure; see subsections 2.2 and 2.3.

2.1.3 This investigation has further revealed that situation awareness and good assessments on the part of the air crew and tower controller, once the situation was a fact, prevented a further escalation of the conflicting situation; see subsection 2.4.

2.1.4 Some factors, such as weather and wind conditions, give preconditions and maneuvering space limitations that are difficult to influence. Other factors, such as organizational choices and procedures are, however, adjustable; see subsection 2.5. Flight operative conditions are treated separately in subsection 2.6.

2.2 Analysis of the sequence of events before the approach was aborted

2.2.1 Underway and during approach to Gardermoen

2.2.1.1 When the NAX741crew was notified by Oslo ATCC that the runway for landing was changed from 01R to 01L, there was still relatively plenty of time to adjust the rate of descent in order to join the correct descent profile, so long as the vectoring onto ILS runway 01L would not be too tight.

2.2.1.2 As NAX741 was approaching the report point ABUBA, the crew received vectoring towards the RWY 01L final approach leg earlier than they had expected. With the winds on altitude as they were, it became difficult to get the speed to go down and intercept the glide path. AIBN agrees with the Commander's reflections that they should not have accepted the last instruction to proceed to the final approach. Based on the public hearing comment from The Norwegian Airline Pilots Association's Flight Safety Committee (see subsection 1.18.6.6), AIBN makes the point that efficiency and time pressure may affect decisions that are made.

2.2.1.3 The final controller was on retraining after leave of absence, and was therefore a candidate under the leadership of an instructor, who at the same time was the on-duty controller. The instructor was sitting in a work position three seats to the right of the final controller. AIBN considers that it would have been more suitable if the instructor could have been sitting closer to the candidate, even though the candidate had come far in the

retraining program. Both candidate and instructor noticed that NAX741 came in high relative to the glide path. The instructor did not, however, give any guidance concerning vectoring of the flight, which would have been easier to do, had he been seated closer to the candidate. Looking back, the AIBN is of the view that instructor and candidate might have considered the following issues:

- Bearing in mind the tailwind on final, which made it difficult to reduce the speed, the final controller could have given NAX741 a prolonged vectoring towards the final approach. They could see that NAX741 was a bit high up and might have asked the crew how many track miles they needed.

- During transfer to sector TMA final, NAX741 had been instructed to reduce their speed to 220 kt IAS (see subsection 1.1.2.5). When NAX741 was transferred from sector TMA final to Gardermoen control tower, indicated speed was 212 kt, ground speed 250 kt, and the aircraft was 6 NM from the runway threshold. The final controller's instruction to reduce the speed to 180 kt IAS or less (see subsection 1.1.2.9), was optimistic. Neither was this instruction in accordance with the recommendations given in ICAO doc 4444 (ref. subsection 1.17.6.3), which recommended a speed adjustment of no more than +/- 20 kt.

- Transfer of the flight from final controller to tower controller was done electronically. AIBN considers that the final controller might well have made the tower controller aware of the flight over the hot line, since the aircraft was above the glide path with high speed, which heightened the probability of a missed approach.

2.2.2 <u>In Gardermoen control zone (CTR)</u>

2.2.2.1 The tower controller had just taken over the work position and had, during the change of watch, been informed that there was a powerful tailwind on final and that three landings had been agreed on the departure runway with a distance of 8 NM.

2.2.2.2 After dispatching a departure, the tower controller saw on the radar screen that NAX741 was on its way in to establish on localizer, app. 10 NM out. The decision to dispatch a departure before the landing was based on experience and expected speed reduction. NAX741 was the first landing on runway 01L since it had been reopened after snow clearance. Thus the tower controller had not experienced how the tailwind that day affected the aircrafts' ability to reduce their speed. Ordinarily speed was reduced sufficiently on the way in for landing, but on this day this did not happen. NAX741 consequently spent less time on the final than the tower controller had expected.

2.2.2.3 AIBN has made a run-through of data from the aircraft's flight data recorder. After NAX741 was established on localizer, several of the parameters were often way outside the criteria for a stabilized approach (the criteria are mentioned in subsection 1.17.2.1). AIBN therefore considers the crew's decision to go around to have been required. AIBN further considers that the approach should have been discontinued at an earlier stage, not leaving the decision to the time when the aircraft crew established visual contact with the runway, at app. 1 NM from the runway threshold.

2.2.2.4 By going around at an earlier stage, the crew would have had more time to implement necessary corrective measures. The tower controller would also have had more space to accommodate separation from other aircraft.

2.2.2.5 Immediately after contact had been established between NAX741 and Gardermoen control tower, the tower controller gave departure clearance to NAX740, which was standing in takeoff position on the runway. The radar screen showed that the arrival, NAX741, was then maintaining a ground speed of 250 kt, and that they were above the glide path at 3.7 NM from the runway threshold. The AIBN assessment is that this information indicated a probability that NAX741 would not be able to complete the landing. AIBN therefore considers that the tower controller would have been wise to wait before giving departure clearance to NAX470 and also instruct NAX741 to abort their approach. This would have resulted in a delayed departure for NAX740 and a delayed landing for NAX741, but would also have ensured that the two aircraft would be separated from each other.

2.2.2.6 When NAX740 started to move on the runway, NAX741 was at less than 2 NM from final with a ground speed of app. 220 kt. This investigation has showed that the crew on NAX741 aborted the approach because it was not stabilized and not because there was another aircraft on the runway. AIBN is of the opinion that if NAX741 had been able to completed the landing, the separation between the landing NAX741 and the departing NAX740 would have been less than a full runway length.

2.2.2.7 NAX740 was in the process of taking off from the runway app. 40 seconds after they had received departure clearance. AIBN's run-through of the aircraft's flight data recorder shows that the NAX470 crew commenced departure at normal time after the departure clearance had been given.

2.3 Analysis of the sequence of events after the approach was aborted

2.3.1.1 AIBN supports the tower controller's assessment not to cancel the departure clearance given to NAX740 once the situation had arisen. The aircraft was about to rotate and had consequently come too far to abort.

2.3.1.2 The NAX740 crew heard that NAX741 reported go-around and received traffic information on NAX740. However, they did not know how far away the other aircraft was. The NAX741 crew did not catch that the other aircraft was cleared for departure, and they assumed that the aircraft was still standing on the runway.

2.3.1.3 The tower controller followed the flights on the radar screen and on the traffic surveillance screen. Both aircraft were climbing one after the other in instrument meteorological conditions. With a relative speed difference of approximately 36 kt (190 kt contra 154 kt; see subsection 1.1.2.17), there was a possibility that the missed approach could catch up with the departure. AIBN supports the tower controller's decision to turn the rearmost aircraft westbound.

2.3.2 <u>Use of "when able"</u>

2.3.2.1 The phraseology that was used to turn the rearmost aircraft westbound: - *"Norshuttle 741, when able, left turn heading 270*", contributed to the NAX741 crew's incorrect impression that they had plenty of time.

2.3.2.2 The use of the phrase *"when able"* is recommended when the aim is to give pilots time to complete all their tasks in a stressed situation on the flight deck, as an aborted approach usually is, especially when it is aborted late. The NAX741 crew had the understanding that the departure had been stopped. The phrase *"when able"* therefore supported their

perception that they were not especially pressed for time. Looking back it becomes evident that a clearer message, such as e.g. “turn left immediately” might have been a better choice. Another possibility would have been to give instructions that also provided others with information that an extraordinary situation was occurring, e.g.: “*NAX741 on missed approach turn left heading 270*”.

What becomes clear looking back is not always possible to see in the midst of an ongoing situation. NAX741 had not reported any reason to the tower controller for their go-around. The tower controller therefore could not know whether or not the crew was able to turn immediately.

2.3.3 Call sign confusion

2.3.3.1 The last digit was the only difference between the call signs of the two flights. AIBN therefore finds it understandable that NAX740 could become confused by the NAX741 call sign and implement a turn in accordance with the clearance given to the other aircraft.

2.3.3.2 AIBN considers it to be safety critical that clearances have an unequivocal “addressee” and be acted upon by the correct aircraft. AIBN reminds both airlines, flight deck crews and air traffic control of the importance of complying with the guidelines given in AIC-N 01/11 (recommendations for choice of call signs), and that the Norwegian Civil Aviation Authority uphold these intentions during enterprise inspections.

2.4 Factors contributing to the normalisation of the dangerous situation

2.4.1 Control during missed approach

2.4.1.1 During the serious aircraft incident with Icelandair 315 in 2002 (see subsection 1.18.2) the crew did not have sufficient control of the aircraft during missed approach, which led to a number of dangerous maneuvers. This luckily did not happen during the incident of our interest between NAX741 and NAX740. However, several of the factors that were at the core of making it necessary to abort the approach coincided:

- Change of runway due to winter maintenance, a strong tailwind on final and a shortened final approach leg contributed to cause the aircraft to come in with a steep descent profile and at a high speed, as a result of which the aircraft therefore was not stabilized on localizer and glide path at the right time. The decision to go around was also made at a late stage.

2.4.1.2 As opposed to the Icelandair incident, the NAX741 crew was in satisfactory control during their missed approach. They maintained control while going around, also when it became necessary to change heading due to the conflict with the other aircraft.

2.4.2 TCAS

2.4.2.1 Traffic Alert and Collision Avoidance System (TCAS) is an important safety barrier for prevention from collisions between aircraft in the air. The systems have limitations on low altitudes, and are therefore ordinarily less suitable during the landing and takeoff stages. TCAS did, however, play a role in this incident. Both aircraft received warnings from TCAS in the form of Traffic Advisory (TA), and the aircrews used the TCAS display to assess where the other aircraft was located relative to own aircraft.

2.4.3 Good assessments and situational awareness among the actors

2.4.3.1 Both aircraft turned in the same direction for a short period of time. The minimum horizontal distance between the aircraft went down to app. 0.2 NM at the same time as the vertical separation was 500 ft. AIBN's assessment is that there was a real danger of collision in this incident. However, the good situational awareness that the aircrews and the tower controller displayed in this situation, prevented a further escalation of the conflict:

- Aircrews shall normally not divert from given ATC clearances. The way this situation developed due to call sign confusion, AIBN considers the NAX741 crew's decision to turn away from the other aircraft which had just taken off ahead of them and was located below them to be a sound assessment.

- When the NAX740 crew became aware of the conflicting aircraft immediately above them, AIBN considers the crew's decision to execute a somewhat shallower climb than normal in order to reduce the conflicting situation to be a sound assessment.

- AIBN wishes to commend the tower controller for "keeping his cool" and providing both aircraft with valuable traffic information, updating the adjoining sector (Oslo Approach) as well as keeping both aircraft on the tower frequency until the conflicting situation had been resolved.

- Situational awareness and sound assessments were thus very important in this situation. AIBN, however, considers established and practiced procedures to be conductive to recognizing situations and averting them before they become critical.

2.5 Organizational choices and procedures

2.5.1 Choice of runway configuration

2.5.1.1 Weather and wind were factors contributing to the occurrence of this incident:

- Snow showers at Oslo Airport made it necessary to close the two runways alternately for periods of app. 15 minutes.

- Tailwind on final made it more challenging for the pilots to reduce the flying speed during approach.

- Visibility conditions were such that the pilots could not see the other aircraft, and the tower controller could not maintain visual separation between the flights.

2.5.1.2 The cooperation agreement between Gardermoen control tower and Oslo ATCC opened up the possibility for accepting landings on the departure runway during the time when the landing runway was closed for snow clearance. The agreement did not, however, give any guidance as to the number of landings that may be accepted on the departure runway. Neither was there any mention of which prerequisites were required for a landing to be accepted on the departure runway, such as e.g. whether or not the Departure sequencer position must be manned. Nor was there any description of whether the on-duty tower controller should be consulted. AIBN is of the opinion that it might well have been

beneficial if the cooperation agreement had given more guidance concerning which required prerequisites should apply, in order to increase predictability for both supervisor and tower controller.

2.5.2 Outbound flight path

2.5.2.1 The first leg of the outbound flight procedures for runway 01L and the missed approach procedure for runway 01 L both follow magnetic heading 014 ° (up to 5 000 ft for missed approach). AIBN is therefore of the opinion that the procedures alone do not secure that IFR traffic is separated from other IFR traffic during simultaneous departure and missed approach on the same runway.

2.5.3 Local procedures and guidelines during missed approach

2.5.3.1 Gardermoen control tower did not have documented local guidelines that could help the tower controller in the assessment of whether there was enough time to dispatch a departure ahead of the landing under the conditions prevailing at the time. As described in subsection 1.18.5.4, work had been done at Gardermoen control tower concerning whether to establish a point on the final which could help the air traffic controller to achieve both runway separation and radar separation when conditions were such that flights could not be supervised visually. AIBN considers it to be suitable to continue working towards establishing local guidelines, but does not take a stand regarding whether the guidelines should be based on a point on the final or time to threshold; see subsection 1.18.5.4.

2.5.3.2 Gardermoen control tower did not have documented local guidelines for how the tower controller should manage traffic during a missed approach. It would be difficult to fix universally valid ways in which to resolve a conflict, as circumstances connected with different conflicting situations rarely resemble one another. Good professional assessments and best practices can, however, be reflected in local procedures in order to ensure that the unit's air traffic controllers handle certain situations in a uniform manner. AIBN is of the opinion that such guidelines would be of help to controllers, who often have to make quick decisions, especially when managing traffic during a missed approach.

2.5.3.3 Air traffic incidents in which a missed approach has come into conflict with a simultaneous departure, have happened previously at Gardermoen; ref. subsection 1.18.3. Related air traffic incidents have also happened at other Norwegian airports, such as e.g. at Flesland in 2012 (see subsection 1.18.4). The safety recommendation (SL No. 2012/06T) that AIBN submitted to Avinor in October 2012 in the report SL RAP 2012/08, remained open as of October 2013:

> *[…] Accident Investigation Board Norway recommends that Avinor assess whether other air traffic control units that bear responsibility for control tower and/or approach control have satisfactory local guidelines for handling traffic management during a missed approach.*

2.5.3.4 As of October 2013 Avinor was in the process of assessing standardization of local procedures in connection with missed approach, i.a. how to ensure separation between departing flights and possible missed approaches. Avinor also assessed the possibility of fixing a point on the final after the passing of which no departure clearances may be issued (see subsection 1.18.5).

2.5.3.5 Locally at Gardermoen control tower they have been working on an assessment as to whether the establishment of a point on the final might help air traffic controllers achieve both runway separation and radar separation when conditions make it impossible to supervise flights visually (see subsection 1.18.5.4). AIBN is confident that Gardermoen control tower in close cooperation with the Flight Safety section at Avinor, Oslo ATCC, Norwegian Civil Aviation Authority and aviation-operational cooperating partners, within reasonable time, will establish good guidelines for handling traffic management during missed approach at Gardermoen.

2.6 Specifics concerning aviation-operational circumstances

2.6.1 Non-stabilized approaches

2.6.1.1 International investigations show that there are approximately 1-3 go-arounds for every 1000 approaches (see subsection 1.18.6), and that only three out of 100 non-stabilized approaches result in a go-around. The threshold among pilots against executing a go-around therefore seems to be too high.

2.6.1.2 AIBN is of the opinion that the airlines must have a high focus on improving statistics indicating that the majority, i.e. 97 % of all pilots according to international surveys, choose to continue the landing even if the aircraft is not stabilized. The pilots must be encouraged to abort approaches if the criteria for stabilized approach are not fulfilled (see subsection 1.17.2.1).

2.6.1.3 The airlines shall monitor and check that the criteria are adhered to, e.g. using FDR data. AIBN is aware that some airlines, also in Norway, have automatic print-out on the flight deck, so that the aircraft crew gets to know if a selection of "stabilized" parameters are not fulfilled during approach and landing. AIBN considers that such a mechanism may contribute to improve the statistics, in the sense that there will be as many stabilized approaches as possible and missed approaches in those cases when the criteria for stabilized approach are not attained.

2.6.2 Absence of data from the CVR

2.6.2.1 The NAX741 crew had unrealistic expectations regarding the possibility of being stabilized no later than at 1000 ft above field elevation (AFE); see subsection 2.2.2.3. The decision to implement missed approach was taken at a late stage. AIBN has not found an unequivocal answer to why the aircraft crew did not choose to abort the approach earlier.

2.6.2.2 As described in subsection 1.11.1.2, data from the cabin voice recorder (CVR) was not secured for either of the aircraft. CVR data could consequently not be used, which the AIBN regrets deeply. Playback of this recording would have contributed to a charting of the interaction between the pilots and the decision-making process related to criteria for stabilized approach and initiation of missed approach.

2.6.2.3 It is a constantly recurring problem that data from the cabin voice recorder is not secured after an aircraft incident. AIBN therefore wishes to remind Norwegian airlines of the requirement to secure data from the cabin voice recorder after an incident or accident.

3. CONCLUSIONS

NAX741 and NAX740 came into conflict with each other during go-around and simultaneous departure, respectively. AIBN's assessment is that there was a real danger of collision during this incident. But once the situation was a fact, situational awareness and sound assessments on the part of the aircraft crews and the tower controller prevented a further escalation of the conflict. AIBN considers established and practiced procedures to be conductive to recognizing situations and averting them before they become critical.

3.1 Findings

a) No defects or irregularities in the involved aircraft have been uncovered.

b) No defects in technical air or ground systems have been uncovered.

c) Involved pilots and air traffic controllers held valid certification, and service hours were within the limitations currently in force. Retraining activities were being held in sector TMA Final.

d) The pilots on both aircraft were experienced and knew Gardermoen well.

e) Change of runway due to winter maintenance, a strong tailwind on final and a shortened final approach leg contributed to cause the aircraft to come in with a steep descent profile and at a high speed, as a result of which the aircraft therefore was not stabilized on localizer and glide path at the right time.

f) The tower controller assessed that there was enough time to dispatch departure for NAX740 before NAX741 landed. Under the prevailing conditions the tower controller proved to have calculated too little time.

g) After NAX741 was established on localizer, several of the parameters were frequently far below the criteria for a stabilized approach. The decision to go around was taken at a late stage.

h) The first leg of the outbound flight procedures for runway 01L and the missed approach procedure for runway 01 L follow the same magnetic heading. The procedures alone therefore do not secure that IFR traffic is separated from other IFR traffic during simultaneous departure and missed approach.

i) The NAX740 crew initiated departure as expected in accordance with the clearance given. The aircraft was about to rotate when NAX741 reported "go-around". The departure of NAX740 had come too far to abort.

j) Visibility conditions were such that the tower controller could not maintain visual separation between the aborted approach, NAX741, and the simultaneous departure. The aircraft were both climbing, one after the other. NAX741 held a higher speed than NAX740. The tower controller therefore instructed NAX741 to turn westbound.

k) NAX740 misread and implemented the clearance given to NAX741. The reason was most likely that the call signs were practically identical.

l) The phraseology that the tower controller used to turn NAX741 westbound included the phrase "*when able*". This contributed to the NAX741 crew's incorrect impression that they had more time before they needed to start the turn.

m) The NAX741 crew stayed in control during the missed approach, also when it became necessary to change the heading due to the conflict with NAX740.

n) Both aircraft received warnings from TCAS in the form of Traffic Advisory (TA), and this served as a risk-reducing contribution.

o) The NAX740 crew reduced the climb speed when they became aware of the conflict with NAX741 above them.

p) The minimum horizontal distance between the aircraft was down to 0.2 NM at the same time as the vertical separation was 500 ft. AIBN's assessment is that there was a real danger of collision during this incident but that the aircraft crews' and the tower controller's sound assessments prevented a further escalation of the conflict.

q) Related aircraft incidents in which a missed approach has come into conflict with a simultaneous departure, have occurred at Gardermoen previously. This has also occurred on other Norwegian airports, including at Flesland in 2011. The safety recommendation related to this incident (SL No. 2012/06T), which AIBN submitted to Avinor in October 2012, remained open as of October 2013.

r) CVR data was not secured, and AIBN therefore lacked relevant information to understand the sequence of events in detail.

3.2 Significant findings

AIBN considers that the following findings were of decisive significance for the sequence of events or are especially important viewed from a flight safety perspective:

a) The aircraft crew of NAX741 had unrealistic expectations to the possibility of becoming stabilized no later than at 1 000 ft above field elevation (AFE). The decision to implement missed approach was taken at a late stage.

b) The final and tower controllers' expectations that the speed for the landing would be reduced sufficiently during approach, were not fulfilled. The missed approach of NAX741 came into conflict with the simultaneous departure of NAX740.

c) Runway 01L was used both for landings and departures. The tower controller needed to secure sufficient separation, also during go-arounds. Gardermoen control tower had not documented local guidelines that could help the tower controller assess whether there might be enough time to take a departure ahead of a landing under the prevailing conditions. Nor were there any documented guidelines for how the tower controller should handle traffic management during missed approach and simultaneous departure from the same runway.

4. SAFETY RECOMMENDATIONS

Accident Investigation Board Norway does not promote any new safety recommendation in connection with this investigation, but refers to a previously forwarded safety recommendation (SL No. 2012/06T), which has not been closed out.

Accident Investigation Board Norway

Lillestrøm, 7 November 2013

APPENDICES

Appendix A: Relevant Abbreviations

Appendix B: Arrival Chart Oslo/Gardermoen RWY 01L/R

Appendix C: Situation Image from the Traffic Surveillance System

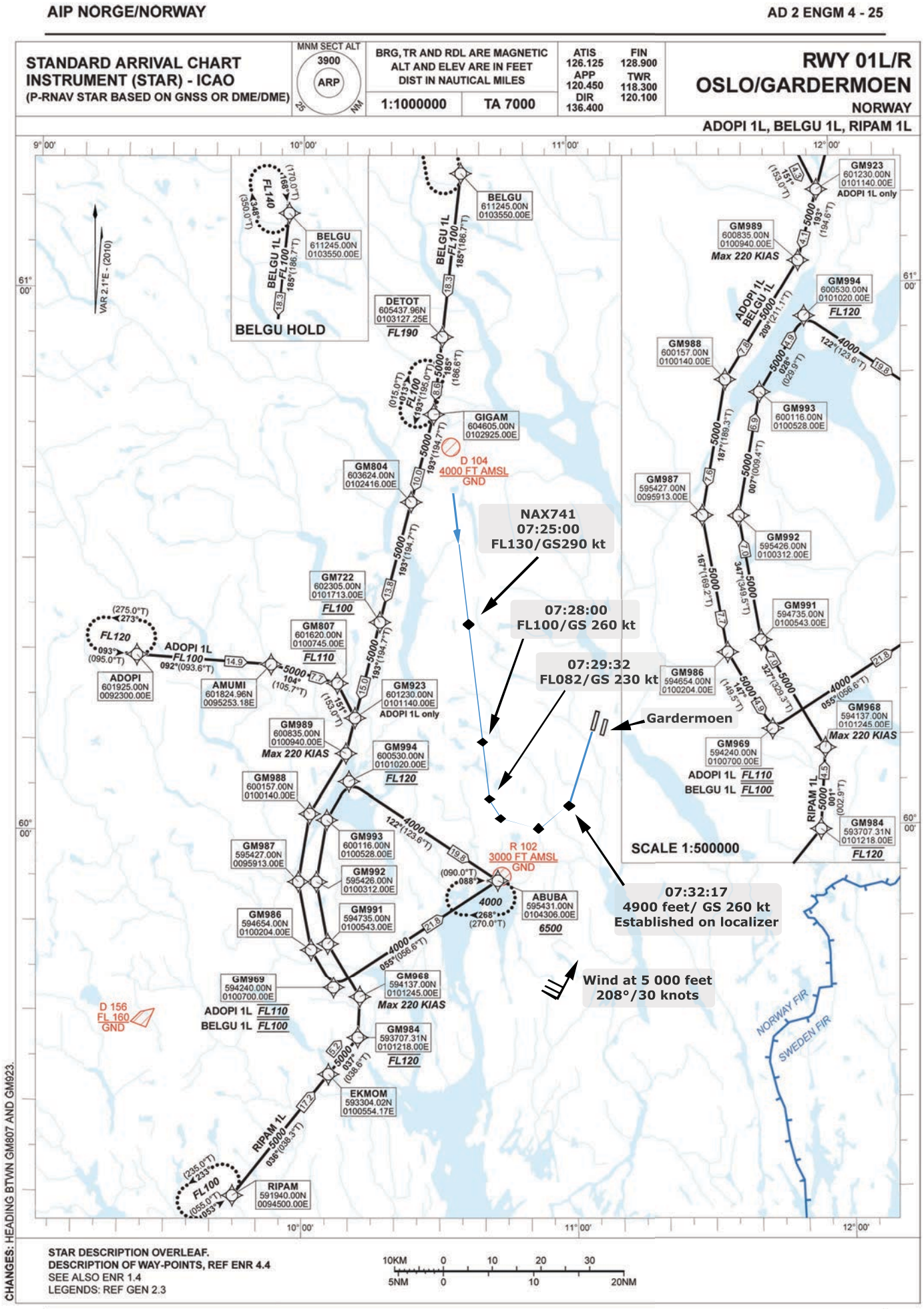
Appendix D: Animation/Correlation of FDR Data

Appendix A Relevant abbreviations

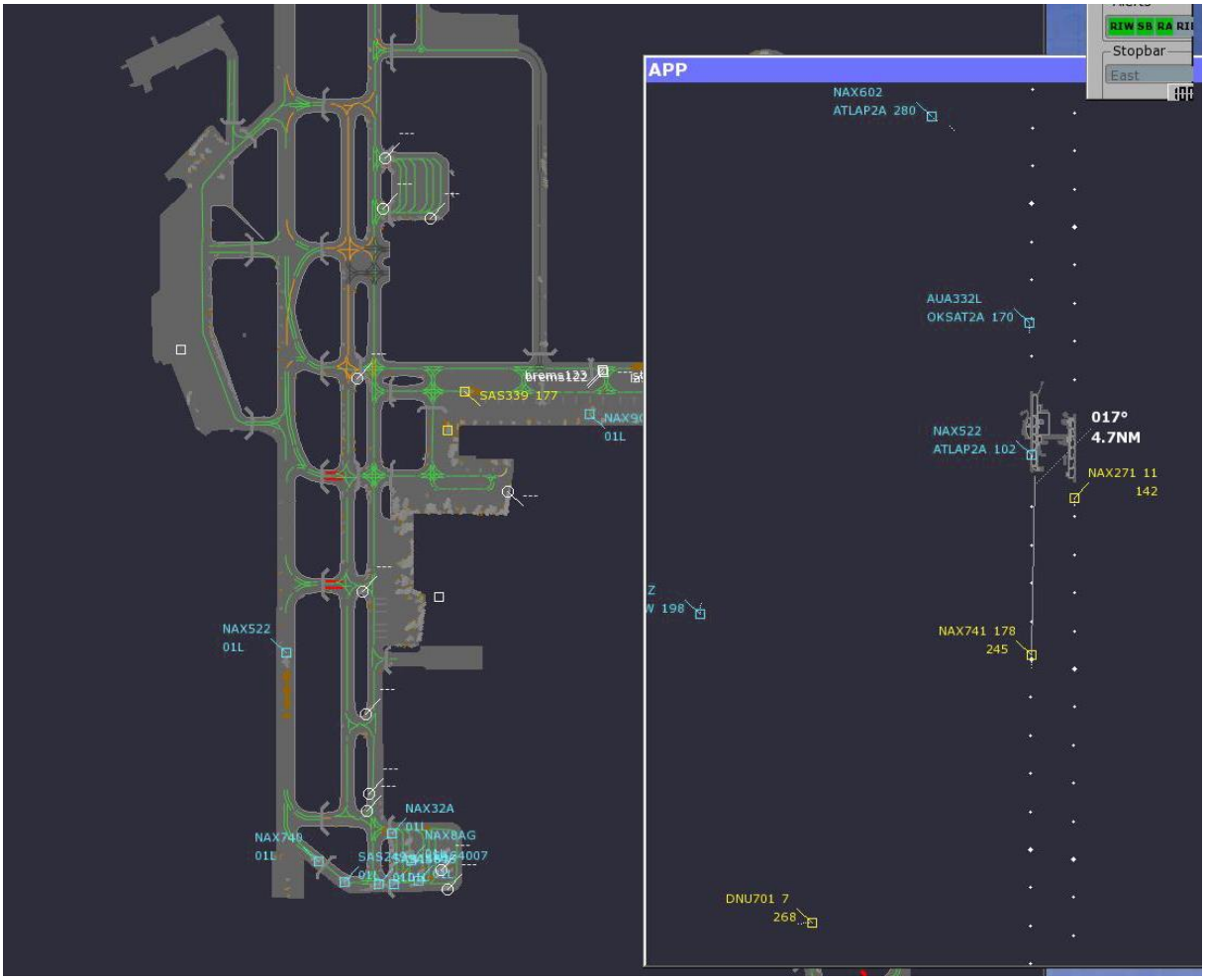
ACAS	Airborne Collision Avoidance System
ACC	Area Control Center
AFE	Above field elevation
AGL	Above ground level
AIBN	Accident Investigation Board Norway
AIP	Aeronautical Information Publications
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider (here: Avinor)
APP	Approach control
ARR	Arrival; sector in the approach control (APP)
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
ATS	Air Traffic Services
BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (the French accident investigation board)
BSL	Bestemmelser for sivil luftfart (Regulations for civil aviation)
CPA	Closest Point of Approach
CTR	Control zone
CVR	Cockpit Voice Recorder
DEP	Departure; sector in the approach control (APP)
DIR	Director; sector in the approach control (APP)
EASA	European Aviation Safety Agency
ENGM	Oslo/Gardermoen
ENOS	OSLO Air Traffic Control Center at Røyken
FMC	Flight Management Computer
FDR	Flight Data Recorder
GND	Ground; sector in the control tower
GS	Ground speed
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument meteorological conditions
LOA	Letter of Agreement
NM	Nautical Mile
OPC	Operator Proficiency Check
PFO	Periodisk faglig oppdatering (Periodic professional update)
RIM	Runway Incursion Monitoring
STCA	Short Term Conflict Alert

TCAS	Traffic Alert and Collision Avoidance System
TCAS RA	TCAS Resolution Advisory
TCAS TA	TCAS Traffic Advisory
THR	Threshold; Runway threshold
TMA	Terminal maneuvering area
TWR	Tower; sector in the control tower
UHF	Ultra High Frequency
UTC	Coordinated Universal Time
VHF	Very High Frequency
VMC	Visual Meteorological Conditions

Appendix B: Arrival Chart Oslo/Gardermoen RWY 01L/R



Appendix C: Situation Image from the Traffic Surveillance System



Playback from the ground surveillance system at time 07:33:22 shows the aircrafts' positions relative to each other approximately one minute before NAX741 reported a missed approach.

The situation image consists of two screens showing traffic on the ground and in the air. Blue track labels for departures; yellow for arrivals. The distance between each white dot on the extended center line of the runway is one nautical mile (NM).

The image to the left shows NAX522 during takeoff run on runway 01L. At the same time NAX740 has crossed the stop bar in holding position at the entry onto runway A1. On the deicing platform south 01L 6 more departures are waiting.
The snow clearance vehicles is about to move from the western to the eastern runway (the last vehicle is "brems 122", white label, taxiway G, north of the terminal).

The image to the right with the caption "APP" (Approach) shows traffic in the air at the same time. NAX271 was the last aircraft to land on the eastern runway, 01R, before it was closed for snow clearance. NAX741 was on approach to runway 01L with a speed of 245 kt ("178" is the parking stand that NAX741 was given). The distance cursor (white line) shows that NAX741 was at appr. 4.7 NM from the runway threshold.
NAX740 was cleared for takeoff at time 07:33:50. NAX741 reported a "go -around " 40 seconds later. Minimum horizontal distance between the aircraft was registered at time 07:35:28 using FDR data; see Appendix D.

Appendix D: Animation/Correlation of FDR data

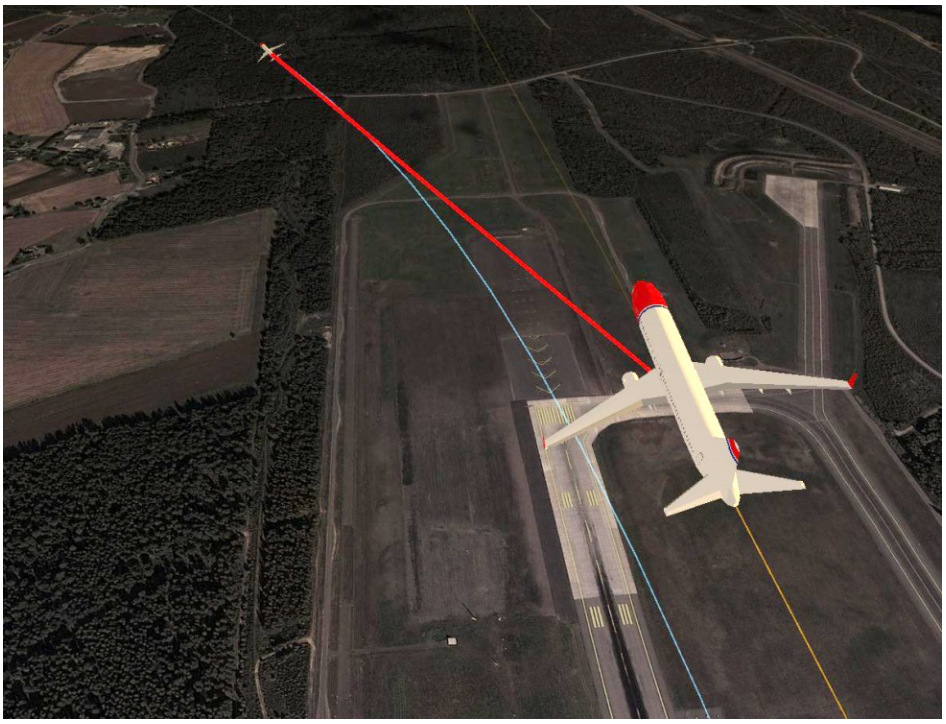


Figure D 1*): At time 07:35:28. Correlation of FDR data shows that the minimum distance between the two aircraft was 0.17 NM horizontally and 500 ft vertically. Both aircraft were in clouds at this time, which is not depicted in the image.*

Slant range (the red line) is 352 m (0.19 NM), altitude difference was 152 m (500 ft), i.e. the distance between the two aircraft, projected onto the line was 317 m (0.17 NM). Rounded to 0.2 NM.

Figure D 2*): The same time as in figure D 1, but looking west.*
The animation images in the figures were produced at Norwegian Air Shuttle based on FDR data from both aircraft.