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Aircraft Accident Investigation Bureau AAIB

Final Report No. 2093 by the Aircraft Accident Investigation Bureau

concerning the serious incident - Airprox

involving the Boeing 737-300 aircraft, registration D-ABXY,

operated by Deutsche Lufthansa under ATC callsign DLH 1LA

and the Airbus A320-200 aircraft, registration JY-AYF,

operated by Royal Jordanian Airlines

under ATC callsign RJA 149

on 24 October 2007

2.4 NM north-north-east of the Kloten beacon

Aéropôle 1, Route de Morens, CH-1530 Payerne

General information on this report

This report contains the Aircraft Accident Investigation Bureau's (AAIB) conclusions on the circumstances and causes of the serious incident which is the subject of the investigation.

In accordance with art 3.1 of the 9th edition, applicable from 1 November 2001, of Annex 13 to the Convention on International Civil Aviation of 7 December 1944 and article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the incident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

All times in this report, unless otherwise indicated, follow the coordinated universal time (UTC) format. At the time of the accident/serious incident, Central European Time (CET) applied as local time (LT) in Switzerland. The relation between LT, CET and UTC is: LT = CET = UTC + 2 hours.

For reasons of protection of privacy, the masculine form is used in this report for all natural persons, regardless of their gender.

Contents

Final Report

Synopsis

Aircraft 1	
Owner	Deutsche Lufthansa AG, Cologne, Germany
Operator	Deutsche Lufthansa AG, Cologne, Germany
Manufacturer	Boeing Commercial Airplanes, Seattle, Washington, USA
Aircraft type	Boeing 737-300
Country of registration	Germany
Registration D-ABXY	
ATC callsign	DLH 1LA
ATC callsign	Lufthansa one lima alfa
Commercial flight number	DLH 3728
Flight rules	IFR
Type of operation	Scheduled flight
Departure point	Frankfurt (EDDF)
Destination point	Zurich (LSZH)
Aircraft 2	
Owner	Hashemite Kingdom of Jordan
Operator	Royal Jordanian Airlines
Manufacturer	Airbus S.A.S., Toulouse, France
Aircraft type	Airbus A320-200
Country of registration	Jordan
Registration JY-	AYF
ATC callsign	RJA 149
Radio callsign	Jordanian one four niner
Flight rules	IFR

Type of operation	Scheduled flight
Departure point	Zurich (LSZH)
Destination point	Amman (OJAI)
Location	2.4 NM north north-east of VHF beacon Kloten (KLO) Swiss sovereign territory
Date and time	24 October 2007, 12:39 UTC
ATC units	Terminal control Zurich (TCZ) Aerodrome control (tower – TWR) Approach control (approach east – APE) Departure control (departure – DEP)
Airspace Class	C
Minimum separation of the two aircraft	1.1 NM horizontally and 600 ft vertically
Applicable minimum separation	3 NM horizontally or 1000 ft vertically
AIRPROX category of the serious incident	ICAO category A – high risk of collision

Investigation

The serious incident took place on 24 October 2007 at 12:39 UTC. Notification was received at the Aircraft Accident Investigation Bureau (AAIB) on 26 October 2007 at 16:06 UTC. After preliminary clarifications, which are usually necessary with this type of serious incident, the investigation was opened on 31 October 2007.

The AAIB reported the serious incident to the investigating authorities of the Federal Republic of Germany and the Kingdom of Jordan. Both states then nominated an authorised representative.

The present investigation report is published by the Swiss AAIB.

Summary

At about 12:35 UTC on 24 October 2007, the Boeing 737-300 commercial aircraft with the ATC callsign DLH 1LA was on an ILS approach on runway 14 in Zurich. At 12:36 UTC, RJA 149 took off from runway 10 on standard departure route VEBIT TWO ECHO. After take-off, this route involves a left turn in a westerly direction to overfly runway 14 again and the runway 14 approach base line is crossed.

At 12:37:41 UTC, DLH 1LA had aborted its ILS approach at 2900 ft QNH for technical reasons, initiated a missed approach procedure and shortly before overflying the end of runway 14 was already at the standard missed approach altitude of 5000 ft.

At the same time, flight RJA 149 was climbing on an intersecting westerly heading and was passing an altitude of 4800 ft QNH, when the traffic alert and collision avoidance system (TCAS) generated a resolution advisory (RA) in both aircraft. The closest point of approach between DLH 1LA and RJA 149 occurred at 12: 39:06 UTC, with a lateral distance of 1.1 NM and an altitude difference of 600 ft ; the minimum separation should have been 3 NM horizontally or 1000 ft vertically.

Causes

The serious incident arose as a result of the inadvertent convergence of a commercial aircraft taking off from runway 10 and a commercial aircraft going around on runway 14, which involved a high risk of collision. It is attributable to a runway use concept in a 'Bise' wind situation which overtaxed the air traffic controllers involved because it featured the following shortcomings:

- Procedural separation was not ensured for the standard departure route VEBIT TWO ECHO from runway 10 and the standard missed approach procedure for runway 14.
- The corresponding safety classification had not registered the hazard adequately.
- The air traffic controllers had been inadequately trained in respect of the possible conflict situation and were therefore surprised by it.

Safety recommendations

Within the framework of the investigation, one safety recommendation was issued.

1 Factual information

1.1 History of the flight

1.1.1 General

The recordings of radiocommunications traffic, radar data and the statements of crew members and air traffic controllers were used for the following description of the history of the flight and flight preparations.

At the time of the serious incident, a commander under supervision was the pilot flying (PF) and a first officer (FO) was the pilot not flying (PNF) in the cockpit of DLH 1LA. A supervising commander was also in the cockpit.

At the time of the serious incident, a commander under supervision was PF and a first officer was PNF in the cockpit of RJA 149. A supervising commander was also in the cockpit.

Both flight DLH 1LA and flight RJA 149 were taking place under instrument flight rules.

In terms of air traffic control, Terminal Control Zurich (TCZ) with the tower, approach and departure units was responsible.

1.1.2 Flight preparations

The Sector East approach controller (approach east - APE) had come on duty shortly before the serious incident and had not been deployed on any other workstation prior to this. He stated that there was a low volume of traffic for his sector.

The aerodrome controller (aerodrome control – ADC) came on duty in the second half of his shift. He had previously been working at other positions. According to his statements, at the time of the serious incident the traffic volume was average and the workload, characterised by take-offs from runway 10 and landings on runway 14, was average to high. The aerodrome controller felt in good form physically.

The departure (DEP) coach, together with his trainee, had come on duty at 12:00 UTC after a briefing and occupied the workstation at 12:15 UTC. Neither had previously been working at another workstation. At the time of the serious incident, the trainee was three days from the final skill assessment (FSA). The coach had been assigned to him for three days; the incident occurred on the second day. According to his statement, the volume of traffic was "average to high" and its complexity was high because of the wind situation. The departure trainee felt well, according to his statements. The departure coach felt in good form physically. He was working with a radiocommunications set consisting of headphones and a clip-on microphone (head set) and, as the trainer, sat on the trainee's left. Air traffic control including radiocommunications was handled by the trainee.

All technical air traffic control systems were operating normally.

The Deutsche Lufthansa Boeing B737-300 aircraft with the ATC callsign DLH 1LA had taken off on 24 October 2007 from Frankfurt (Germany) on a flight to Zurich. For the commander in training, the flight served as a final check examination for the upgrade to become a captain.

The Royal Jordanian Airlines Airbus A320-200 with the ATC callsign RJA 149 was scheduled for a flight from Zurich to Amman (Jordan) on 24 October 2007.

According to the statements of the flight crews on both aircraft, the flights had proceeded with no noteworthy anomalies up to the serious incident.

1.1.3 History of the serious incident

At 12:31:52 UTC, the crew of DLH 1LA made contact with Zurich Approach East (APE) on the 120.750 MHz frequency and requested clearance to continue their descent. At 12:32:00 UTC, after flying into the Terminal Control Area (TMA), the Approach East controller cleared them to descend to flight level FL 80, at 12:32:46 UTC to 5000 ft and at 12:34:50 UTC to 4000 ft.

At 12:34:40 UTC, the crew received an instruction to turn left onto heading 160° and clearance for an instrument approach (instrument landing system ILS) on runway 14. This clearance was linked to a request to report when they were established on the approach path. At 12:36:50 UTC, the crew reported that they were established on the ILS 14 localiser. Following this came the APE controller's instruction to contact aerodrome control on the 118.100 MHz frequency.

At 12:37:08 UTC, the crew of DLH 1LA reported to Zurich tower and then received from aerodrome control (ADC) wind information of 040° with a speed of 6 kt and landing clearance for runway 14. At this time, the aircraft was approximately 5.7 NM before the threshold of runway 14. There was no longer any aircraft approaching runway 14 in front of DLH 1LA.

The Royal Jordanian Airlines Airbus A320-200, ATC callsign RJA 149, was cleared to take off from runway 10 in Zurich at 12:35:38 UTC. It had been assigned departure route VEBIT TWO ECHO.

At 12:37:23 UTC, the crew of RJA 149 were instructed by aerodrome control to contact departure control (DEP). After their first call at 12:37:29 UTC, the departure controller identified the aircraft and instructed the crew to climb to FL 120 and report their current altitude. The crew confirmed the instruction to climb to FL 120 and reported passing 4200 ft at 12:37:39.

At 12:37:33 UTC, an executive aircraft received clearance to take off from runway 10. A few seconds later, it began its take-off run and lifted off.

At 12:37:41 UTC, the pilot flying DLH 1LA switched off the autopilot and initiated a go-around. At this time, the aircraft was approximately 4.5 NM before the threshold of runway 14. The missed approach procedure was begun at an altitude of 2900 ft QNH; the aircraft's landing gear was extended and the flaps were set at 30°.

The commander later cited the following as a justification for the go-around: "*The flight was laterally and vertically established. However there was an over speed condition with power in idle. According to company procedure all mentioned parameters have to be within certain limits latest at 1000 ft above airport level*
(AAL). A glance to the Radio Altimeter showing 1000 ft above ground level (AGL) – high terrain in the approach path – and not AAL lead to the decision to abort the approach".

At 12:38:10 UTC, the crew of DLH 1LA informed the ADC controller: *"And tower Lufthansa one Lima Alfa, going around runway one four". At this time the* DLH 1LA was approximately 3.2 NM from the threshold of runway 14. The ATCO then gave the following instruction: "*Lufthansa one Lima Alfa, roger, follow standard missed approach procedure, five thousand feet*". The instruction was immediately confirmed by the crew.

The ATCO then pressed the go-around button in the tower approach communication system (TACO). This notified approach control; no further coordinations took place.

According to the aerodrome controller's statement, RJA 149, which had taken off, was visible on the radar. However, his attention was on a departure from runway 10 following the Jordanian aircraft. Departures from runway 10 must be coordinated with approaches on runway 14 (cf. section 1.6.3.2). In this case, he was concentrating on this departure and on the approach of DLH 1LA.

As a result of the audio "go-around" message, the departure trainee and the coach realised more or less simultaneously that the Lufthansa aircraft was already climbing and had already passed approximately 4000 ft. RJA 149 was on a westerly heading, on the assigned departure route. The conflict which was now developing was detected at the same time by the coach and the trainee. At 12:38:30 UTC, the trainee issued traffic information to the crew of RJA 149 about traffic which was just passing 4000 ft in the course of a missed approach procedure: "*Jordanian one four niner, traffic on your twelve o'clock, five miles, it's going around now passing four thousand, climb immediately to six thousand feet*". The answer according to the radiotelephony recording is not comprehensible. The departure trainee then issued the instruction "*climb immediately to 6000 ft"*, in order to establish vertical separation as quickly as possible.

The departure coach then took over radiotelephone communications. However, he did not have the impression that his trainee was overstretched. His intervention was intended to ensure that the subsequent instructions were given quickly and correctly, as time was pressing and everything was happening in a few seconds. This assumption of control did not surprise the trainee. He later assessed it as a spontaneous reaction, which he could understand.

At 12:38:39 UTC, the short-term conflict alert (STCA) became visible on the ATC radar screens. At this time DLH 1LA was at the 12 o'clock position in relation to RJA 149 and 4.1 NM away.

At 12:38:47 UTC, the crew of RJA 149 were instructed by the departure coach: "*Jordanian one four niner, turn right immediately".* The first word before the call-sign is unintelligible on the readback from the crew. The ATCO immediately asked whether the crew had visual contact with the other aircraft. There was no answer.

On the traffic alert and collision avoidance system (TCAS), the crew of DLH 1LA detected that an aircraft was converging from the left above them. On the basis of this TCAS information and not because they had visual contact with the converging aircraft, they reported to aerodrome control at 12:38:48 UTC: "*Lufthansa one Lima Alfa we have a target two miles, er, eleven o'clock position*". At approximately the same time they attained the standard missed approach altitude of 5000 ft QNH. The ADC controller then replied: "*Just wanted to tell you, that is an airbus three twenty, five thousand two hundred feet, at your ten o'clock position two miles".* The crew then immediately reported: "*Lufthansa one Lima Alfa is on a TCAS descent, TCAS descent*". During the TCAS traffic advisory (TA) and resolution advisory (RA) the landing gear was retracted, the flaps were in position 1 and the indicated airspeed was approximately 200 knots.

At 12:39:01 UTC, the departure controller informed the crew of RJA 149: "*Jordanian one four niner, traffic twelve o'clock half a mile".* This information was answered only with "okay". At 12:39:12 UTC, DEP then instructed the crew: "*Jordanian one four niner, you're now clear of traffic and turn left now heading two three zero".*

The closest point of approach between DLH 1LA and RJA 149 occurred at 12:39:06 UTC, with a lateral distance of 1.1 NM and an altitude difference of 600 ft.

The minimum separation prescribed in this case is 3 NM horizontally or 1000 ft vertically.

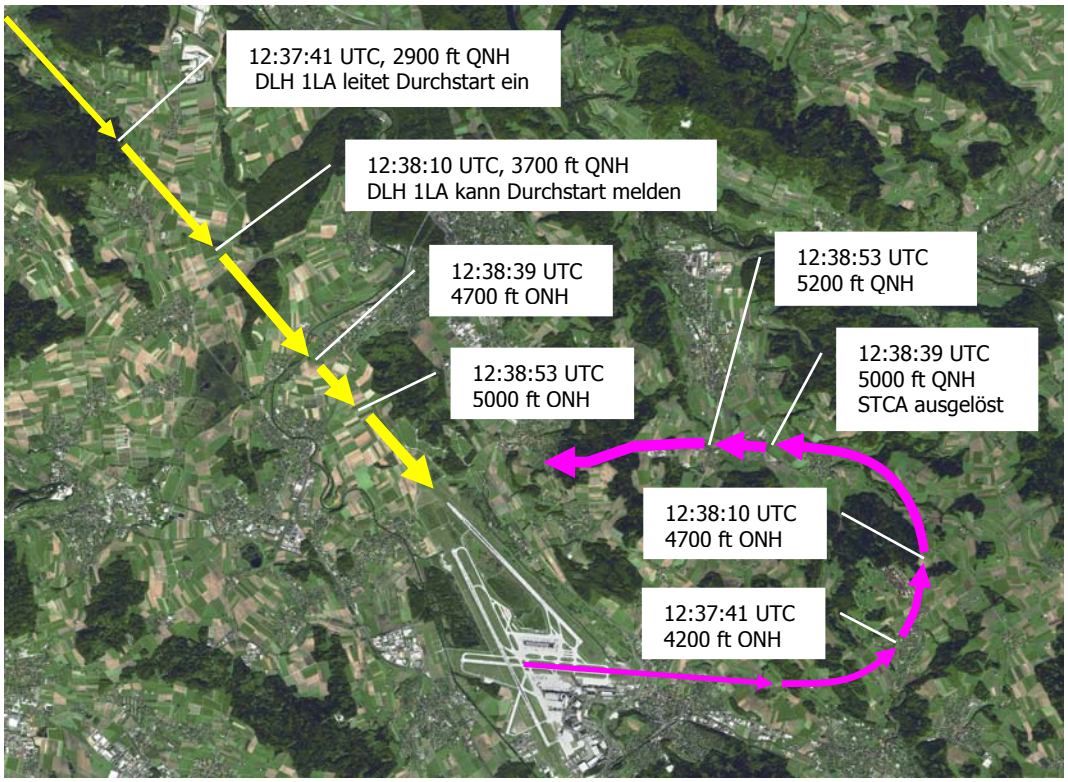

Figure 1: Schematic representation of some selected situations during the serious incident. Flight DLH 1LA is shown using yellow arrows and flight RJA 149 is shown using magenta arrows. The final position of the lines of arrows corresponds to the minimum distance between the two aircraft at 12:39:06 UTC.

At 12:39:17 UTC, the ADC controller informed the crew of DLH 1LA that the danger with the other aircraft no longer existed and that it would cross behind them. The crew replied with the information that they were now climbing back to 5000 ft.

At 12:39:39 UTC, DEP requested confirmation from the crew of RJA 149 that they were turning left and then assigned heading 220°. This instruction was confirmed by the crew with the comment that they had received a TCAS resolution advisory. The ATCO asked for a repetition, which was made as follows: "*Okay, we have a resolution advisory, RA for our TCAS, for traffic*". The DEP controller thanked them, saying that this was now understood and shortly afterwards instructed them to turn left, in the direction PINOB. The departure coach then handed traffic control back to the trainee.

As the crew of RJA 149 later stated, they had first detected the conflict on the TCAS display when passing 4800 ft QNH. They reported the TCAS resolution advisory (RA) after the two aircraft had crossed. During the TCAS TA and RA, the aircraft was in clean configuration, i.e. both the gear and the high-lift devices were retracted. There was never any visual contact with DLH 1LA.

During their second landing approach, at 12:42 :30 UTC the APE controller asked the crew of DLH 1LA for the reason for the go-around. The crew replied: *"Lufthansa one Lima Alfa, we were not established for the approach".* At 12:47:02 UTC, a further question followed concerning the altitude at which the go-around was initiated. The crew replied*:"….altitude was two thousand nine hundred feet".*

Flight DLH 1LA landed shortly afterwards in Zurich, whilst RJA 149 continued its flight to its destination of Amman.

1.1.4 Location of the serious incident

Geographical position	2.4 NM north-north-east of the Kloten VHF omnidirectional radio beacon (KLO)
Date and time	24 October 2007, 12:39:06 UTC
Lighting conditions	Daylight
Height above sea level or flight altitude	DLH 1LA: 4900 ft/QNH RJA 149: 5500 ft/QNH

1.2 Personnel information

1.2.1 Crew of DLH 1LA

1.2.1.1 Commander under supervision

1.2.1.1.1 General

Person	German citizen, born 1969
Licence	Airline transport pilot licence aeroplane (ATPL(A)) according to joint aviation requirements (JAR), first issued by the German supervisory authority on 11 May 1993
Ratings	Type rating Boeing 737-300 to 800 as pilot in command
Instrument flying rating	Instrument flying category 3 for Boeing 737 IR ME(A)
Last proficiency check	Simulator check
Medical fitness certificate	Class 1
Last medical examination	21 February 2007

1.2.1.1.2 Flying experience

Total	8000 hours
on the type involved in the incident	2140 hours

1.2.1.2 Copilot

Person	German citizen, born 1983

1.2.2 Flight crew of RJA 149

1.2.2.1 Commander under supervision

1.2.2.1.1 General

Person	Jordanian citizen, born 1969
Licence	Airline transport pilot licence aeroplane (ATPL(A)), issued by the supervisory authority of the Kingdom of Jordan on 19 August 2004
Relevant ratings	Type rating for Airbus A320
Medical fitness certificate	Class 1 Valid till 26 November 2007

1.2.2.1.2 Flying experience

Total	10 000 hours
on the type involved in the incident	3000 hours

1.2.2.2 Copilot

Person Unkn	own

1.2.3 Air traffic control

1.2.3.1 Air traffic controller 1

1.2.3.1.1 Person

Function	Approach controller sector approach east (APE)
Person	Austrian citizen, born 1967
Start of duty on the day of the incident	Shortly before the serious incident
Licence	Licence for air traffic controller in an aerodrome control unit, first issued by Austro Control on 29 September 1992, extended by radar licence on 8 January 1995. Air traffic controller licence based on European Community directive 2006/23, first issued by the FOCA on 26 August 2001

1.2.3.1.2 Additional information

After the "go-around call" by the aerodrome controller, the APE controller went to the departure controller and looked at what had occurred. He stated that the situation had greatly alarmed him. The later justification from the crew of DLH 1LA for initiating the missed approach "…we were not established" did not coincide with his observations, as he stated that the approach was proceeding correctly. Under the prevailing conditions (weather, airspeed and altitude of the aircraft), it was his view that a go-around would not have been expected. He stated that he had never experienced a similar incident before.

1.2.3.2 Air traffic controller 2

1.2.3.2.1 Person

Function	Aerodrome controller, aerodrome control (ADC)
Person	Swiss citizen, born 1976
Start of duty on the day of the incident	between 7 and 8 UTC
Licence	Air traffic controller licence based on European Community directive 2006/23, first issued by the FOCA on 28 August 2004, valid till 18 August 2008.
Relevant ratings	Aerodrome control, valid till 18 August 2008

1.2.3.2.2 Additional information

According to the ADC controller's statement, on the basis of the radar information during the approach there was nothing which would have indicated a go-around.

He also stated that he had never experienced such an incident before. However, on the basis of the crossing flight paths, this problem was apparently already known, by analogy with runways 14/16, and had already been discussed internally. In his opinion, the incident was not covered by procedures. Nor could he recall that this problem had ever been broached officially.

1.2.3.3 Air traffic controller 3

1.2.3.3.1 Person

Function	Trainee departure coach (DEP)
Person	Swiss citizen, born 1970
Start of duty on the day of the incident	12:00 UTC
Licence	Air traffic controller licence based on European Community directive 2006/23, first issued by the FOCA on 15 November 1996, valid till 19 March 2008

Relevant ratings	Approach radar control, valid till 19 March 2008 Coaching, valid till 19 March 2008

1.2.3.3.2 Additional information

According to his statements, the departure coach had never experienced a comparable situation before. He was surprised that there had been no signs of a go-around and that he had not been expecting one. He explained that such situations would certainly have been trained for within the framework of a proficiency training and assessment concept (PTC), but only from the viewpoint of the ADC controller and only in regard to separation after the respective end of a runway had been overflown. The problem of departures on SID VE BIT TWO ECHO with regard to approaches and missed approaches on runway 14 would persist. He suggested either changing the departure route or increasing separation between approaches.

In conclusion, the coach noted that the rate of climb of DLH 1LA seemed to him to be relatively high during the go-around manoeuvre.

1.2.3.4 Air traffic controller 4

1.2.3.4.1 Person

Function	Departure (DEP) trainee controller
Person	Swiss citizen, born 1982
Start of duty on the day of the incident	12:00 UTC
Licence none	
Relevant ratings	none

1.2.3.4.2 Additional information

The departure trainee had never experienced a similar situation and was initially taken by surprise. According to his statement, this conflict situation had not been dealt with in the training phase or on the simulator.

In conclusion, the trainee noted that the rate of climb of DLH 1LA seemed to him to be relatively high during the go-around manoeuvre.

1.3 Aircraft information

1.3.1 DLH 1LA aircraft

Registration D-ABXY

Aircraft type	Boeing 737-300
Characteristics	Twin-jet short-haul and medium-haul commercial aircraft
Manufacturer	Boeing Commercial Airplanes, Seattle, Washington, USA

	Owner	Deutsche Lufthansa AG, Cologne, Germany
	Operator	Deutsche Lufthansa AG, Cologne, Germany
1.3.2	RJA 149 aircraft	
	Registration JY-	AYF
	Aircraft type	Airbus A320-200
	Characteristics	Twin-jet short-haul and medium-haul commercial aircraft
	Manufacturer	Airbus S.A. S., Toulouse, France
	Owner	Hashemite Kingdom of Jordan
	Operator	Royal Jordanian Airlines

1.4 Meteorological information

1.4.1 General

The information in sections 1.4.2 to 1.4.4 was provided by MeteoSwiss.

1.4.2 General meteorological situation

The weather in Switzerland was defined by a low-pressure area which was centred over the Mediterranean and a high-pressure area over Scandinavia and Russia. As a result of the influence of high pressure, a "Bise" situation arose in the Mittelland region, which in the lower atmospheric strata was causing humid, cold air to be driven towards the north side of the Alps.

1.4.3 Weather at the time of the serious incident

The following information on the weather at the time of the serious accident is based on a spatial and chronological interpolation of the observations of different weather stations.

Quotation from MeteoSwiss report

Altitude	*Visibility [km]*	*Temperature/dewpoint [°C]/[°C]*	*Wind [degree/kt]*	*Peak gusts [kt]*
Ground LSZH	*20*	*6/1*	*040/5*	*14*
1000 ft AAL	*~10*	*3/1*	*050/15*	*20*
2000 ft AAL	*~5*	*1/-1*	*060/15*	*20*
3000 ft AAL	*IMC*	*-2/-2*	*060/15*	*-*
4000 ft AAL	*IMC*	*-4/-5*	*080/20*	*-*

Cloud: base 7-8/8 at 3600 ft AMSL
ceiling at approx. 6000 ft AMSL

1.4.4 Aerodrome meteorological reports

From commencement of operation on the morning of 24 October 2007 up to the serious incident, the following aerodrome meteorological reports (aviation routine weather report in aeronautical meteorological code – METAR) applied:

240420Z 04011KT 010V070 8000 OVC013 04/01 Q1016 NOSIG

240450Z 03007KT 360V070 8000 OVC014 04/01 Q1016 NOSIG

240520Z 04008KT 360V070 8000 OVC014 04/01 Q1016 NOSIG

240550Z 05005KT 340V080 8000 OVC015 04/01 Q1016 NOSIG

240550Z 05005KT 340V080 8000 OVC015 04/01 Q1016 NOSIG

240620Z 07008KT 030V120 9999 OVC016 04/01 Q1017 NOSIG

240650Z 05006KT 010V100 9999 OVC015 04/00 Q1017 NOSIG

240720Z 05007KT 010V100 9999 OVC015 04/01 Q1017 NOSIG

240750Z 05010KT 9999 OVC016 04/00 Q1017 NOSIG

240820Z 05009KT 9999 OVC020 04/00 Q1017 NOSIG

240850Z 06009KT 9999 FEW017 OVC023 05/00 Q1017 NOSIG

240920Z 05011KT 010V080 9999 SC018 OVC023 05/01 Q1017 NOSIG

240950Z 04008KT 010V080 9999 SC018 OVC023 05/01 Q1017 NOSIG

241020Z 05009KT 010V070 9999 SC018 OVC023 05/01 Q1017 NOSIG

241050Z 05011KT 010V100 9999 FEW018 BKN023 05/01 Q1017 NOSIG

241120Z 05009KT 9999 BKN020 05/00 Q1017 NOSIG

241150Z 06009KT 9999 BKN022 05/00 Q1017 NOSIG

241220Z 04009KT 9999 BKN022 06/00 Q1016 NOSIG

1.4.5 Weather conditions according to information from the crew of DLH 1LA

The descent in the initial and intermediate approach was carried out under visual meteorological conditions (VMC). The final approach, initiation of the missed approach procedure and the initial climb after initiation of the go-around manoeuvre took place under instrument meteorological conditions (IMC).

1.5 Safety systems

1.5.1 Airborne collision avoidance system[1]

Functioning collision avoidance systems (traffic alert and collision avoidance system (TCAS)) were fitted to both aircraft; they provided traffic information (traffic advisories TA) and instructions for the resolution of the conflict (resolution advisories RA). According to the available information, both flight crew reacted immediately and in accordance with the system commands.

[1] Airborne collision avoidance system (ACAS) is the term for the basic concept. The International Civil Aviation Organization (ICAO) uses this term when drafting standards with which the system must comply. The traffic alert and collision avoidance system (TCAS) is a concrete implementation of this concept.

1.5.2 Short-term conflict alert

The Skyguide radar system included a convergence warning system (short-term conflict alert – STCA). In accordance with its design, it made the air traffic controllers aware of the impending conflict in the present case.

1.6 Organisational and management information

1.6.1 National procedures

1.6.1.1 General

The Swiss aeronautical information publication (AIP) is a reference work produced in accordance with the standards of the International Civil Aviation Organisation (ICAO), with information relevant to aviation. It describes the general rules and procedures, such as aerodrome charts with take-off and landing procedures and information on radio navigation devices. At the time of the serious incident, the following regulations, among others, applied.

1.6.1.2 Approaches

2.21.2.1 ***Approaches***

The descent shall be arranged so as to maintain ENR configuration as long as possible considering safety and ATC requirements. Speed reduction and extension of landing gear and high lift devices are to be planned in such a way, that landing configuration is established and correct approach speed is reached shortly prior to or at D5 IKL respective IZH.

1.6.1.3 Missed approaches and go-around procedures

2.21.2.1.2 ***Missed Approach ILS RWY 14:***

Climb on TR137. Initial climb to 5000 ft. At D4 IKL past the station, turn left (MAX IAS 210 kt). Establish TR360 to intercept R054 KLO. At D9 KLO past the station, continue climb to 7000 ft. Proceed to ZUE at 6000 ft or above. At ZUE intercept R097 ZUE. Proceed to AMIKI.

1.6.1.4 Standard departure routes for instrument approaches on runway 10

RNAV SID RWY 10

VEBIT TWO ECHO DEPARTURE

PROCEDURE DESIGN GRADIENT (PDG) 6.5% to 2500 ft.

Climb straight ahead. At D2.1 KLO or 2500 ft, whichever is later, turn left (MAX IAS 210 kt during turn). Intercept R055 WIL.

Proceed via BREGO, ZH558 to VEBIT. Cross BREGO at 5 000 ft or above, ZH554 at 6000 ft, ZH558 at 7000 ft or above. RNAV applicable when passing BREGO.

INITIAL CLIMB CLEARANCE 5000 ft. When instructed contact Zurich DEP 125.950. For routing after VEBIT, see LSZH AD 2.24.6 – 3.

In this context it should be noted that on the chart for runway 10 standard departures (SID chart ICAO LSZH AD 2. 24. 7. 2 -1 standard departure SID RWY 10), an additional height restriction is entered which is not reproduced in the text of SID VEBIT TWO ECHO (LSZH AD 2. 24. 7. 2 – 3): "*Cross R 360 KLO 4000 ft or above".*

1.6.2 Air traffic control procedures

1.6.2.1 General

The relevant basis for the procedures of these units is specified in the air traffic management manual (ATMM) of the aerodrome and approach air traffic control unit.

At the time of the serious incident, the following regulations, among others, applied.

1.6.2.2 Allocation of tasks

1.6.2.2.1 ADC

ATMM ZURICH TWR/APP, SECTION 3 – TOWER, DUTIES AND RESPONSIBILITIES
1.5.2.4 ADC1 may adjust departure sequence after coordination with GRO

1.6.2.2.2 GRO

ATMM ZURICH TWR/APP, SECTION 3 – TOWER, DUTIES AND RESPONSIBILITIES
1.5.4.1 GRO shall:
b) verify the departure sequence and intervals proposed by TACO and adjust if necessary, taking into consideration the ATFM slots

1.6.2.3 Separation between runway 10 departures and runway 14 approaches

„5.15 IFR SEPARATION BETWEEN DEPARTURES RWY 10 AND APPROACHES RWY 14

5.15.1 When a departure has started take-off roll on RWY 10, an arrival to RWY 14 shall be on the ground or:

a) not closer than 3 NM final if the departing aircraft is a jet or a turboprop

b) not closer than 6 NM final if the departing aircraft is a piston or a heavy

Note: "On the ground" means that the aircraft has touched down on the runway with all wheels."

1.6.3 Runway utilisation concept for Zurich airport

1.6.3.1 General

The operating regulations for Zurich airport prescribe the following concerning runway utilisation: *"The following runway priority arrangement applies to departures between 07.00 and 21.00: runway 28, 10, 34, 32, 16. If the priority runway to be used for departures is not available for safety reasons (e.g. insufficient runway length, special weather conditions, runway condition) or operational reasons (e.g. opposing traffic; snow clearance, runway cleaning), the next runway in the priority sequence is to be used."*

In the event of a strong north-easterly wind (a 'Bise' wind), this generates a tailwind component on runway 28. If this tailwind component exceeds 7 to 10 knots, take-offs are as a rule switched to runway 10. A margin of discretion is granted to the daily ops manager (DOM) for this runway change. In view of the prevailing weather conditions, runway 10 is brought into service rarely and sporadically. Because of the significant capacity limitations and the complex procedures, this procedure is consequently applied only if it is absolutely essential.

1.6.3.2 Utilisation concept for runway 10

The runway 10 utilisation concept includes a high burden of coordination and workload for the ADC and GRO controllers. This is due, among other things, to the following circumstances, which played a part in the present serious incident:

1. Timing between take-offs and landings:

Because of the layout of the runways, a crossing point occurs along the extended centreline of runways 10 and 14. According to pilot's statements, in the event of a pronounced 'Bise' wind situation, there is also an increased probability of a go-around on runway 14, due to turbulence on final approach generated by wind and topography.

In order to resolve a possible conflict with departures, every take-off from runway 10 has to be correlated in terms of time and distance (distance from touchdown) with every landing on runway 14. This dependency prevents fluid traffic management and requires a lot of attention from the ADC controller.

For the ADC controller, this means: aircraft A lands on runway 14; this has to be verified visually. At the same time, aircraft C is already on its approach some 4 NM from the threshold of runway 14. At this moment, a time window of approximately 20 to 30 seconds duration occurs, within which the ADC controller has to clear aircraft B for take-off from runway 10, receive confirmation of this and observe the take-off roll of the aircraft. If, at the point in time at which aircraft C passes a distance of 3 NM from the threshold of runway 14, aircraft B has not yet started its take-off, the take-off clearance for aircraft B must be cancelled. A take-off window for aircraft B on runway 10 only becomes available after aircraft C has landed. If aircraft B takes off as expected, the chronological conditions are generally sufficient to allow the next aircraft to line up on runway 10, so that the next landing slot on runway 14 can be used for a take-off on runway 10.

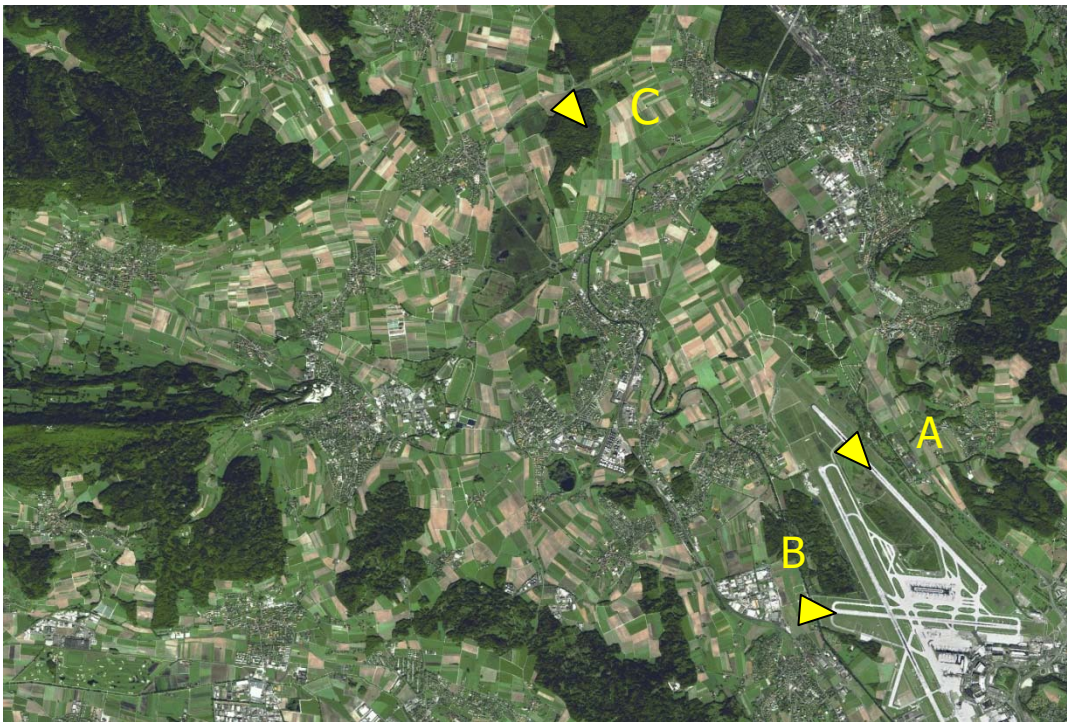

Figure 2: Schematic representation of the coordination concept for a simultaneous approach on runway 14 and a take-off on runway 10. If aircraft A has landed on runway 14 and the next aircraft, aircraft C, approaching runway 14 is still at least 3 NM from the runway threshold, aircraft B must have started its take-off roll on runway 10.

2. Departure planning:

In addition to the timing for take-offs and landings described above, the GRO controller must, if necessary in coordination with the ADC controller, plan the foreseeable traffic flow and landing distances several minutes in advance. In addition, greater landing separations are required for runway 14 for the timing described above for runway 10 departures of aircraft in the heavy wake turbulence category (including the B 757).

Since only limited passing opportunities are available on the taxiways for runway 10, the departure sequence can be changed only to a limited extent. Consequently, planning for increased landing separations has to be adjusted in the departure sequence.

A further difficulty may arise for the ADC controller from the combination of certain departure routes with the different performance characteristics of departing aircraft types. In principle, take-off separations are adjusted in each case according to the expected climb characteristics and speed.

If an aircraft follows a specific departure route, the same flight path is barred to a subsequent aircraft for a certain time. This time span depends on the combination of speed and climbing performance of the departing aircraft. Normally, therefore, a slower aircraft flying in front is taken off the departure route by departure control as quickly as possible using vectors, so that the route becomes free for a subsequent, faster aircraft. However, a clearance deviating from the

departure route may be given by air traffic control for noise abatement reasons only when the corresponding aircraft has reached 5000 ft QNH.

If the aircraft in front is faster than the one following it, the ADC controller will try to allow the latter to take off with the shortest possible gap. Conversely, behind a slow aircraft the gap in relation to the following, faster aircraft has to be increased.

The largely uniform take-off rhythm from runway 10 dictated by the landings on runway 14 makes such adaptations to the sequence more difficult and demands constant deliberation. Depending on the situation, the ADC controller has to allow one or more take-off windows for runway 10 to go unused.

1.6.4 Safety clarifications

1.6.4.1 Summary

The standard departure procedures for runway 10 exhibit various points of conflict with the standard missed approach procedures for runway 14, since the corresponding flight paths cross.

On 9 May 2006 the Federal Office of Civil Aviation (FOCA) asked the Skyguide company to provide proof that safety is adequately guaranteed, among other things, for the procedure applied at the time of the serious incident to runway 10 take-offs and runway 14 landings. A group of experts from Skyguide, Zurich airport and an airline subsequently conducted functional hazard assessment (FHA) GATO 14/10 and 34/32 according to ESARR 4; this was submitted to the FOCA on 14 June 2007 and subsequently approved by the latter. This safety clarification came to the conclusion that "*safety can be adequately guaranteed with the currently applicable procedures*".

With regard to the present serious incident, the following extracts from FHA GATO 14/10 and 34/32 are of significance:

1.6.4.2 Goal

"The goal is to demonstrate that the existing system is acceptably or at least tolerably safe. If the assessment uncovers hazards which are considered as unacceptable, these shall be addressed and mitigated immediately. Additionally, any other observations about how the safety level could be improved shall be addressed."

1.6.4.3 Scope of the safety clarification

"The scope of the safety case is to identify the hazards associated with

- *Potential conflicts between IFR departures on any SID RWY 10 LSZH and IFR arrivals LSZH RWY 14 on any published instrument approach procedure conducting a missed approach.*

(…) within the following system boundaries:

- *The departure phase from the issuance of the take-off clearance RWY 10 or RWY 32 until the departing aircraft reaches 5000 ft AMSL.*
- *Arriving aircraft from FAP/FAF RWY 14 or RWY 34 until the end of the missed approach procedure."*

1.6.4.4 Description of the hazard

In the FHA, the combination of a departure from runway 10 and a go-around by an aircraft approaching runway 14 is listed as the first hazard (hazard 01 – H01): *"Departing flight on SIDs VEBIT 2E, ALBIX 1D or WIL 1D and missed approach performed by an arrival RWY 14."*

1.6.4.5 Consequence of the hazard

With regard to the consequences of such a situation on aviation safety, the FHA mentions the following points: *"Increase in workload, non-standard situation which requires priority treatment."* The safety classification further assumes that such a situation is only of short duration: "*Two aircraft involved for a short period of time*".

1.6.4.6 Dealing with the hazard

The FHA assumes that in the event of a hazard due to the combination of a runway 10 departure and a runway 14 go-around such a situation would be detected quickly, because handling it is part of the standard training of an air traffic controller: *"The situation is likely to be detected, recovery from the situation is possible, as it is part of the standard ATCO training."*

1.6.4.7 Frequency

As an acceptable frequency for such a hazard the FHA states that this should not happen more often than once per month: *"H01 shall not occur more than once per month to once per year".*

1.6.4.8 Assessment of the hazard

The following fundamentals are assumed for a statistical assessment of the hazard:

- The total operating time of Zurich airport air traffic control is 400 000 minutes per year or about 18 hours per day.
- Each year the utilisation concept for runway 10 is applied for 12 000 minutes.
- Each year, 1500 departures take place on runway 10 standard instrument departures.
- The period within which a departing aircraft may be exposed to the hazard is approximately one minute.
- Each year 120 go-arounds take place on runway 14 approaches.
- Each year five go-arounds take place on runway 14 approaches while runway 10 is being used for take-offs.
- In the ten years preceding the FHA, according to the authors of the safety clarification no incident was reported in which safety was compromised during a runway 14 go-around and a simultaneous take-off from runway 10.
- *"The probability that a GA 14 occurs when a DEP 10 is in the hazard area is approx. 0.625 per year. This is assuming that a DEP 10 and a GA 14 occur completely independently".*
  In summary, the FHA therefore came to the conclusion that the probability of an aircraft being below 5000 ft AMSL while a go-around is occurring on a runway 14 approach is approximately 62.5% per year. In other words, on the basis of this probability, such a situation occurs every 1.5 years. It is assumed that a departure from runway 10 and a go-around on runway 14 are two completely independent events.

1.6.4.9 Conclusion of the safety clarification

The safety clarification comes to the following conclusion:

"Based on this FHA it can be concluded that the current OPS procedures are acceptably safe and the mitigations in place are appropriate."

1.6.4.10 Recommendation of the safety clarification

The following recommendation is formulated at the end of the safety clarification:

"Even though the present operation is assessed as being safe, a better segregation of the SIDs and the missed approach nominal tracks could further improve safety by enabling a less complex operation."

2 Analysis

2.1 Technical aspects

Both for the aircraft involved and for the air traffic control systems concerned, there are no indications of any pre-existing technical defects which might have caused or influenced the serious incident.

2.2 Human and operational aspects

2.2.1 Operating concept

Apart from the timing of take-offs and landings as described, visual flight traffic must, if necessary, also be integrated into the traffic concept. According to the ATCO's statements, the close coordination of departure planning with the GRO controller and consideration of the different weight and airspeed categories makes traffic planning more difficult because it demands greater concentration. Consequently, this runway utilisation concept is distinctly more demanding than other concepts.

2.2.2 Air traffic control

The approach of DLH 1LA took place under APE radar vectors until the aircraft entered the runway 14 ILS. Radar vectors and descent instructions were without anomalies and at 12:36:50 UTC the crew reported that they were established on the localiser. According to the statement by the APE, the approach took place without any indication of a possible missed approach. Equally there were no comments concerning vectors or establishment by the crew during the approach.

At 12:35:38 UTC, RJA 149 received take-off clearance, took off from runway 10 and flew on SID VEBIT TWO ECHO. After a left turn, the departure route then crossed the runway 14 final approach on a westerly heading. As a rule, DEP gives a clearance for a climb above 5000 ft as early as the first call. In this case, DEP had cleared RJA 149 to climb to FL 120 after the transfer from ADC.

The ADC controller then concentrated on an aircraft which had received clearance to take off from runway 10 at 12:37:33 UTC and which was on its initial climb. He then cleared an executive aircraft to taxi from the northern taxiway onto runway 10. At approximately this time, the crew of DLH 1LA initiated the go-around. The ADC controller, however, was not aware of this, as he was busy planning the next departure and was concentrating on the area of runway 10 and its taxiways.

After the crew of the executive aircraft had read back this clearance, he instructed an aircraft waiting on the southern taxiway to taxi onto runway 10 as soon as the executive aircraft had taken off. Immediately after the crew concerned had confirmed the conditional clearance, the frequency was free for the first time since DLH 1LA had initiated its missed approach procedure. The crew of DLH 1LA were now able to report that they had initiated a go-around.

The ADC controller now realised that DLH 1LA was going around, upon which he immediately triggered the call-out using the go-around button. By means of this measure he indicated to the other controllers in DEP and APP that a go-around was in progress.

The ADC controller then cleared DLH 1LA for the standard missed approach procedure up to 5000 ft. For the crew of DLH 1LA this was confirmation of the standard missed approach procedure.

The ADC controller was made aware of the conflict between DLH 1LA and RJA 149 shortly afterwards, when the STCA alert was triggered at 12:38:39 UTC.

The coach and his trainee at the DEP position had almost simultaneously detected the impending conflict and somewhat earlier than the ADC controller. At 12:38:30 UTC the trainee attempted to establish the necessary vertical separation by issuing traffic information to RJA 149 and instructing the aircraft to expedite its climb to 6000 ft.

After RJA 149 was first cleared to climb to FL 120, the new instruction to climb quickly to 6000 ft was capable of being misunderstood. At this time, RJA 149 was climbing to 4700 ft.

The coach then took over radiotelephone communications. The entire sequence of events took place within a short time. Attempting to resolve the impending loss of vertical separation had little effect, given the flight phase in which RJA 149 found itself. At this time, RJA 149 was retracting its high-lift devices and was therefore not in a good position to increase its rate of climb.

2.2.3 Flight crews

2.2.3.1 DLH 1LA

There were no anomalies for the crew of DLH 1LA during the descent or during alignment on the instrument landing system. The observations of the air traffic controllers and the recordings of the radar data confirmed an approach within the usual range in terms of altitude and heading. The Commander under observation stated that because of overspeed with simultaneous idle power he had initiated the go-around when a radar altitude of 1000 ft AGL (above ground level) was indicated.

The go-around procedure is applied when it becomes apparent in the course of an approach that the aircraft is not aligned both laterally and vertically on the landing runway or on the instrument landing system when it is at an altitude of 1000 ft AAL (above airport level) at the latest. Moreover, landing configuration, power setting and speed must correspond to the target values. In the present case, according to the crew's assessment, at least one of these values was not within the required range, and this is why the go-around was initiated. This behaviour is usual and appropriate and is also expressly required in the training of cockpit crews.

Aircraft currently in service generally attain high rates of climb in the first phase of a go-around, because at the time of the go-around at the destination aerodrome the fuel for the flight from the departure aerodrome to the destination aerodrome has been consumed, resulting in a relatively low total aircraft mass compared with take-off. In addition, the change in configuration (retracting the gear and partial retraction of flaps and slats) is already taking place during the transition from a descent to a climb.

Furthermore, substantially more kinetic energy is stored in an aircraft during the approach than during take-off, especially if the go-around is initiated because of an approach which is too fast or too high. All these factors result in an aircraft generally exhibiting a distinctly higher rate of climb in the first phase of a go-around than during a take-off. This is a desirable effect, because it ensures that a safe distance between the ground and the aircraft is attained quickly.

In the present case, the standard missed approach altitude of 5000 ft was only about 2000 ft higher than the altitude at which the go-around was initiated. This meant that DLH 1LA reached an altitude of 5000 ft approximately one minute after initiating the go-around and before the threshold of runway 14.

If all parameters are not within the required limits during an approach, the crew may abort an approach at any time and initiate a go-around manoeuvre. The initiation of the go-around by the crew of DLH 1LA was therefore a safety precaution.

The TCAS descent was initiated by the crew without any delay and reported to ATC as soon as the frequency occupancy allowed.

2.2.3.2 RJA 149

RJA 149 was already on the Zurich Departure frequency. According to information from the instructing Commander, acceleration for the purpose of retracting the flaps (acceleration/clean-up) began during the climb at an altitude of 4400 ft. DLH 1LA, which was climbing and converging from ahead and to the right, was still on the Zurich Tower frequency and was noticed during the climb at 4800 ft QNH as a result of the TCAS traffic advisory (TA).

At this time both aircraft were under instrument meteorological conditions. During the TCAS TA and RA the aircraft was in clean configuration. On the basis of the crew statements it can be assumed that the TCAS RA was followed. RJA 149 had in fact already completed the flaps/slats retraction procedure, but may have accelerated further.

In this flight condition only little kinetic energy is available to carry out an upward avoiding manoeuvre, which may have led to the relatively low increase in the rate of climb. It was only possible to comply with the ATC instruction "*climb immediately to 600ft"* to a limited extent for the same reason. The crew followed the corresponding instructions and warnings (TA/RA) in accordance with procedures.

The crew of RJA 149 did not send the essential radio report: *"Jordanian one four niner, TCAS climb".* This report is essential so that air traffic control is informed of a TCAS manoeuvre and may for its part not intervene further until the crew report: *"clear of conflict".*

2.3 Organisational aspects and general conditions

If the VEBIT 2E standard departure procedure is compared with the runway 14 standard missed approach procedure applicable at the time of the serious incident, it is apparent that no standard separation exists between these two procedures. This is known to the air traffic controllers. Separation is guaranteed solely by corresponding instructions from the air traffic controllers and this reduces the procedure's error tolerance.

Moreover, the runway 10 utilisation concept features a relatively high coordination effort and workload for aerodrome control. In view of the fact that it is applied only for about 3 % of the annual operating time, air traffic controllers are not very familiar with it, and this makes it even more challenging. Regular training in this concept on the simulator would therefore be essential.

To clarify the risks, in its letter of 9 May 2006 the Federal Office of Civil Aviation asked Skyguide to provide proof that safety can be adequately guaranteed for the procedure applied at that time of the serious incident to runway 10 take-offs and runway 14 landings. In order to provide such proof, Skyguide conducted a so-called functional hazard assessment (FHA).

This was submitted shortly before the serious incident and approved by the FOCA. This safety clarification anticipates that in the event of a go-around by an aircraft approaching runway 14 during a take-off from runway 10 with a subsequent left turn to the west may lead to an increased workload for controllers and may cause an extraordinary situation which demands that priorities be set. The FHA further assumes that the situation can be detected and resolved quickly, as it is part of the standard training of an air traffic controller.

However, as the present serious incident illustrates, the controllers involved were surprised by the situation which arose and later stated that they had never experienced such a situation before. In particular, however, there was also no indication that such combinations of departure and missed approach procedures had ever been practised in the simulator.

Hence it is clear that the assumption, or rather the assessment, of the safety clarification that such a situation can be dealt with by a controller solely on the basis of his standard training was incorrect.

In the functional hazard assessment, the lack of procedural separation between the standard departure procedures for runway 10 and the missed approach procedure on runway 14 is not dealt with. This is a further indication that the safety clarification is content to guarantee the safe execution of a demanding and risky procedure solely by means of controllers' skills and possible courses of action.

It is striking that the FHA actually maintains that the procedures examined would exhibit acceptable safety levels yet recommends that in future the flight paths of standard departure and missed approach procedures should be spatially separated in order to improve safety and achieve less complex operation.

The fact that since then no improvements have been made in this respect indicates the ineffectiveness of such proposals put forward solely as desirable improvements.

Furthermore, it seems that the degree of independence of this safety clarification is questionable, as for the most part the companies involved were the same as those which designed or calculated the corresponding procedures or which influenced their selection.

In summary, it is appropriate to conclude that the operating concept for a 'Bise' wind situation as applied at the time of the serious incident exhibited substantial defects and consequently in the present case was no longer able to be implemented safely by the air traffic controllers involved.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The investigation produced no indications of any pre-existing technical faults which might have caused the incident.
- On both aircraft the TCAS generated a resolution advisory, the instructions of which were obeyed immediately and correctly by the crews.

3.1.2 Crews

- The crews of the two aircraft involved in the serious incident were in possession of the licences necessary to exercise their activities.
- The cockpit of DLH 1LA was occupied by a commander under supervision, a first officer and a supervising commander.
- The commander in training on DLH 1LA had 8000 hours of flying experience, including 3000 hours on the type B737.
- The cockpit of RJA 149 was occupied by a commander under supervision, a first officer and a supervising commander.

3.1.3 Air traffic control personnel

- The air traffic controllers and the trainee controller were in possession of the licences necessary for the exercise of their activities.
- The departure position was occupied by a coach and a trainee.
- The departure coach was sitting on the left of the trainee and working with a headset.
- At the time of the serious incident, the trainee had three days to go before the final skill assessment.

3.1.4 Sequence of the serious incident

- DLH 1LA was flying under instrument flight rules and when the go-around was initiated was in contact with Zurich ADC and within its area of competency.
- At the time of the serious incident, DLH 1LA was within Zurich DEP's area of competency but was still in contact with Zurich ADC.
- RJA 149 was flying according to instrument flight rules and was in contact with Zurich DEP and was within its area of responsibility.
- At 12:35:38 UTC, RJA 149 was cleared to take off from runway 10. It followed the VEBIT 2E standard departure route and at 12:37:33 UTC received clearance to climb to flight level FL 120.
- At 12:37:33 UTC, an executive aircraft received clearance to take off from runway 10.
- At 12:37:141 UTC during its ILS approach on runway 14, DLH 1LA initiated a go-around at an altitude of 2900 ft QNH.
- The ADC air traffic controller was not initially aware of the go-around by DLH 1LA because he was busy planning the next departure and was concentrating on the area of runway 10 and its taxiways.
- Since the frequency was occupied, the crew of DLH 1LA were only able to report their go-around to aerodrome control at 12:38:10 UTC.
- The ADC "call-out" after the "going around" report from the DLH crew took place without delay by means of an entry in the TACO system.
- At 12:38:15 UTC, DLH 1LA was instructed to follow the standard missed approach procedure for runway 14 and to climb to 5000 ft QNH.
- The go-around call-out was registered by the coach and trainee together. They both also realised that DLH 1LA had already passed approximately 4000 ft QNH and that RJA 149 was on a westerly heading. The ensuing conflict situation was also detected by them both.
- The instruction to the crew of RJA 149 to turn right immediately was given at 12:38:47 UTC by the coach, but it was not obeyed.
- At 12:38:53 UTC, DLH 1LA had reached an altitude of 5000 ft QNH.
- The TCAS system in DLH 1LA generated a traffic advisory (TA), followed by a resolution advisory (RA), upon which the crew carried out a TCAS descent and reported this immediately to aerodrome control at 12:39:00 UTC.
- The closest point of approach between DLH 1LA and RJA 149 occurred at 12:39:06 UTC, with a lateral distance of 1.1 NM and an altitude difference of 600 ft.
- The minimum separation prescribed in this situation is 3 NM horizontally or 1000 ft vertically.

- The TCAS system in RJA 149 initially generated a traffic advisory (TA), followed by a resolution advisory (RA). The crew obeyed the "climb climb" instructions, but there was no corresponding report to ATC.
- According to the radiotelephony recordings on the 125.950 MHz Zurich departure frequency, several replies by the crew of flight RJA 149 are partly or completely unintelligible.

3.1.5 General conditions

- Visual meteorological conditions (VMC) prevailed in the Zurich control area.
- During the incident, the aircraft involved were above the control area under instrument meteorological conditions (VMC); the crews had no visual contact with each other.
- According to the air traffic controllers' statements, there was an average volume of traffic, with a high level of complexity.
- At the time of the serious incident, there was no procedural separation between the departure routes from runway 10 in Zurich, which after a left turn cross the centre line of runway 14 on a westerly heading, and the missed approach procedure for runway 14.
- The runway 10 utilisation concept features a relatively high coordination effort and workload for aerodrome control.
- The safety clarification for the runway 10 utilisation concept assumes that a hazardous convergence of two aircraft can be detected and resolved quickly, as it forms part of the standard training of an air traffic controller.
- The controllers involved were surprised by the situation which arose and later stated that they had never experienced such a situation before.
- There was also no indication that such combinations of departure and missed approach procedures had ever been practised in the simulator.

3.2 Causes

The serious incident arose as a result of the inadvertent convergence of a commercial aircraft taking off from runway 10 and a commercial aircraft going around on runway 14, which involved a high risk of collision. It is attributable to a runway utilisation concept in a 'Bise' wind situation which overtaxed the air traffic controllers involved because it featured the following shortcomings:

- Procedural separation did not exist between the standard departure route VEBIT TWO ECHO from runway 10 and the standard missed approach procedure for runway 14.
- The corresponding safety clarification had registered the hazard only inadequately.
- The air traffic controllers had been inadequately trained in respect of the possible conflict situation and were therefore surprised by it.

4 Safety recommendations and measures taken since the serious incident

4.1 Safety recommendations

4.1.1 Safety deficit

On 24 October 2007, a serious incident occurred 2.4 NM north-north-east of the Kloten VHF omnidirectional radio beacon (KLO) between an IFR approach on runway 14 and an IFR departure from runway 10. The approaching aircraft had initiated a go-around for technical reasons and shortly before passing the threshold of runway 14 had already attained the standard missed approach altitude of 5000 ft.

The aircraft departing from runway 10 was on the VEBIT TWO ECHO standard departure route assigned by air traffic control, climbing to FL 120 in a westerly direction and was passing an altitude of 4800 ft when a TCAS warning was received. After reception of the traffic advisory (TA) from the traffic alert and collision avoidance system (TCAS), there followed a corresponding resolution advisory RA for both aircraft. The crews followed the TCAS instructions in accordance with procedures.

At the time of the serious incident, there was no procedural separation between the departure routes from runway 10 and the missed approach procedure for runway 14 in Zurich as the former crosses the centre line of runway 14 on a westerly heading after a left turn.

The runway 10 utilisation concept features a relatively high coordination effort and workload for aerodrome control.

The standard missed approach altitude was redefined in June 2008 as 4000 ft. This change was not in fact made as a result of this incident. Though it does reduce the risk of conflict between departures from runway 10 and runway 14 missed approaches, procedural separation is not, however, guaranteed even in the current situation.

To clarify the risks, in its letter of 9 May 2006 the Federal Office of Civil Aviation asked Skyguide to provide proof that safety can be adequately guaranteed for the procedure applied at that time of the serious incident involving runway 10 take-offs and runway 14 landings. In order to provide such proof, Skyguide conducted a so-called functional hazard assessment (FHA).

This was submitted shortly before the serious incident and approved by the FOCA. It is noteworthy that this safety clarification did not deal with the lack of procedural separation between the departure and the go-around which led to the present serious incident.

The investigation showed that the assumption by the safety clarification that such a situation can be handled by air traffic controllers solely on the basis of standard training was incorrect.

Furthermore, it seems that the degree of independence of this safety clarification is questionable, as for the most part the companies involved were the same as those which designed or calculated the corresponding procedures or which influenced their selection.

4.1.2 Safety recommendation No. 369

The Aircraft Accident Investigation Bureau is not issuing a safety recommendation concerning the lack of procedural separation, but refers to safety recommendation No. 369 issued on 10 June 2005: *"The Federal Office for Civil Aviation should arrange that for traffic situations such as the one under consideration ATC applies procedures which guarantee minimum separation under all circumstances, both in IMC and in VMC."* Implementation of this safety recommendation would also eliminate the present safety deficit.

4.1.3 Safety recommendation No. 426

The FOCA should ensure that until safety recommendation No. 369 is implemented, air traffic controllers are adequately trained in applying the current procedures.

4.2 Measures taken since the serious incident

In a statement dated 31.10.2010, the Civil Aviation Safety Officer of the DETEC published the following decision regarding the safety recommendation No. 369 issued by the Aircraft Accident Investigation Bureau on 10 June 2005:

"Implemented Safety Action for CD-2008-26C

Implemented measures

Skyguide has introduced radar separation for IFR aircraft operating in VMC in the vicinity of *an airport. If below minimum vectoring altitude, the flight crew must perform approaches and departures between ground and minimum vectoring altitude at own navigation.*

Additionally FOCA has imposed the introduction of cut-off points for arriving aircraft on a RWY where the missed approach procedure of that RWY is conflicting with the SID of another RWY and the conflict point is below minimum radar vectoring altitude.

Both measures have a positive effect on safety, however, influence capacity dramatically. The demonstration of acceptable safety when conducting further optimization steps toward better capacity is guaranteed by mandatory application of safety risk assessment and mitigation processes, as well as the acceptance procedure from FOCA."

Payerne, 30 November 2010 Aircraft Accident Investigation Bureau

This report contains the AAIB's conclusions on the circumstances and causes of the accident/serious incident which is the subject of the investigation.

In accordance with art 3.1 of the 9th edition, applicable from 1 November 2001, of Annex 13 to the Convention on International Civil Aviation of 7 December 1944 and article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the incident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.