Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Schweizerische Sicherheitsuntersuchungsstelle SUST
Service suisse d'enquête de sécurité STSB
Servizio d'inchiesta svizzero sulla sicurezza SISI
Swiss Transportation Safety Investigation Board STSB

Aviation Division

Final Report No. 2278 by the Swiss Transportation Safety Investigation Board STSB

concerning the serious incident (AIRPROX)

involving the B738 aircraft, registration TC-JGV,

operated by Turkish Airlines
under the ATC call sign THY1QM

and the F100 aircraft, registration OE-LVL,

operated by Tyrolean Airways
under the ATC call sign AUA582W

on 31 March 2014

at Geneva airport (LSGG) / GE

Aéropôle 1, 1530 Payerne
Tel. +41 58 466 33 00, Fax +41 58 466 33 01
info-av@sust.admin.ch
www.stsb.admin.ch

Causes

L'incident grave est dû au rapprochement dangereux entre un avion au décollage et un avion en phase d'atterrissage, sur la piste béton 05, en raison de l'intégration inappropriée d'un départ au niveau de la voie de circulation Z.

L'enquête a identifié le facteur suivant jouant un rôle systémique dans l'incident grave :

- paramétrage du système RIMCAS (*runway incursion monitoring and conflict alert sub-system*).

General information on this report

This report contains the Swiss Transportation Safety Investigation Board's (STSB) conclusions on the circumstances and causes of the serious incident which is the subject of the investigation.

In accordance with Article 3.1 of the 10th edition, applicable from 18 November 2010, 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 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/incident prevention, due consideration shall be given to this circumstance.

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

For reasons of data protection, this report uses the generic masculine.

All information, unless otherwise indicated, relates to the time of the serious incident.

All times in this report, unless otherwise indicated, are stated in Coordinated Universal Time (UTC). At the time of the serious incident, Central European Summer Time (CEST) applied as local time in Switzerland. The relation between LT, CEST and coordinated universal time (UTC) is: LT = CEST = UTC + 2 hours.

Contents

Final report

Summary

Aircraft 1	
Owner	Turkish Airlines, Ataturk Airport, Yesilkoy, Istanbul
Operator	Turkish Airlines, Ataturk Airport, Yesilkoy, Istanbul
Manufacturer	Boeing Commercial Airplanes, Seattle, Washington, United States of America
Aircraft type	Boeing B737-800
Classification of the aircraft	Category 3
Country of registration	Turkey
Registration	TC-JGV
Flight number	TK1919
ATC flight plan call sign	THY1QM
Callsign	Turkish one quebec mike
Flight rules	Instrument flight rules (IFR)
Type of operation	Scheduled flight
Departure point	Istanbul (LTBA)
Destination point	Geneva (LSGG)
Aircraft 2	
Owner	Austrian Airlines AG, Office Park 2, A-Vienna
Operator	Tyrolean Airways Tiroler Luftfahrt GmbH, A-Innsbruck
Manufacturer	Fokker - Aircraft B.V., Netherlands
Aircraft type	F100
Classification of the aircraft	Category 3
Country of registration	Austria
Registration	OE-LVL
Flight number	OS582
ATC flight plan call sign	AUA582W
Call sign	Austrian five eight two whiskey
Flight rules	Instrument flight rules (IFR)
Type of operation	Scheduled flight
Departure point	Geneva (LSGG)
Destination point	Vienna (LOWW)

Location	Runway 05, Geneva International Airport (LSGG)
Date and time	31 March 2014, 15:43:56 UTC
ATS unit	Control tower (aerodrome control – ADC) Geneva

Airspace	Control zone (CTR) LSGG, Class D
Closest point of approach between the two aircraft	Lateral separation of 1206 m, on the runway
Prescribed minimum separation	2400 m in reduced runway separation minima conditions
Airprox category	ICAO category A – high risk of collision

Investigation

The serious incident occurred on 31 March 2014 at 15.43 UTC. It was notified on 11 April at 14:29 UTC. The Swiss Accident Investigation Board (SAIB) opened an investigation on 16 April 2014.[1]

The final report is published by the STSB.

Synopsis

On the afternoon of 31 March 2014, the Boeing 737-800 operating flight THY1QM was making a visual approach on runway 05 in good weather conditions. When it was on final 7.5 NM from the runway threshold, the aerodrome controller was lining up and holding the Fokker 100 which was operating flight AUA582W. To expedite the flow of traffic, he previously cleared a PC12 for take-off from intersection taxiway Z, but waited until the latter was a sufficient distance away before clearing AUA582W for take-off. The controller realised that his tactic would cause a dangerous convergence between THY1QM and AUA582W. The activation of the RIMCAS[2] runway safety net a few seconds later confirmed and attested to this concern. Confronted by the alert, he judged that clearing THY1QM to land involved less risk that ordering a simultaneous go-around and aborted take-off. When THY1QM was crossing the runway 05 threshold, it was 1206 m from AUA582W which was lifting off, whereas the prescribed reduced runway separation minima is 2400 m.

Causes

The serious incident is attributable to the dangerous convergence of an aircraft on take-off and an aircraft in landing phase, on concrete runway 05 because of the inappropriate integration of a take-off from intersection taxiway Z.

The investigation identified the following factor playing a systemic role in the serious incident:

- the parameterisation of the RIMCAS system (Runway Incursion Monitoring and Conflict Alert Sub-System).

Safety recommendations

The report revealed a safety deficit which gave rise to a safety recommendation.

[1] The SAIB (Swiss Accident Investigation Board) became the STSB (Swiss Transportation Safety Investigation Board) on 1 February 2015

[2] RIMCAS: Runway Incursion Monitoring and Conflict Alert Sub-System

1 Factual information

1.1 Pre-flight history and history of the serious incident

1.1.1 General

The history of the serious incident was established using the recordings of the radiotelephone communications, the radar data and plots, the information from SAMAX runway monitoring system[3] and the Mode S downlink transmissions. It is also based on the comments made by the commander of THY1QM and the statements of the air traffic controllers involved in the serious incident.

The scheduled flights involved, with ATC call signs AUA582W and THY1QM, were flying under instrument flight rules (IFR). They were in contact with the Geneva control tower (TWR) air traffic control units, where the following three workstations were occupied:

- Ground control (GND)
- Aerodrome control (ADC)
- Control tower supervisor

Runway 05 was in use and the operational conditions allowed the application of reduced runway separation minima for aircraft moving on the runway and in flight in the control tower's area of responsibility.

1.1.2 History of the serious incident

At 15:38:32 UTC on 31 March 2014, the flight crew of the Boeing 737-800 registration TC-JCV, operating flight THY1QM from Istanbul (LTBA) destination Geneva (LSGG), reported on the Geneva control tower frequency. The aircraft was making a visual approach on runway 05 and was at an altitude of 6,600 ft at the end of the downwind leg of the right-hand circuit, approximately 15 NM from the displaced runway threshold[4]. The weather was fine, the sky was practically cloudless and visibility was over 25 km.

At 15:40:23 UTC, the aerodrome controller[5] cleared the flight crew of the Fokker 100 operating flight AUA582W destination Vienna (LOWW) to line up and hold at the beginning of runway 05 behind a Falcon F7X in departure phase. He then asked THY1QM, which was at that time 9.8 NM from the runway threshold, to reduce its speed to 160 kt. The controller's workload was medium.

The controller noticed that the Falcon was in the "Light" wake turbulence category[6], enabling the immediate departure of the PC12 registration LX-JFH on hold on taxiway Z. He then instructed its pilot to line up and hold on runway 05 and then informed AUA582W that it would be number two behind a take-off from intersection taxiway Z.

At 15:41:36 UTC, when it entered the runway, LXJFH was cleared to take off. At this moment, THY1QM was 6 NM from the threshold and AUA582W was lined up and holding: the controller could not clear its departure as long as there was a risk

---

[3] SAMAX: Swiss airport movement area control system

[4] The threshold of runway 05 is displaced 330 m from the beginning of the runway. In the rest of the report the term “threshold” refers to “displaced threshold”.

[5] Except where indicated, in the rest of the report the term “controller” refers to the aerodrome controller.

[6] Wake turbulence category used in Switzerland, in which “Light” refers to aircraft with a maximum take-off mass of between 7001 and 40,000 kg.

of conflict with the PC12. He realised that THY1QM was nearing the runway, to the extent of compromising the minimum separation between the two aircraft at the moment when AUA582W would take off. He reacted by issuing AUA582W an initial climb altitude of 4000 ft, then instructed THY1QM which was then 5 NM from the threshold at an indicated airspeed of 160 kt, to reduce its approach speed to its minimum value.

The commander of THY1QM concluded from the radiotelephone communications that a conflict was developing with the traffic lined up at the beginning of runway 05. He further reduced his speed by adopting the landing configuration which allowed the most significant reduction. The flight crew decided to keep the two autopilots engaged as long as possible in order to have the option of carrying out an automatic go-around.

LXJFH took off at 15:42:24 UTC and six seconds later the controller instructed its pilot to climb at the best rate until an altitude of 5000 ft had been passed. At 15:42:59 UTC, he instructed the pilot to turn left onto a heading of 010°. THY1QM was then 2.2 NM from the runway 05 threshold and was approaching at an indicated airspeed of 147 kt.

At 15:43:04 UTC, the controller cleared AUA582W to take off and, after the readback, informed THY1QM that an aircraft had initiated its departure.

At 15:43:27 UTC, the RIMCAS safety net indicated a potentially dangerous convergence on the runway, by illuminating the radar labels of THY1QM and AUA582W in orange on the screens of the SAMAX runway monitoring system. The controller, who was busy looking outside in order to manage his traffic, did not notice the alert.

Fifteen seconds later, at 15:43:42 UTC, the radar labels turned red and the aural alert “RIMCAS” was issued, indicating that the convergence of THY1QM and AUA582W was becoming critical and that immediate corrective action should be considered. THY1QM was at a height of 200 ft, 0.5 NM from the threshold and 1215 m from AUA582W, which was crossing taxiway F with a ground speed of 85 kt.

Confronted with the alert, the controller judged that separation was being re-established and considered that a go-around was not necessary. This option, as well as the aborted take-off which would then have had to be ordered to AUA528W had an uncertain outcome. He therefore opted not to intervene and cleared THY1QM to land at 15:43:44 UTC.

At 15:43:56 UTC, THY1QM crossed the threshold of runway 05 and was 1206[7] m from AUA582W; the prescribed minimum separation is 2400 m. The aircraft were travelling at the same ground speed of 134 kt and from this moment the distance between them increased. The two pilots of THY1QM mutually confirmed that the aircraft which was taking off had indeed lifted off and continued the approach. It then seemed to them that the reduced separation minima were complied with.

At 15:44:00 UTC, AUA582W took off and three seconds later THY1QM touched down on the runway. It vacated the runway normally via taxiway C.

[7] The measurement accuracy is ± 5 m.

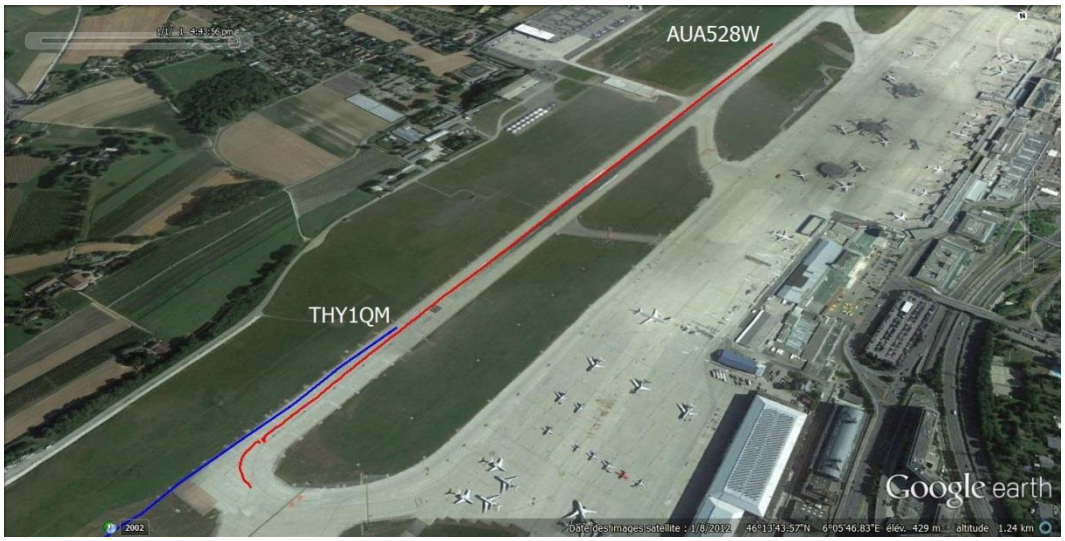

Fig. 1: Trajectories and positions of THY1QM (blue, threshold 05) and AUA582W (red) at 15:43:56 UTC

1.1.3 Location of the serious incident

Position	Geneva Airport (LSGG), Swiss territory
Date and time	31 March 2014, 15:43:56 UTC
Lighting conditions	Daylight

1.2 Personnel information

1.2.1 Flight crew THY1QM

1.2.1.1 Commander

Person	Greek citizen, born in 1961	
Licence	Airline transport pilot licence aeroplane – ATPL(A) according to Joint Aviation Requirements (JAR), issued by the Hellenic Civil Aviation Authority (HCAA)	
Flying experience	Total hours	18 750 h
	Of which on the type involved	9100 h
	During the last 90 days	207:47 h
	Of which on the type involved	207:47 h

All the available data indicates that the commander began his duty rested and in good health. Nothing indicates that fatigue contributed to the occurrence of the serious incident.

1.2.1.2 Copilot

Person	Turkish citizen born in 1971	
Licence	ATPL(A) according to JAR, issued by the Turkish Directorate General of Civil Aviation (DGCA)	
Flying experience	Total hours	4910 h
	Of which on the type involved	1450 h
	During the last 90 days	187:34 h
	Of which on the type involved	187:34 h

All the available data indicates that the copilot began his duty rested and in good health. Nothing indicates that fatigue contributed to the occurrence of the serious incident.

1.2.2 Flight crew AUA582W

1.2.2.1 Commander

Person	Austrian citizen born in 1975	
Licence	ATPL(A) according to JAR and the Department of Civil Aviation of Austria, issued by Austro Control GmbH	
Flying experience	Total hours	7794 h
	Of which on the type involved	1131 h
	During the last 90 days	149:32 h
	Of which on the type involved	149:32 h

All the available data indicates that the commander began his duty rested and in good health. Nothing indicates that fatigue contributed to the occurrence of the serious incident.

1.2.2.2 Copilot

Person	Austrian citizen born in 1980	
Licence	ATPL(A) according to JAR and the Department of Civil Aviation of Austria, issued by Austro Control GmbH	
Flying experience	Total hours	6000 h
	Of which on the type involved	2300 h
	During the last 90 days	142:27 h
	Of which on the type involved	142:27 h

All the available data indicates that the copilot began his duty rested and in good health. Nothing indicates that fatigue contributed to the occurrence of the serious incident.

1.2.3 Air traffic control unit personnel

1.2.3.1 Aerodrome controller

Person	Swiss citizen, born in 1975
Licence	Air Traffic Controller Licence based on European Community Directive EU-R805/2011

All the available data indicates that the aerodrome controller began his duty rested and in good health. Nothing indicates that fatigue contributed to the occurrence of the serious incident.

1.2.3.2 Ground controller

Person	Swiss citizen, born in 1988
Licence	Air Traffic Controller Licence based on European Community Directive EU-R805/2011

All the available data indicates that the ground controller began his duty rested and in good health. Nothing indicates that fatigue contributed to the occurrence of the serious incident.

1.2.3.3 Control tower supervisor

Person	Swiss citizen, born in 1971
Licence	Air Traffic Controller Licence based on European Community directive EU-R805/2011

All the available data indicates that the control tower supervisor began his duty rested and in good health. Nothing indicates that fatigue contributed to the occurrence of the serious incident.

1.3 Aircraft information

1.3.1 TC-JGV

Aircraft type	Boeing 737-800
Characteristics	Medium-and short range twin engine aircraft for passenger transport, low-wing metal construction
Manufacturer	Boeing Commercial Airplanes, Seattle, Washington, USA
Owner	Turkish Airlines General Management Building, Ataturk Airport, Yesilkoy, Istanbul, Turkey
Operator	Turkish Airlines General Management Building, Ataturk Airport, Yesilkoy, Istanbul, Turkey
Significant equipment	Traffic alert and Collision Avoidance System (TCAS)

1.3.2 OE-LVL

Aircraft type	F100
Characteristics	Short-range twin engine aircraft for passenger transport, low-wing metal construction
Manufacturer	Fokker Aircraft Services B.V., Schiphol, the Netherlands
Owner	Austrian Airlines AG, Office Park 2; A-1300 Vienna Airport
Operator	Tyrolean Airways, Tiroler Luftfahrt GmbH, A-Innsbruck
Significant equipment	Traffic alert and Collision Avoidance System (TCAS)

1.4 Meteorological information

1.4.1 General meteorological situation

The axis of a narrow ridge was passing over the Alps and extended from the west of the Mediterranean as far as Iceland. Switzerland was between two anticyclones, one centred west of the Mediterranean, the other located over the North Sea. The weather was dry and partially sunny.

1.4.2 Meteorological situation in the Geneva region at the time of the serious incident

Weather/cloud	1/8 to 2/8 at 5 000 ft AAE[8] 5/8 to 7/8 at 23 000 ft AAE

[8] AAE: Above Aerodrome Elevation

Visibility	25 km
Wind	050°/5 kt, varying between 020° and 080°
Temperature / dew point	18 °C / 3 °C
Atmospheric pressure	1013 hPa, pressure reduced to sea level, calculated using the values of the ICAO standard atmosphere
Trend	No significant change forecasted

1.4.3 Astronomical information

Position of the sun	Azimuth: 250°	Elevation: 23°
Lighting conditions	Daylight	

1.4.4 Meteorological and operational information relating to the approach

The Geneva automatic terminal information service (ATIS) transmitted information W at 15:20 UTC:

INFO WHISKEY RWY: RWY IN USE 05 ILS MET REPORT LSGG 1520Z
VRB BTN 360 AND 070 DEG 3 KT CAVOK[9] 19/04 QNH 1013 NOSIG
SPEED LIMITATION ACTIVE

In clear text this means that the approach in use was the runway 05 ILS[10] instrument landing system and that speed limitation for arrivals was in force.

The prevailing meteorological conditions were as follows:

Cloud	No cloud below an altitude of 10,600 ft
Wind	Variable between 360° and 070°, 3 kt
Horizontal visibility	≥ 10 km
Temperature	19 °C
Dew point	4 °C
Atmospheric pressure QNH	1013 hPa
Short-term forecast (significant change expected for the 2 hours following the observation time)	No significant change forecasted

1.5 Aids to navigation

The navigation aids at Geneva Airport did not play a part in the serious incident. AUA582W was on runway 05 and THY1QM was making a visual approach, i.e. one carried out whilst maintaining visual contact with the ground.

1.6 Communications

The serious incident occurred when the conflicting aircraft were in contact with the aerodrome controller. The radiotelephony communications took place in English with the flight crews of AUA582W and THY1QM, and in French with the pilot of LXJFH.

[9] The term "CAVOK" (ceiling and visibility OK) is used instead of the visibility, weather and cloud groups when horizontal visibility is ≥ 10 km, when no cloud is below 5000 ft or the minimum sector altitude (MSA), when there is no cumulonimbus or any significant meteorological phenomenon, at the time of the observation.

[10] ILS: Instrument Landing System

1.7 Aerodrome information

1.7.1 General

Geneva Airport is located at the western end of Switzerland. Some 188,768 movements, i.e. take-offs or landings, occurred there in 2013. The concrete runway accommodated 179,212 movements, including 95.1% between 06:00 and 22:00 local time.

In March 2014, one third of the daily traffic peaks occurred in the period between 15:00 and 15:59 UTC, including the maximum peak which totalled 47 movements. On the day of the serious incident, the heaviest hourly traffic flow was 42 movements, between 08:00 and 08:59 UTC and 17:00 and 17:59 UTC.

1.7.2 Runway equipment and dimensions

The data relating to the runway of Geneva international airport are as follows:

Designations and surface	Dimensions	Equipment
23/05 - concrete	3900 x 50 m	ILS23-LLZ CAT III/ILS05-LLZ CAT I
		05 and 23 PAPI 3°L

Runway 05: take off run available (TORA) 3900 m / landing distance available (LDA) 3570 m, elevation of runway threshold 1411 ft.

1.8 Flight recorders

At the time when the serious incident was reported to the SAIB, the recordings of conversations in the cockpit (cockpit voice recorder - CVR), were no longer available. Taking into account the elements already available for the needs of the investigation, it was not necessary to have recourse to the flight data recordings (flight data recorder - FDR).

1.9 Tests and research

Not applicable

1.10 Organisation and management information

1.10.1 Air navigation services

1.10.1.1 General

Originating from the private limited company Swisscontrol, since 1 January 2001 the Skyguide company has been providing air traffic control in Swiss airspace and the foreign airspace for which control has been delegated to Switzerland.

The following information is extracted from or if necessary summarised from the air traffic management manuals (ATMM) for Switzerland and Geneva. The specific references are indicated at the beginning of the sub-section.

1.10.1.2 Reduced Runway separation

"ATMM Geneva TWR/APP, Section TWR, B.3.2 REDUCED RWY SEPARATION"

Aircraft classification

For the purpose of reduced runway separation, aircraft shall be classified as follows:

a) ***Category 1 aircraft***

Single-engine propeller aircraft with a maximum certificated take-off mass of 2000 kg or less;

b) ***Category 2 aircraft***
Single-engine propeller aircraft with a maximum certificated take-off mass of more than 2000 kg but less than 7000 kg;
and twin-engine propeller aircraft with a maximum certificated take-off mass of less than 7000 kg;
the latter can be understood as the twin-engine propeller aircraft of the wake turbulence category "LIGHT".

c) ***Category 3 aircraft***
All other aircraft.

Applicability

In respect of aircraft categories above, reduced runway separation may be applied under the following conditions:

a) reduced RWY separation minima shall only be applied during hours of daylight to 1 hour before the end of the evening civil twilight;

b) appropriate wake turbulence separation minimum is applied;

c) visibility is at least 5 km and the ceiling not less than 1000 ft;

d) the tailwind component does not exceed 5 kt;

e) minimum separation continues to exist between two departing aircraft immediately after take-off of the second aircraft;

f) traffic information is issued to the flight crew of the succeeding aircraft; and

g) the surface friction is not adversely affected by runway contaminants such as ice, slush, snow, water, etc.

Landing aircraft

When using reduced separations, separate a succeeding landing:

any aircraft from a preceding Category 3 aircraft by ensuring that the succeeding aircraft does not cross the landing threshold until the preceding aircraft is airborne and has passed a point at least 2400 meters from the landing threshold of the runway (see figure 2).

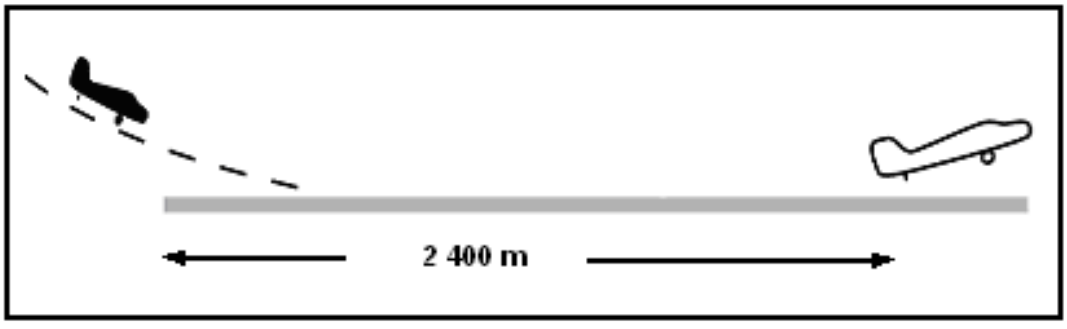

Fig. 2: Reduced runway separation for Category 3 aircraft

1.10.1.3 Multiple Line ups

"ATMM Geneva TWR/APP, Section TWR, B.4.3 MULTIPLE LINE UPS"

- *Do not issue line up clearance to an aircraft if this aircraft will be required to hold on the runway for more than 90 seconds beyond the time it would normally be expected to depart;*
- *When an aircraft lines up at the beginning of runway 05, the lining up of another aircraft for an intersection take-off is not permitted, except from taxiway F;*
- *ADC must see both aircraft.*

1.10.1.4 Departures Runway 05

"ATMM Geneva TWR/APP, Section TWR, C.4.1.1 ALTERNATE ROUTE 05"

ALTERNATE ROUTE 05

(Avoid use by aircraft that are noisy and/or have a low rate of climb.)

If a departure 05 must take place and a risk exists of conflict with preceding traffic, or with traffic on arrival for runway 23, the strict limitations of Art. 27 OSIA permit deviating the departing traffic if necessary:

- *left turn overhead GVA VOR (noise abatement);*
- *heading between 020° and 045°;*
- *terrain: when the heading given to an aircraft takes it to the west of GLA, terrain clearance can be guaranteed by the heading instruction with the addition of "INTERCEPT QDM[11] 040° TO GLA".*
- *from 4000 ft, the minimum vectoring altitudes (MVA) shall be respected;*
- *below 4000 ft, below the 4000 ft sector, the only obstacle to be taken into consideration is the Signal de Bougy, 036°, 18 NM, 2400 ft.*

This route does not conform to PANS-OPS[12] standards and shall only be allocated in the form of a visual climb: "visual climb until passing 4000 ft", taking into account the minimum vectoring altitude - MVA above this altitude.

1.10.1.5 Take-off clearance

"ATMM Switzerland, Aerodrome control, 4.9.3 TAKE-OFF CLEARANCE"

Determine the position of an aircraft before issuing take-off clearance. The aircraft position may be determined visually, by flight crew's report, or through the use of ASD.

Do not clear an aircraft to take off until the preceding 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 (see Figure 9-3).

[11] Magnetic track to GLA beacon

[12] Air traffic control acronym of "*procedures for air navigation services – aircraft operations*"

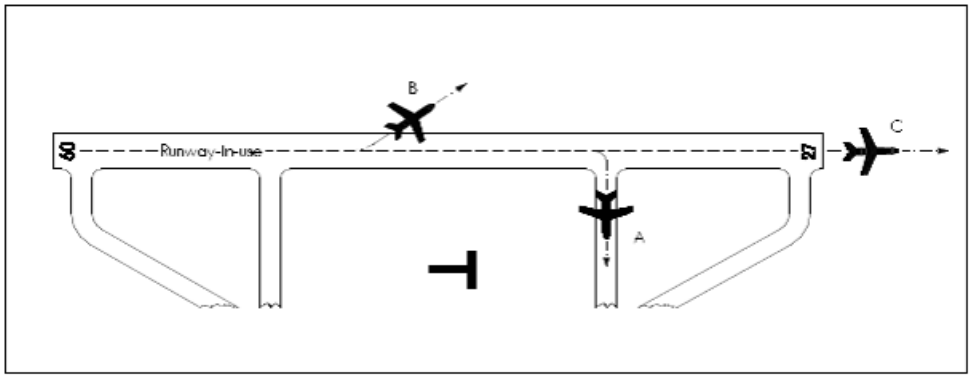

Fig. 3: *Figure 9-3 shows the positions to be reached by a landing aircraft (A) or a departing aircraft (B or C) before an arriving aircraft may be cleared to cross the threshold of the runway-in-use, or a departing aircraft may be cleared to take off*

1.10.1.6 Concrete runway capacity

"ATMM Geneva TWR/APP, section TWR, B.7.1.1 CONCRETE RUNWAY CAPACITY, TFV LSGG1"

In principle, the concrete runway capacity determines the airport capacity. The standard capacity of runway A is 40 movements per hour maximum, arrivals and departures mixed. This volume permits management of traffic peaks at Geneva airport.

1.11 Additional information

1.11.1 SAMAX runway monitoring system

The SAMAX runway monitoring system is an advanced surface movement guidance and control system (A-SMGCS) which provides guidance and monitoring resources for monitoring aircraft and vehicles on the ground on Geneva Airport's movement area. As a function of the required runway capacity[13] under different conditions of visibility, it makes it possible to ensure the safety, order and rate of airport aircraft and vehicle movements, under all circumstances related to traffic density and the complexity of the general layout of the airport.

This system receives information from several types of sensors, processes them using its merge module and displays them on a dedicated display system. It consists of the following three main elements:

- the primary surface radar (surface movement radar - SMR) which ensures detection of objects on or near to the ground in the airport area and its immediate vicinity. Its function is to present, regardless of the weather conditions, a reliable and accurate image of mobile and stationary objects on the ground, including aircraft and terrestrial vehicles moving on the runways, taxiways, traffic areas and other movement areas on or adjacent to the airport, under specified system and service conditions of performance;
- the multistatic radar system (multistatic dependent system - MDS), consisting of several receivers processing data from transmitters located at different positions, making it possible to obtain data relating to the positioning of aircraft and vehicles equipped with various types of transponders;
- the data processing system (nova data processing system) the function of which is to process all the data from the SMR, MDS and other external

[13] runway capacity: the number of aircraft movements which aeronautical authorities determine can safely be operated, usually stated as the total number of landings and take-offs per hour

sources, in order to provide the air traffic controller and other users with the following main functionalities:

- display of ground traffic;
- display of the map of Geneva Airport;
- monitoring of stop bars and lighting;
- monitoring of runway incursions and of conflict alerts.

The aerodrome controllers use the SAMAX runway monitoring system:

- to monitor the targets on a main window of traffic containing a synthetic display of the symbol indicators;
- to see, on the primary radar video image (SMR), the flights in approach phase with indication of their distance or time remaining to the runway threshold;
- to be automatically warned of risks relating to a target.

1.11.2 RIMCAS safety net

Geneva Airport is equipped with the RIMCAS safety net which, within a volume determined by the approach trajectory and the runway protection areas, detects possible conflict situations between aircraft in flight and vehicles and aircraft moving on the runway and its environs. It operates using information provided by the SAMAX system.

When low-visibility operation procedures are in force, the zone protected on the ground also includes the CAT II/III protection zones and its dimensions on both sides of the runway centre line are increased. For the case of aircraft on final approach, two alerts of increasing severity are activated when the latter are flying 80 seconds and then 40 seconds from the runway threshold and there is an incursion into the protected zone on the ground by a moving object.

In good visibility, the RIMCAS system is based on the time to the closest point of approach (TCPA) between two moving objects. When the time taken to cross the oblique distance which separates them falls below threshold values, alerts are issued.

The issued alerts are of three types: those which imply an aircraft on approach “arrival alerts”, those relating to an aircraft on departure “departure alerts” and finally those which relate to aircraft which have just landed “alerts on landed a/c”.

The serious incident resulted in the issuing of an alert of the first type. In this case, when a potentially dangerous convergence is detected, the RIMCAS system issues, at the appropriate time, two alert phases at the control positions.

For runway 05, phase 1 becomes active when an aircraft on approach is at flying time of 30 seconds from the threshold; it is informative and indicates a potentially dangerous situation on the runway by illuminating in orange the radar labels of the aircraft/vehicles which are converging.

At fifteen seconds flying time from the threshold, if this situation persists, phase 2 becomes active and constitutes a critical alert condition which may require immediate corrective action. The radar labels are then illuminated in red and the aural alert “RIMCAS” is issued. For this phase close to the runway threshold, the triggering of the alert also depends on the distance to the closest point of approach, taking into consideration the observed distance between the conflicting aircraft, its rate of change and the change of this rate.

1.11.2.1 RIMCAS alerts issued at the time of the serious incident

At 15:43:27 UTC, when THY1QM was on approach and 30 seconds from the runway 05 threshold and AUA582W was initiating its take-off, the RIMCAS system issued a phase 1 (orange) alert. Fifteen seconds later, at 15:43:42 UTC, the alert changed to phase 2 (red). THY1QM was at a height of 200 ft and 1215 m from AUA582W which was in take-off roll phase.

Fig. 4: Phase 1 RIMCAS alert (orange)

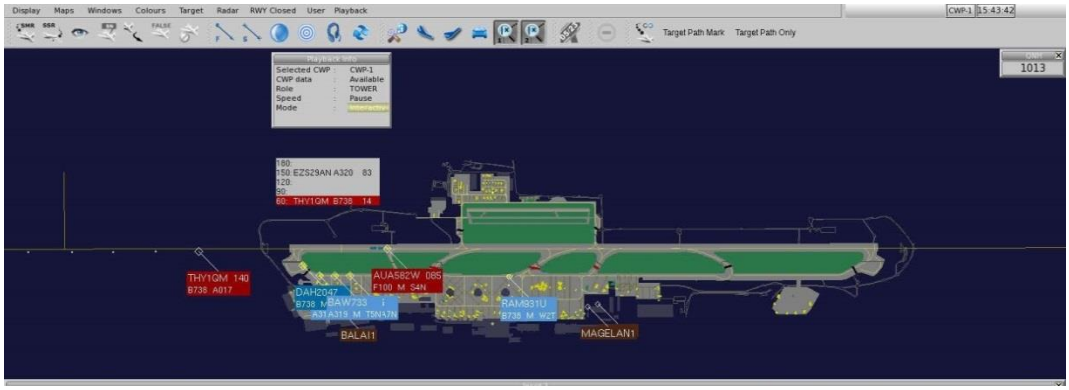

Fig. 5: Phase 2 RIMCAS alert (red)

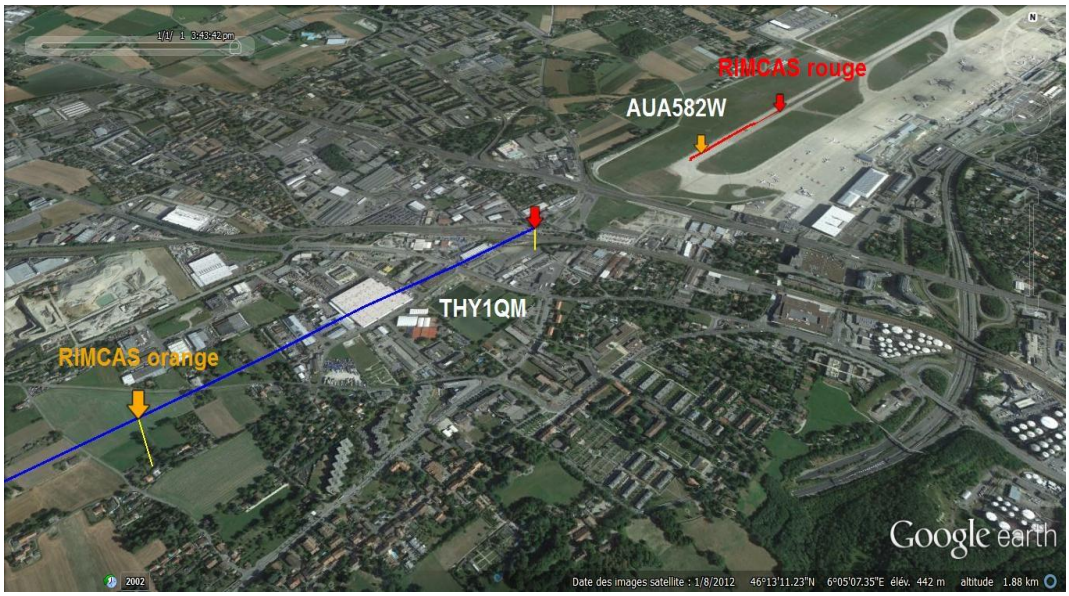

Fig. 6: RIMCAS alerts issued at the time of the serious incident

1.11.2.2 Operational procedures relating to the RIMCAS safety net

Since their commissioning, the SMGCS and RIMCAS systems have been the subject of two teaching modules (SMGCS level 1 and level 2) included in the training of TWR/APP controllers. For controllers licensed before commissioning of these systems, they are introduced to them during the periodic refresher courses. In particular it is specified in the level 2 module that the RIMCAS system provides assistance with detecting conflicts but in no case represents a means of resolving them or providing solutions for them: the controller must ensure that separation between aircraft is complied with.

Controllers have at their disposal a user manual for the SAMAX system in which one section is dedicated to a description of the guiding principles of the RIMCAS system, including the different types and phases of the alerts it issues.

The measures to be taken in response to these alerts are not the subject of specific procedures or particular attention during the regular training for emergency situations.

1.11.3 Convergence dynamic

At 15:43:04 UTC, AUA582W was cleared to take off (beginning of the radiotelephony message), started to move at 15:43:20 UTC and lifted off 40 seconds later, at 15:44:00 UTC. The take-off run was 1660 m.

At 15:43:27 UTC, when the RIMCAS system issued the phase 1 (orange) alert, THY1QM was 1.1 NM from the runway threshold with a ground speed of 147 kt. AUA582W had just begun its take-off, had a ground speed of 20 kt and had covered a distance of 55 m.

At 15:43:42 UTC, the RIMCAS system issued the phase 2 (red) alert. THY1QM was at a height of 200 ft, 0.5 NM from the threshold and 1215 m from AUA582W, which was crossing taxiway F with a ground speed of 85 kt.

At 15:43:56 UTC, THY1QM crossed the threshold of runway 05 and was 1206 m from AUA582W. The aircraft were travelling at the same ground speed of 134 kt and from this moment their separation increased.

The flight crew of THY1QM reduced their indicated airspeed in accordance with the controller's instructions.

1.11.4 Similar losses of separation

During the investigation, three cases of loss of separation on the runway at Geneva Airport similar to the one dealt with in this report were the subject of incident reports (air traffic incident report – ATIR).

Case 1. Incident on 30.06.2014	Runway 05	Call signs and types of aircraft involved DW468/SB20 DW471/SB20
At 12:28 UTC on 30 June 2014, a near miss occurred between two Saab 2000 aircraft on runway 05. When it crossed the threshold to land, DWT471 was 1227 m from DWT468, which was on its take-off roll. The RIMCAS system issued a phase 1 (orange) alert.		
Case 2. Incident on 18.08.2014	Runway 23	Call signs and types of aircraft involved AHO748Y/C525 AFR1642/A321
At 07:58 UTC on 18 August 2014, a loss of separation occurred on runway 23 between an Airbus A321 on final approach and a Cessna C525 in landing roll-out phase. When AFR1642 crossed the runway threshold, AHO748Y was taking the rapid exit taxiway. The RIMCAS system issued phase 1 (orange) and 2 (red) alerts.		

Case 3. Incident on 20.02.2015	Runway 23	Call signs and types of aircraft involved MSR771/B738 EZS82CF/A320
At 12:13 UTC on 20 February 2015, a loss of separation occurred on runway 23 between a Boeing B738 on final approach and an A320 which was rolling for take-off. When it crossed the runway threshold, MSR771 was 1237 m from EZS82CF. The RIMCAS system did not issue an alert.		

2 Analysis

2.1 Technical aspects

2.1.1 Phase 1 RIMCAS system alert

When low-visibility procedures are not in force, the phase 1 RIMCAS visual alert 1 (orange) is designed to activate when an aircraft on approach which is 30 seconds from the runway threshold becomes the cause of a potentially dangerous convergence with an aircraft/vehicle on the runway. In the conflict which is the subject of the serious incident, the calculated convergence was never virtual because the distance between the two aircraft at the time that THY1QM crossed the runway threshold could only be less than the minimum prescribed separation of 2400 m.

At the time the orange alert was triggered, AUA582W had just begun its take-off roll and was travelling at a ground speed of 20 kt. With a take-off run of 1660 m, lasting 40 seconds, it was not possible that 30 seconds later, when it crossed the runway threshold, that THY1QM could be 2400 m or more from AUA582W.

The speeds of the aircraft on approach and the performance of the aircraft on take-off are characteristic of the majority of category 3 airliners. The question is then posed as to the usefulness of an “orange” alert, the severity of which is in fact that of a “red” alert and the manifestation of which is only visual.

This characteristic is explained by the fact that the RIMCAS system is better adapted to issuing alerts conditioned by the low-visibility operation procedures. The air traffic is then subjected to greater separations and the aerodrome controller manages it on his SAMAX radar screen. Under these conditions it is no longer possible to integrate at the last moment an aircraft in an arrival/departure sequence regulated by a minimum separation of 8 NM between each aircraft. Consequently, RIMCAS alerts are in principle triggered only by runway incursions. In front of his radar screen, the controller sees the phase 1 alert and the advance warning of 80 seconds is sufficient in this context for him to resolve the problem.

In addition, the phase 1 alert is not aural and cannot warn the controller when he is managing his traffic visually. If there was an aural alert, it would be a reminder that the aircraft on approach is 30 seconds from the runway threshold and would constitute a useful reference point for decision-making.

2.1.2 RIMCAS system alerts

For the three cases of loss of separation on a runway reported in section 1.11.4, the nature of the RIMCAS alerts which were issued were different, in that in all cases the distances between the aircraft in a conflict situation were less than 2400 m. The first case gave rise to a phase 1 alert only, the second gave rise to the same sequence of alerts as that of the serious incident (phase 1 followed by phase 2) and the last case, finally, did not result in the issue of an alert.

This disparity is explained by the fact that the RIMCAS system is based on the TCPA time, which is dependent on the ratio of distance between the two aircraft and their relative speed rather than their separation alone. When conditions allow the application of reduced separation minima, the controller must make sure that incoming traffic is separated by 2400 m from departing traffic. He therefore refers to a distance, whereas the RIMCAS system operates on the basis of time. As attested by the dangerous convergence of the serious incident under investigation and those mentioned above, the imminence of an inevitable loss of separation is not necessarily reported or even correctly reported by a RIMCAS alert.

This characteristic may be perceived by controllers as a shortcoming in the effectiveness of the system.

2.2 Human and operational factors

2.2.1 Air traffic control aspects

2.2.1.1 The aerodrome controller

The aerodrome controller decided to slot the PC12 between the Falcon F7X and AUA582W after having noted at a late stage that the wake turbulence classes of the aircraft were appropriate for this. He saw a brief opportunity to expedite traffic and to reduce the holding time of the PC12, without having planned this. The following control requirements (see section**Fehler! Verweisquelle konnte nicht gefunden werden.**) were not complied with:

- lining up for a take-off from intersection taxiway Z was not permitted because of the presence of AUA582W at the beginning of runway 05;
- the 90 second limit which among other things conditions the issuing of a line-up clearance was exceeded.

The starting point of the serious incident was the decision to introduce a relatively slow PC12 into the final phase of an arrival/departure sequence of two category 3 twin-jet aircraft. By instructing the PC12 to take its best rate of climb speed when he intended for it to turn left only after passing the GVA VOR, the controller delayed the point at which when he could clear AUA582W for take-off.

The stress caused by the dangerous convergence of THY1QM and AUA582W lead to the controller perceiving the relative motion of the aircraft wrongly, since he thought that separation was being restored when the phase 2 RIMCAS alert was triggered. The difference in ground speeds was then still 55 kt; it was not until 14 seconds later that the convergence ended.

2.2.1.2 RIMCAS procedures

The RIMCAS system is based on the concept of time which an aircraft will take to go to the closest point of approach in the same manner as onboard collision-avoidance systems. Nevertheless, unlike the latter, it does not provide any indication in order to ensure separation between two conflicting moving objects.

Although it is specified to controllers that the RIMCAS system only constitutes an aid to detecting conflicts, the investigation indicates that if it was specifically parameterised for conditions other than those of low visibility, this safety net would be more effective. Measures to be taken in relation to correctly calibrated RIMCAS alerts could then be drawn up. As an example deriving directly from the serious incident, an aural phase 1 alert would have drawn the controller's attention to the fact that a limit had been exceeded.

2.2.2 Flight management aspects

2.2.2.1 Flight crew of flight THY1QM

The flight crew of flight THY1QM promptly obeyed the speed reduction instructions issued by the controller.

2.2.3 Endangerment

The potential dangers inherent in such an incident arise from the distance, now insufficient, between the two aircraft. If the flight crew of the aircraft on final approach ascertains that an aircraft is still on the runway, they may decide to go around and enter into conflict with the aircraft which is taking off. If on the other hand they decide to land and the aircraft on the runway aborts its take-off, the convergence may become highly critical.

3 Conclusions

3.1 Findings

3.1.1 Technical aspect

- The phase 1 alert of the RIMCAS system is informative though only issues a visual alert.

3.1.2 Flight crews

- The pilots of flights THY1QM and AUA582W held the licences and qualifications necessary to make the flight in accordance with the regulations in force.

3.1.3 Air traffic control

- The air traffic controllers involved in the serious incident held the licences and qualifications in accordance with the regulations in force.
- The workload was medium.

3.1.4 History of the serious incident

- At 15:40:23 UTC, the aerodrome controller cleared AUA582W to line up and hold at the beginning of runway 05 behind a Falcon F7X in departure phase.
- A 15:41:36 UTC, when it joined runway 05 from taxiway Z, LXJFH was cleared to take off.
- At 15:43:04 UTC, i.e. 2 minutes 41 seconds after the line-up clearance, the controller cleared AUA582W to take off.
- At 15:43:27 UTC, the RIMCAS safety net reported a potentially dangerous convergence on the runway between THY1QM and AUA582W. The controller, who was busy managing his traffic visually, did not notice the alert.
- At 15:43:42 UTC, the RIMCAS system issued the aural alert “RIMCAS” indicating that the convergence between THY1QM and AUA582W was becoming critical. THY1QM was at a height of 200 ft, 0.5 NM from the threshold and 1215 m from AUA582W which was taking off.
- Faced with the alert, the controller chose not to intervene and cleared THY1QM to land.
- At 15:43:56 UTC, THY1QM crossed the threshold of runway 05 and was 1206 m from AUA582W.
- At 15:44:00 UTC, AUA582W lifted off and THY1QM landed three seconds later.

3.1.5 Environmental framework

- The operational conditions made it possible to apply reduced separation minima on the runway in service 05.

3.2 Causes

The serious incident is attributable to the dangerous convergence of an aircraft on take-off and an aircraft in landing phase, on concrete runway 05 because of the inappropriate integration of a take-off from intersection taxiway Z.

The investigation identified the following factor playing a systemic role in the serious incident:

- the parameterisation of the RIMCAS system (Runway Incursion Monitoring and Conflict Alert Sub-System).

4 Safety recommendations, safety advices and measures taken since the serious incident

Safety recommendations

According to the provisions of Annex 13 of the International Civil Aviation Organization (ICAO) and Article 17 of Regulation (EU) No. 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC, all safety recommendations listed in this report are intended for the supervisory authority of the competent state, which must decide on the extent to which these recommendations are to be implemented. Nonetheless, any agency, any establishment and any individual is invited to strive to improve aviation safety in the spirit of the safety recommendations pronounced.

Swiss legislation provides for the following regulation regarding implementation in the Ordinance on the Safety Investigation of Transport Incidents (OSITI):

„Art. 48 Safety recommendations

[1] The STSB shall submit the safety recommendations to the competent federal office and notify the competent department of the recommendations. In the case of urgent safety issues, it shall notify the competent department immediately. It may send comments to the competent department on the implementation reports issued by the federal office.

[2] The federal offices shall report to the STSB and the competent department periodically on the implementation of the recommendations or on the reasons why they have decided not to take measures.

[3] The competent department may apply to the competent federal office to implement recommendations."

The STSB shall publish the answers of the relevant Federal Office or foreign supervisory authorities at www.stsb.admin.ch in order to provide an overview of the current implementation status of the relevant safety recommendation.

Safety advices

The STSB may publish safety advices in response to any safety deficit identified during the investigation. Safety advices shall be formulated if a safety recommendation in accordance with Regulation (EU) No. 996/2010 does not appear to be appropriate, is not formally possible, or if the less prescriptive form of a safety advices is likely to have a greater effect. The legal basis for STSB safety advices can be found in Article 56 of the OSITI:

"Art. 56 Information on accident prevention

The STSB may prepare and publish general information on accident prevention."

4.1 Safety recommendations

4.1.1 RIMCAS system

4.1.1.1 Safety deficit

A Boeing 737-800 was making a visual approach in good weather on runway 05 of Geneva Airport. When it was on final some 7.5 NM from the displaced runway threshold, the aerodrome controller was lining up and holding the Fokker 100 at the beginning of the runway. To expedite the flow of traffic, he previously cleared a PC12 for take-off from intersection taxiway Z, but waited until the latter was a sufficient distance away before clearing AUA582W for take-off. The runway safety net (runway incursion monitoring and conflict alert sub-system - RIMCAS) reported

the imminent convergence of the Boeing 737-800 and the Fokker 100 on the runway with an “orange” alert, the severity of which was in fact the same as that of a “red” alert though the manifestation of which is only visual. The controller, who was busy looking outside in order to manage his traffic, did not notice the alert.

Fifteen seconds later, the radar labels turned red and the aural alert “RIMCAS” was issued, indicating that the convergence of THY1QM and AUA582W was becoming critical and that immediate corrective action should be considered.

Confronted with the alert, the controller judged that a go-around was inappropriate and cleared the aircraft on approach to land. When the latter crossed the displaced threshold of runway 05 it was 1206 m from the aircraft in take-off phase, whereas the prescribed minimum separation is 2400 m.

4.1.1.2 Safety recommendation no. 508

The Federal Office of Civil Aviation (FOCA) should ensure that the parameterisation of the RIMCAS system (Runway Incursion Monitoring and Conflict Alert Sub-System) is reviewed so that the safety net is effective for weather conditions other than those of low visibility.

4.2 Safety advices

None

4.3 Measures taken since the serious incident

None

Payerne, 5 December 2016 Investigation Bureau STSB

This final report was approved by the Board of the Swiss Transportation Safety Investigation Board STSB (Art. 10 lit. h of the Ordinance on the Safety Investigation of Transportation Incidents of 17 December 2014).

Berne, 1st December 2016