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Swiss Accident Investigation Board SAIB

Aviation Division

Final Report no. 2165 of the Swiss Accident Investigation Board SAIB

concerning the serious incident - Airprox
involving the Airbus A319 aircraft, registration D-AKNK,
operated by Germanwings GmbH
under flight number GWI 2529
and the Raytheon 390 Premier 1 aircraft, registration
D-IAGG,
operated by Hahn Air Lines
under flight number HHN 201
on 10 June 2011
18 NM NE Fribourg VOR/DME

General information on this report

This report contains the Swiss Accident Investigation Board's (SAIB) conclusions on the circumstances and causes of the accident which is the subject of the investigation.

In accordance with Art 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 accident 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 incident, Central European Summer Time (CEST) applied as local time (LT) in Switzerland. The relation between LT, CEST and UTC is:

LT = CET = UTC + 2 hours

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Final Report

Synopsis

Aircraft 1

Owner	Celestial Aviation Trading, Aviation House IRL- Shannon County Clare/Ireland
Operator	Germanwings GmbH, Germanwings-Str. 2 D-51147 Cologne, Germany
Manufacturer	Airbus S.A.S., Toulouse, France
Aircraft type	A319-112
Country of registration	Germany
Registration	D-AKNK
Flight number	GWI 2529
Radio callsign	Germanwings two five two niner
Flight rules	IFR
Type of operation	Scheduled flight
Departure point	LEBL, Barcelona
Destination point	EDDS, Stuttgart

Aircraft 2

Owner	Hahn Air Interline Services GmbH, an der Trift 65, D-63303 Dreieich, Germany
Operator	Hahn Air Lines GmbH, an der Trift 65, D-63303 Dreieich, Germany
Manufacturer	Raytheon Aircraft Company, USA
Aircraft type	Raytheon 390 (Beech 390 Premier 1A)
Country of registration	Germany
Registration	D-IAGG
Flight number	HHN 201
Radio callsign	Rooster two zero one
Flight rules	IFR
Type of operation	Non scheduled flight
Departure point	LSZH, Zurich
Destination point	LEPA, Palma de Mallorca

Location	18 NM NE Fribourg VOR/DME
Date and time	10 June 2011, 08:38 UTC
ATS unit	Swiss Radar Area East
Airspace	Class C
Minimum separation of the aircraft according to the radar system	0.6 NM horizontally and 50 ft vertically
Applicable minimum separation	5 NM horizontally or 1000 ft vertically
Airprox category of the serious incident	ICAO category A - high risk of collision

Investigation

The serious incident occurred on 10 June 2011 at 08:38 UTC. The notification was received on 10 June 2011 at 12:49 UTC. The investigation was opened on 15 June 2011.

The AAIB reported the serious incident to the investigation authorities of the German Federal Republic, which subsequently nominated an authorised representative. This final report is published by the Swiss Accident Investigation Board (SAIB).

Summary

The Germanwings Airbus A319, which was descending, was cleared to flight level FL 250 by the Geneva area control centre (ACC). Geneva area control centre then handed the aircraft over to Zurich ACC. There was an agreement in existence between Geneva and Zurich which provided for such a handover at FL 280 without further coordination. The Geneva ACC air traffic controller entered FL 280 into the system as the cleared altitude but had given the A319 clearance to FL 250 over the radio.

At the same time the Hahn Air Raytheon 390 aircraft which had taken off from Zurich was climbing to its cruising altitude on an opposite heading and had been cleared to FL 270 by Geneva ACC. When the descending A319 had passed FL 280 and the climbing Raytheon 390 was converging on a virtually opposite flight path, both the Geneva ACC air traffic controllers and the Zurich ACC controllers noticed the conflict and tried to influence the flight path of the aircraft which was on their frequency. When the traffic alert and collision avoidance system (TCAS) of the two aircraft responded, the crews immediately followed the corresponding resolution advisories (RA). During the RA, the air traffic controller gave an instruction to the crew of the Raytheon 390 to descend immediately. The crew of the Raytheon 390 followed this instruction and no longer followed the TCAS advisory; this led to a further reduction in the separation of the two aircraft at the crossing point.

According to the radar recording, at the crossing point the lateral separation was 1.3 NM and the altitude difference was 75 ft.

Causes

The serious incident is attributable to the fact that air traffic control gave clearance to an aircraft which led to a hazardous convergence with another aircraft. The fact that one of the flight crews then followed the resolution advisories of the traffic alert and collision avoidance systems (TCAS) only initially and instead followed the instructions of air traffic control meant that the convergence involved had a high risk of collision.

The following factors have been identified as causative for the serious incident:

- The air traffic controller entered the flight level prescribed for this flight as a clearance into the air traffic control system, but gave a different clearance to descend by radio.
- None of the five air traffic controllers who were involved in managing the aircraft concerned noticed the discrepancy between the descent clearance in the system and the radio message.
- The crew of the aircraft followed the instructions of air traffic control instead of continuing to follow the diverging resolution advisory of the TCAS.

The following factors contributed to the genesis of the serious incident:

- An Air Force exercise led to an increased workload and a more difficult overview for civil air traffic control.
- The use of a non-standard phraseology by air traffic control.

The following factors contributed systemically to the occurrence of the serious incident:

- Air traffic control had no safety net at their disposal which would have been able to detect the working error of an air traffic controller at an early stage.
- Working processes in air traffic control which made it difficult to detect routine working errors.

In the context of the investigation, a safety recommendation was issued.

According to the provisions of Annex 13 of the ICAO, all safety recommendations listed in this report are intended for the supervisory authority of the competent state, which has to decide on the extent to which these recommendations are to be implemented. Nonetheless, any agency, establishment or individual is invited to strive to improve aviation safety in the spirit of the safety recommendations pronounced.

In the Ordinance on the Investigation of Aircraft Accidents and Serious Incidents (OIAASI), the Swiss legislation provides for the following regulation regarding implementation:

“Art. 32 Safety recommendations

¹ DETEC, on the basis of the safety recommendations in the SAIB reports and in the foreign reports, shall address implementation orders or recommendations to the FOCA.

² The FOCA shall inform DETEC periodically about the implementation of the orders or recommendations pronounced.

³ DETEC shall inform the SAIB at least twice a year on the state of implementation by the FOCA.”

1 Factual information

1.1 History of the flight

1.1.1 General

For the following description of the flight preparations and history of the flight, the recordings of the radiotelephony, radar data, data of the conflict alert system (short term conflict alert - STCA), the stored data in the traffic alert and collision avoidance system (TCAS), the data transmitted to the radar stations via the mode S downlink of the transponder and the statements made by crew members and air traffic controllers were used.

1.1.2 Flight preparations

On the morning of 10 June 2011, an Airbus A319 aircraft of the Germanwings airline with flight number GWI 2529 was on a flight from Barcelona to Stuttgart. The commander in the left seat was acting as pilot not flying (PNF) and the copilot in the right seat was acting as pilot flying (PF).

At about the same time the Hahn Air Premier 1 aircraft with flight number HHN 201 was making a flight from Zurich to Palma de Mallorca. Both crew members were qualified as commander with the additional qualification to control the aircraft from the right-hand seat (right-hand seat qualification). The pilot in the left-hand seat was the pilot flying (PF). The pilot in the right-hand seat was the pilot not flying (PNF).

Both flights were being made under instrument flight rules (IFR).

1.1.3 Air traffic control units involved

1.1.3.1 General

In air traffic control, the Geneva Area Control Centre (Geneva ACC) was occupied with Sectors L12 and INSE, and the Zurich Area Control Centre Zurich (Zurich ACC) was occupied with Sectors West and M2. In the radiotelephony communications, the listed sectors of the Geneva and Zurich control centres were called with Swiss radar.

1.1.3.2 Configuration of the air traffic control units in Geneva

Sectors L3 and L4	FL 315 – FL 354	Sector L3 and L4 coupled, hereinafter designated L34
Sector L2	FL 285 – FL 314	Sector L1 and L2 coupled, hereinafter designated L12
Sector L1	FL 245 – FL 284	
Sector INSE	FL 080 – FL 244	Sector INSE

In Sector L12 a radar executive (RE) and a radar planner (RP) trainee supervised by a coach were working.

The INSE Sector was occupied by one radar executive (RE) and one radar planner (RP).

1.1.3.3 Configuration of the Zurich area control centre

Sector M3	FL 285 – FL 325	Sector M2 and M3 coupled, hereinafter designated M2
Sector M2	FL 245 – FL 285	
Sector West	FL 105 / 125 – FL 245	Sector West

Both sectors were occupied by one radar executive (RE) and one radar planner (RP) respectively.

1.1.4 History of the serious incident

At 08:15:20 UTC the crew of the Germanwings Airbus A319 aircraft with flight number GWI 2529 reported for the first time to Sector L34 of the Geneva Area Control Centre, stating their call sign and their current flight level of FL 340. They then received clearance for the route along the KINES - MOLUS - KORED waypoints.

At Zurich airport, the Hahn Air Premier 1 aircraft with flight number HHN 201 had taken off from runway 28 shortly after 08:25 UTC. At 08:28:17 UTC the crew reported for the first time to Sector West of the Zurich Area Control Centre. The RE controller then gave them clearance to climb to FL 230.

At 08:30:59 UTC in the Geneva Area Control Centre, the RE controller at Sector L34 cleared the crew of GWI 2529 to descend to FL 320.

At 08:31:57 UTC, the radar planner (RP) at Zurich Sector M2 made a telephone request to Sector L12 in Geneva for a change of 15 degrees left to the heading of GWI 2529, in order to facilitate the continued climb of an aircraft which had taken off in Geneva. This instruction was forwarded from Sector L12 to Sector L34, which was in contact with flight GWI 2529 at this time. Shortly afterwards, the Sector L34 RE controller instructed GWI 2529 to change its heading by 15 degrees to the left.

At 08:32:46 UTC, the Sector L34 RE controller instructed the crew of GWI 2529 to switch to the Sector L12 frequency of the Geneva Area Control Centre. At this time the aircraft was passing waypoint SOSAL.

The RE and RP controllers at Sector INSE of Geneva ACC were expecting HHN 201 in a few minutes from Zurich ACC Sector West. Since they had to maintain separation between HHN 201 and another flight with destination Geneva, they intended to enable HHN 201 to make a climb which was as uninterrupted as possible. At 08:31:58 UTC the Sector INSE RP controller in Geneva therefore requested clearance from Sector West in Zurich for flight HHN 201 to climb to FL 240. Immediately afterwards, he requested a further climb clearance from Sector M2 in Zurich. Both requests were approved by Zurich, the latter without specifying a limit. Sector INSE in Geneva was therefore able, after acquiring HHN 201, to give corresponding clearance to continue the climb.

Subsequently, at 08:33:03 UTC, the Sector INSE RP controller coordinated the continued climb of HHN 201 with the Sector L12 RP controller at Geneva Area Control Centre. The Sector L12 RP controller cleared the aircraft to climb to flight level FL 250.

At 08:33:35 UTC, the crew of HHN 201 reported to the West RE controller at Zurich ACC that they would shortly reach FL 230 and would like to continue the

climb. They were then instructed to switch to the Sector INSE frequency of Geneva ACC.

At 08:33:46 UTC, the crew of HHN 201 reported to Sector INSE of Geneva ACC. The air traffic controller gave the crew clearance to climb to FL 250 with routing via waypoints ULMES - VADAR - MILPA.

At 08:34:10 UTC, the Sector L12 RE controller at Geneva ACC gave GWI 2529, which had in the meantime descended to FL 320, the following clearance to descend: "*Germanwings two five two niner, descend FL 250, on heading, rate 2000 more*". At the same time he entered flight level FL 280 for this flight, along with the rate of descent of 2000 feet per minute, via the cleared flight level (CFL) input menu of the radar display in the air traffic management system (ATM). At this time he was not aware of the discrepancy between the descent clearance which had been given and the entry into the ATM system. During this phase, the coach was discussing with the trainee another traffic situation which required two coordinations, one of which had taken place, with the next one having to follow without delay. That is why neither of them noticed the discrepancy either.

At 08:34:19 UTC, the radar stations recorded via the mode S downlink of flight GWI 2529 that the crew had preselected flight level FL 250 in their flight control unit (FCU). This information was not available to the air traffic controllers in Geneva or Zurich.

At 08:35:01 UTC, the Sector L12 RE controller gave GWI 2529 an instruction to contact ACC Zurich. At 08:35:18 UTC, the crew of GWI 2529 reported to Sector M4 of Zurich ACC: "*Radar, servus, Germanwings two five two niner, descending level two five zero*". Neither of the Sector M2 air traffic controllers realised that the flight level reported by the crew of flight GWI 2529 did not correspond to the flight level of FL 280 coordinated between Zurich and Geneva. A flight level of FL 280 was generally agreed for a transfer of flights with destination Stuttgart.

In Geneva, the Sector INSE RE controller had cleared flight HHN 201 to climb to FL 250, and after further coordination with Sector L12, to climb to FL 260 and then to FL 270.

When HHN 201 was approximately between FL 230 and FL 240, climbing to FL 270, the crew noticed, according to their statement, that on the navigation display, into which the TCAS display is integrated, that a descending aircraft was approaching them from ahead on the left.

The crew wanted to report this observation to the Sector INSE controller, though this was not possible because of the high level of occupancy of the frequency. A little later, the TCAS on HHN 201 generated the traffic advisory (TA): "*traffic, traffic*". The pilot flying then switched off the autopilot.

In the meantime, GWI 2529 had continued to fly on the 034° heading agreed with Sector M2 in Zurich, until at 08:36:42 UTC the crew received an instruction from the Sector M2 RE controller to fly direct to waypoint ARSUT. At 08:36:44 UTC, i.e. while this instruction was still being transmitted, the TCAS on GWI 2529 issued a traffic advisory (TA). The instruction from air traffic control was then acknowledged by the crew with "*stand by*".

At this moment the Sector M2 RE controller realised that according to the radar display, flight GWI 2529 had already descended below FL 280. As a reflex action, she intervened at 08:36:49 UTC on the frequency: "*Germanwings two five two niner, please, ah, confirm maintain level two seven zero?*" According to her statement, this was the nearest possible flight level to stop the descent of GWI 2529. At 08:36:55 UTC the crew confirmed: "*Maintaining two seven zero, germanwings two five two niner*". The copilot acting as pilot flying switched off the

autopilot and began to control the aircraft manually in level flight. The crew of GWI 2529 tried to acquire visual contact with the aircraft which was the cause of the transition to level flight at flight level FL 270 as requested by air traffic control and which triggered the traffic advisory. On the navigation display, the pilots saw that an aircraft was approaching them from ahead on the right. However, visual contact could not be established despite the clear weather.

Shortly beforehand, the Sector L12 RP controller in Geneva had observed that GWI 2529 was approaching the flight level FL 280 specified in the system for the handover, at an unchanged rate of descent of over 2000 ft/min. From this he inferred that GWI 2529 would descend below this flight level. At 08:36:47 UTC the Sector L12 RP controller in Geneva therefore requested the M2 Sector RP controller in Zurich to stop the descent of GWI 2529: *“Stop the Germanwings two five two niner, our hotel hotel november is going to 270”*. The Sector M2 RP controller then informed the Sector L12 RP controller in Geneva that ACC Zurich would be turning GWI 2529 to the left. The Sector L12 RP controller forwarded this message at 08:36:59 UTC by telephone to the Sector INSE RP controller, requesting him to turn HHN201 immediately to the left: *“Hotel, hotel, november, left, left, immediately!”*

At 08:36:52 UTC the short term conflict alert (STCA) in Sector M2 in ACC Zurich triggered an alert.

Eight seconds after the instruction to maintain flight level FL 270, at 08:36:57 UTC, the TCAS on GWI 2529 issued a resolution advisory (RA) *“maintain vertical speed, crossing maintain”*, which required a rate of descent of 1500-2000 ft / min. The crew followed this instruction immediately.

At the same time, the Sector M2 RE controller instructed the crew of GWI 2529 to change their heading by 30 degrees to the left. Since she received no response from the crew, at 08:37:07 UTC she again gave the instruction to GWI 2529 to turn away to the left *“Germanwings two five two niner turn left immediately”*.

At 08:36:59 UTC, the air traffic control STCA conflict alert system triggered an alarm in Sectors L12 and INSE in Geneva.

At 08:37:12 UTC the crew of GWI 2529 confirmed the initiation of a left turn *“Turning left, ah, we have a TCAS RA, Germanwings two five two niner”* and informed air traffic control that they were following a TCAS resolution advisory.

At 08:37:25 UTC, the TCAS on GWI 2529 issued another RA *“Increase descent, increase descent”*. The crew of GWI 2529 increased the rate of descent as required by the RA.

At 08:36:59 UTC, via the mode S downlink, the TCAS on HHN 201 reported the triggering of a corrective resolution advisory of the altitude crossing climb type, which with the aural instruction *“Climb, crossing climb; climb, crossing climb”* prescribed a rate of climb of 1500 to 2000 ft/min, which corresponded to a slight increase in the rate of climb at that time.

The crew of HHN 201 followed this RA and, according to their statement, at the same time initiated a 20 degree evasive manoeuvre to the left, on the basis of the aircraft positions on the TCAS display. The radar recordings show no such change in heading. An immediate report of the resolution advisory to air traffic control was apparently not possible in this phase because of the high occupancy of the frequency.

Since the penetration of GWI 2529 into Sector INSE was not envisaged, no corresponding flight information was displayed on this sector's radar screen. Only when the STCA indicated a conflict between GWI 2529 and HHN 201 was Sector

INSE made aware of the dangerous situation. According to the STCA recordings, at this point in time HHN 201 was at 26,182 ft and GWI 2529 was at 26,906 ft. The measurement accuracy of these altitudes is 25 ft. The lateral distance was 7.56 NM.

According to the statements of the Sector INSE air traffic controller, after the STCA alert there was no time for a consultation with other sectors. Also, they did not know on which frequency GWI 2529 was being handled. For this reason the Sector INSE RE controller decided to instruct the crew of HHN 201 at 08:37:08 UTC to descend immediately to flight level FL 260: *“Rooster two zero one, descend immediately to flight level two six zero, descend immediately to flight level two six zero!”*

The crew of HHN 201 confirmed the instruction to descend at 08:37:11 UTC with the words: *“Descending immediately to flight level two six zero, Rooster two zero one”*. The crew of HHN 201 broke off their climb and started their aircraft on its descent. At 08:37:13 UTC, HHN 201 reached the highest flight level recorded in the course of this serious incident, FL 266.5, and then began a descent. At this point the RA altitude crossing climb had been active for 14 seconds and remained valid for a further 18 seconds, until 08:37:31 UTC. From 08:37:13 UTC, HHN 201 was therefore in the descent demanded by air traffic control, whilst an active RA was demanding a climb of 1500-2000 ft/min.

At 08:37:18 UTC, i.e. 10 seconds after the instruction to descend, the Sector INSE air traffic controller tried to resolve the conflict by asking the crew of HHN 201 to turn right: *“Turn right heading three two zero”*, which was read back by the crew as *“right turn heading three.. one zero”*. At this point, the INSE air traffic controller realised that because of the convergence geometry of the two aircraft, the TCAS was probably already generating resolution advisories. He therefore instructed HHN 201 at 08:37:25 UTC to follow the instructions of this unit: *“Two zero one, follow TCAS, opposite traffic one mile, follow TCAS”*, which was answered by the crew with *“yeah we follow TCAS, traffic in sight”*. At this time, the two aircraft were at the smallest distance from each other.

At 08:37:31 UTC, HHN 201 was at FL 256.25, i.e. 100 feet below GWI 2529, whose mode S transponder was at this time transmitting a flight level of FL 257.25. Subsequently, the TCAS computers on the two aircraft involved changed the evasion directions. The TCAS on HHN 201 switched to a preventive RA, which issued *“monitor vertical speed”* as an aural command and therefore in the present case required the current rate of descent to be maintained. Optically, in the vertical speed indicator (VSI), the range for climb was shown in red and the range for descent was shown in green. At the same time, i.e. six seconds after the *“increase descent”* RA, the TCAS on GWI 2529 ordered a change from the originally downward RA to an upward RA, by issuing a *“Climb, climb now; Climb, climb now”* RA with a required rate of climb of 1500-2000 ft/min; this was implemented by the crew.

At 08:37:39 UTC, when the distance between the two aircraft was increasing again, the TCAS computers on both aircraft issued the *“clear of conflict”* message.

According to the analysis of the data memory of the TCAS computer on GWI 2529, the smallest lateral and vertical distance at the time of crossing was 0.6 NM and 130 ft respectively. This evaluation is based on updating in a one-second cycle.

At the time of the closest approach at 08:37:35 UTC, the distance between the two aircraft according to the STCA log was 0.52 NM in the horizontal plane and 236 ft in the vertical plane. The distance measurements of the radar system at

this time indicated a lateral separation of 0.6 NM and an altitude difference of 50 ft.

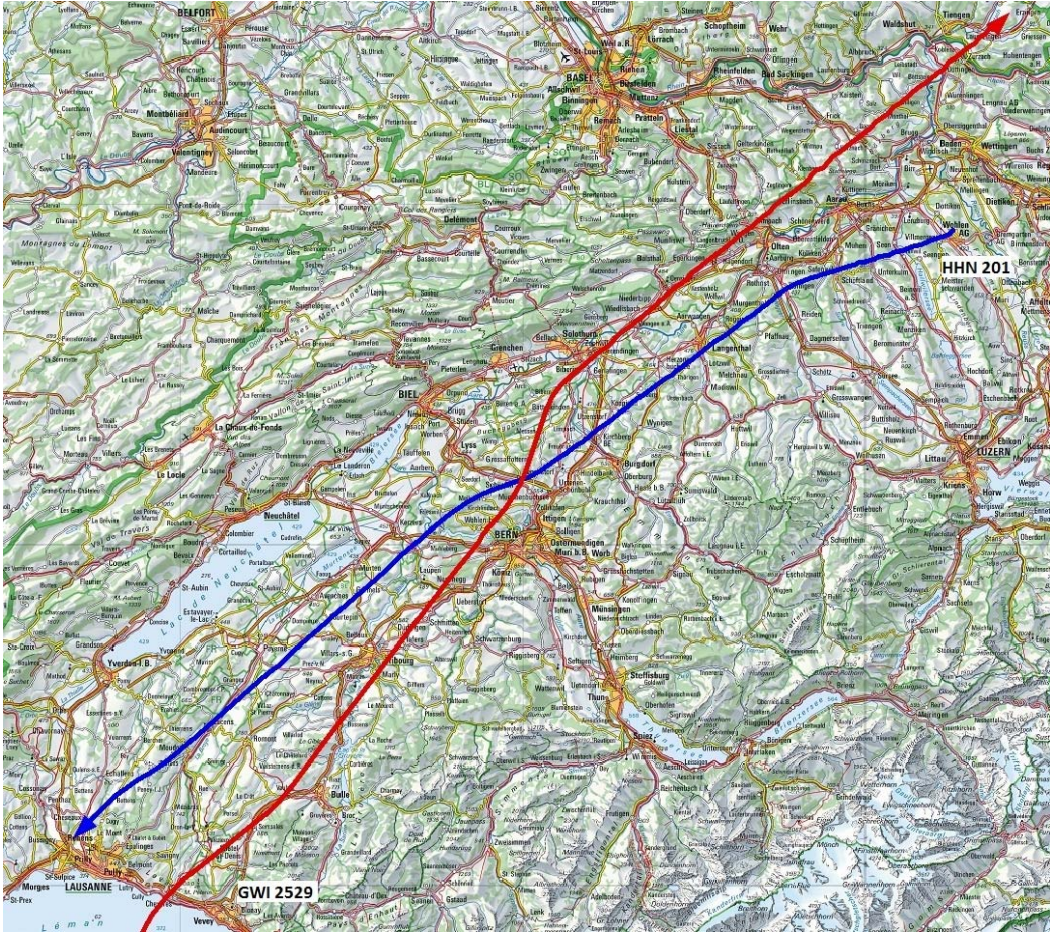


Figure 1: Flight paths of GWI 2529 and HHN 201

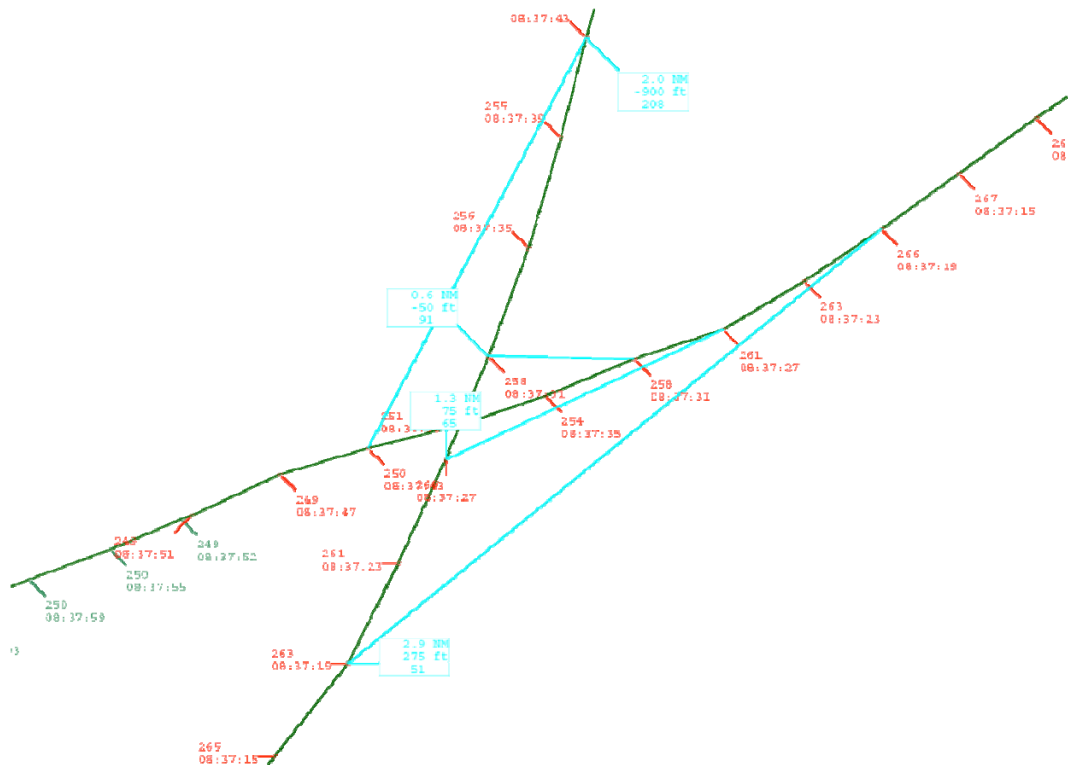


Figure 2: The radar recording shows the situation during the crossing of the two aircraft. GW2529 passes the crossing point at a lateral distance of 1.3 NM and a vertical distance of 75 ft ahead of HHN 201. At the time of the closest point of approach, the distance is 0.6 NM in the lateral plane and 50 ft in the vertical plane. This evaluation is based on the radar image, which is updated in a 4-second cycle.

1.1.5 Location of the serious incident

Position	18 NM north-east of VOR/DME Fribourg
Date and time	10 June 2011, 08:38 UTC
Lighting conditions	Daylight
Altitude or flight level	approx. FL 260

1.2 Personnel information

1.2.1 Crew of GW1 2529

1.2.1.1 Commander

1.2.1.1.1 Training

Person	German citizen, born 1967
Licence	Airline transport pilot licence aeroplane (ATPL(A)) according to joint aviation requirements (JAR), first issued by the German Federal Aviation Office (LBA) on 27 July 1993
Ratings	Type rating A318/19/20/21 as pilot in command, valid till 28 June 2012. Radio licence: voice, navigation and aeronautical radio service rating for ground or air radio equipment in English or German for flights according to visual

		or instrument flight rules
		Language qualification: English level 4, valid till 13 December 2013
	Instrument flying rating	Category III instrument flying on A318/19/20/21, last extended on 28.5.2011, valid till 28 June 2012.
	Last proficiency check	Line check: 18 April 2011 Licence proficiency check (LPC) / Operator proficiency check (OPC): 28 May 2011
	Training on ACAS	Initial training as part of captain's training 21 June - 26 June 2003, Lufthansa Flight Training, Berlin Schönefeld, Germany TCAS Recurrent Training: 28 May 2011 during LPC/OPC, Lufthansa Flight Training, Berlin Schönefeld, Germany
	Medical fitness certificate	Class 1, no restrictions
	Last medical examination	30 June 2010
	Commencement of pilot training	January 1992
1.2.1.1.2	Flying experience	
	Total	9535:00 hours
	on the type involved in the incident	8035:00 hours
	during the last 90 days	178:20 hours
	of which on the incident type	178:20 hours
1.2.1.1.3	Crew times	
	Start of duties in the 48 hours before the serious incident	8 June 2011: off duty 9 June 2011: 03:40 UTC 10 June 2011: 03:45 UTC
	End of duties in the 48 hours before the serious incident	8 June 2011: off duty 9 June 2011: 11:06 UTC
	Flight duty times in the 48 hours before the serious incident	8 June 2011: off duty 9 June 2011: 7:26 hours
	Rest times in the 48 hours before the serious incident	from 8 to 9 June 2011: 40:34 hours from 9 to 10 June 2011: 16:39 hours
	Flight duty at the time of the serious incident	4:53 hours
1.2.1.2	Copilot	
1.2.1.2.1	Training	
	Person	German citizen, born 1984
	Licence	Multi-crew pilot licence aeroplane – MPL(A) according to joint aviation requirements (JAR), first issued by the

	German Federal Aviation Office (LBA) on 10 February 2011.
Ratings	Type rating A318/19/20/21 as responsible copilot, valid till 30 November 2011. Radio licence: voice, navigation and aeronautical radio service rating for ground or air radio equipment in English or German for flights according to visual or instrument flight rules. Language qualification: English level 4, valid till 15 October 2012
Instrument flying rating	Category III instrument approaches with A318/19/20/21, first issued on 19 November 2010, valid till 30 November 2011.
Last proficiency check	Line check: 28 April 2011 LPC: 19 November 2010 OPC: 22 May 2011
Training on ACAS	Initial training as part of A318/19/20/21 type conversion, 5 October - 17 November 2010, Lufthansa Flight Training, Vienna TCAS Recurrent Training: 22 May 2011 during OPC, Lufthansa Flight Training, Berlin Schönefeld
Medical fitness certificate	Class 1 with the restriction holder shall wear corrective lenses Start of validity: 8 November 2010 End of validity: 28 November 2010
Last medical examination	8 November 2010
Commencement of pilot training	2 April 2008
1.2.1.2.2 Flying experience	
Total	278:00 hours
on the type involved in the incident	173:00 hours
during the last 90 days	155:00 hours
of which on the incident type	155:00 hours
during the last 24 hours	5:55 hours
1.2.1.2.3 Crew times	
Start of duties in the 48 hours before the serious incident	8 June 2011: off duty 9 June 2011: 03:45 UTC 10 June 2011: 03:45 UTC
End of duties in the 48 hours before the serious incident	8 June 2011: off duty 9 June 2011: 13:20 UTC
Flight duty times in the 48 hours before	8 June 2011: off duty 9 June 2011: 12:13 hours

	the serious incident	
	Rest times in the 48 hours before the serious incident	from 8 to 9 June 2011: 26:57 hours from 9 to 10 June 2011: 14:25 hours
	Flight duty at the time of the serious incident	4:53 hours
1.2.2	Crew of HHN 201	
1.2.2.1	Commander (in the left-hand seat)	
1.2.2.1.1	Training	
	Person	German citizen, born 1971
	Licence	Commercial pilot licence aeroplane (CPL(A)) according to joint aviation requirements (JAR), first issued by the German Federal Aviation Office (LBA) on 29 April 1997.
	Ratings	Type rating RA390 as pilot in command, valid till 18 November 2011, and C525, valid till 21 October 2011. Radio licence: voice, navigation and aeronautical radio service rating for ground or air radio equipment in English or German language for flights according to visual or instrument flight rules Language qualification: English level 6, unlimited validity.
	Instrument flying rating	Category I instrument approaches on RA390 aircraft, last extended on 14 January 2011, valid till 16 January 2012.
	Last proficiency check	Licence proficiency check (LPC) / Operator proficiency check (OPC): 14 January 2011
	Training on ACAS	TCAS Recurrent Training: 28 July 2009, 10 November 2009. Premier recurrent course: 31 March to 2 April 2011. All at Flight Safety Hawker Beechcraft Learning Center, Wichita, Kansas, USA
	Medical fitness certificate	Class 1, no restrictions Start of validity: 15 March 2011 End of validity: 18 March 2012
	Last medical examination	15 March 2011
	Commencement of pilot training	1993
1.2.2.1.2	Flying experience	
	Total	8120:00 hours
	on the type involved in the incident	120:00 hours

during the last 90 days 27:55 hours
of which on the incident type 27:55 hours

1.2.2.1.3 Crew times

Start of duties in the 48 hours before the serious incident	8 June 2011:	07:00 UTC, office duties
	9 June 2011:	02:45 UTC
	10 June 2011:	04:30 UTC
End of duties in the 48 hours before the serious incident	8 June 2011:	13:00 UTC, office duties
	9 June 2011:	05:45 UTC
Flight duty times in the 48 hours before the serious incident	8 June 2011:	6:00 hours
	9 June 2011:	3:00 hours
Rest times in the 48 hours before the serious incident	from 8 to 9 June 2011:	13:45 hours
	from 9 to 10 June 2011:	22:45 hours
Flight duty at the time of the serious incident	4:08 hours	

1.2.2.2 Copilot (commander in the right-hand seat)

1.2.2.2.1 Training

Person	German citizen, born 1967
Licence	Commercial pilot licence aeroplane (CPL(A)) according to joint aviation requirements (JAR), first issued by the German Federal Aviation Office (LBA) on 18 December 1992.
Ratings	Type rating RA390 as pilot in command, valid till 19 January 2012, and C525, valid till 31 October 2011. Radio licence: voice, navigation and aeronautical radio service rating for ground or air radio equipment in English or German for flights according to visual or instrument flight rules. Language qualification: English level 6, unlimited validity
Instrument flying rating	Category I instrument approaches on RA390 aircraft, last extended on 16 December 2010, valid till 19 January 2012.
Last proficiency check	Licence proficiency check (LPC) / Operator proficiency check (OPC): 16 December 2010
Training on ACAS	TCAS recurrent training: 28 July 2009, 10 November 2009. Premier recurrent course: 31 March to 2 April 2011. All at Flight Safety Hawker Beechcraft Learning Center, Wichita, Kansas, USA
Medical fitness certificate	Class 1, no restrictions Start of validity: 1 March 2011

		End of validity: 19 March 2012
	Last medical examination	1 March 2011
	Commencement of pilot training	1990
1.2.2.2.2	Flying experience	
	Total	11,279:00 hours
	on the type involved in the incident	415:00 hours
	during the last 90 days	64:10 hours
	of which on the incident type	61:05 hours
1.2.2.2.3	Crew times	
	Start of duties in the 48 hours before the serious incident	8 June 2011: off duty 9 June 2011: 02:45 UTC 10 June 2011: 04:30 UTC
	End of duties in the 48 hours before the serious incident	8 June 2011: Off duty 9 June 2011: 05:45 UTC
	Flight duty times in the 48 hours before the serious incident	8 June 2011: off duty 9 June 2011: 3:00 hours
	Rest times in the 48 hours before the serious incident	from 8 to 9 June 2011: > 36 hours from 9 to 10 June 2011: 22:45 hours
	Flight duty at the time of the serious incident	4:08 hours
1.2.3	Air traffic control employees	
1.2.3.1	Air traffic controller 1	
	Function	Radar Executive, Sector L12
	Person	Swiss citizen, born 1986
	Work days before the day of the incident	2
	Start of duty on the day of the incident	6:40 UTC
	Licence	Air traffic controller licence based on European Community Directive 2006/23, first issued by the Federal Office of Civil Aviation (FOCA) on 10 March 2009
	Ratings	RAD (ACS) Radar (area control surveillance), valid till 6 July 2012
	Current competences	LSAG Sector-(Group) UTA, valid till 6 July 2012 English level 4, valid till 31 March 2012
	Medical fitness certificate	Class 3, no restrictions, valid till 9 March 2013
1.2.3.2	Air traffic controller 2	
	Function	Radar planner coach, Sector L12
	Person	German citizen, born 1984

	Work days before the day of the incident	2
	Start of duty on the day of the incident	08:20 UTC
	Licence	Air traffic controller licence based on European Community Directive 2006/23, first issued by the FOCA on 14 September 2007
	Ratings	RAD (ACS) radar (area control surveillance), valid till 26 May 2012
	Current competences	LSAG Sector-(Group) UTA, valid till 26 May 2012 English level 5, valid till 8 October 2016
	Medical fitness certificate	Class 3, no restrictions, valid till 18 October 2011
1.2.3.3	Air traffic controller 3	
	Function	Trainee radar planner, Sector L12
	Person	Swiss citizen, born 1982
	Work days before the day of the incident	2 rest days
	Start of duty on the day of the incident	08:20 UTC
	Licence	Student licence for air traffic controller, first issued by the FOCA on 17 March 2010, valid till 17 March 2012
	Current competences	English level 4, valid till 8 March 2013
	Ratings	ACS (area control surveillance)
	Medical fitness certificate	Class 3, no restrictions, valid till 12 March 2012
1.2.3.4	Air traffic controller 4	
	Function	Radar executive, Sector INSE
	Person	Swiss citizen, born 1977
	Work days before the day of the incident	2
	Start of duty on the day of the incident	06:50 UTC
	Licence	Air traffic controller licence based on European Community Directive 2006/23, first issued by the FOCA on 28 September 2000
	Ratings	RAD (ACS) radar (area control surveillance), valid till 26 November 2011
	Current competences	LSAG Sector-(Group) CTA, valid till 26 November 2011 English level 4, valid till 30 January 2014
	Medical fitness certificate	Class 3, no restrictions, valid till 26 November 2011

1.2.3.5	Air traffic controller 5	
	Function	Radar planner, Sector INSE
	Person	Swiss citizen, born 1980
	Work days before the day of the incident	3
	Start of duty on the day of the incident	05:30 UTC
	Licence	Air traffic controller licence based on European Community Directive 2006/23, first issued by the FOCA on 24 September 2002
	Ratings	RAD (ACS) radar (area control surveillance), valid till 30 September 2011
	Current competences	LSAG Sector-(Group) CTA, last revalidation on 16 February 2011 LSAG Sector-(Group) UTA, valid till 30 September 2011 English level 5, valid till 8 February 2014
	Medical fitness certificate	Class 3, no restrictions, valid till 30 September 2011
1.2.3.6	Air traffic controller 6	
	Function	Radar Executive, Sector M2
	Person	Swiss citizen, born 1985
	Work days before the day of the incident	2
	Start of duty on the day of the incident	05:30 UTC
	Licence	Air traffic controller licence based on European Community Directive 2006/23, first issued by the FOCA on 17 September 2009
	Ratings	RAD (ACS) radar (area control surveillance), valid till 07 December 2011
	Current competences	LSAZ Sector-(Group) UTA, valid till 7 December 2011 English level 4, valid till 29 September 2012

	Medical fitness certificate	Class 3, no restrictions, valid till 2 September 2011
1.2.3.7	Air traffic controller 7	
	Function	Radar planner, Sector M2
	Person	Swiss citizen, born 1977
	Work days before the day of the incident	2
	Start of duty on the day of the incident	03:30 UTC
	Licence	Air traffic controller licence based on European Community Directive 2006/23, first issued by the FOCA on 18 December 1997
	Ratings	RAD (ACS) radar (area control surveillance), valid till 10 March 2012
	Current competences	LSAZ Sector-(Group) CTA/UTA, valid till 10 March 2012 English level 5, valid till 28 July 2014
	Medical fitness certificate	Class 3 with restriction, valid till 10 March 2012
1.3	Aircraft information	
1.3.1	Aircraft 1	
	Registration	D-AKNK
	Aircraft type	A319-112
	Characteristics	Twin-jet short-haul and medium-haul commercial aircraft
	Manufacturer	Airbus S.A.S., Toulouse, France
	Year of manufacture	1999
	Serial number	1077
	Owner	Celestial Aviation Trading, Aviation House IRL-Shannon County Clare, Ireland
	Operator	Germanwings GmbH, Germanwings-Str. 2 D-51147 Cologne, Germany
	Equipment	Honeywell Aerospace TPA – 81A TCAS, Software Version 7.0
1.3.2	Aircraft 2	
	Registration	D-IAGG
	Aircraft type	Raytheon 390 (Beech 390 Premier 1A)
	Characteristics	Twin-jet executive aircraft
	Manufacturer	Raytheon Aircraft Company, USA
	Year of manufacture	2002
	Serial number	RB-35

Owner	Hahn Air Interline Services GmbH, an der Trift 65, D-63303 Dreieich, Germany
Operator	Hahn Air Lines GmbH, an der Trift 65, D-63303 Dreieich, Germany
Equipment	Rockwell Collins TCAS-4000, Software Version 7.0

1.4 Meteorological information

1.4.1 General

The information in section 1.4 was provided by MeteoSwiss.

1.4.2 General meteorological situation

At high altitude, a depression extended from south-east Greenland to northern France. On the ground, pressure contrasts were low. Initially, a shallow ridge of high pressure extended from France to eastern Germany. Pressure over central Europe fell during the morning. An occlusion over France was approaching the Jura at midday.

1.4.3 Weather in Bern and environs

Fairly sunny weather prevailed over the Swiss Plateau. Along the Jura and over the higher Swiss Plateau, cumulus humilis type clouds emerged. Cirrus clouds were passing at high altitude.

1.4.4 Weather at FL 258 at the time of the serious incident

At FL 258 the air was dry and visibility was unrestricted. At a temperature of minus 33 degrees, the spread was between 18 and 23 K. On the southern edge of the depression, the wind was blowing from the west south-west. At mid-morning the average wind speed was nearly 40 knots.

Cloud	Apart from 1-3/8 cirrus, the sky above FL258 was cloudless	
Visibility	Over 10 kilometres	
Wind	240° / 39 kt	
Temperature/dewpoint	-33 °C / -51 °C	

1.4.5 Astronomical information

Position of the sun	Azimuth: 110°	Elevation: 48°
Lighting conditions	Daylight	

1.4.6 Webcam images



Figure 3: Bern-Gurten webcam, north-north-east view, 08:15 UTC.

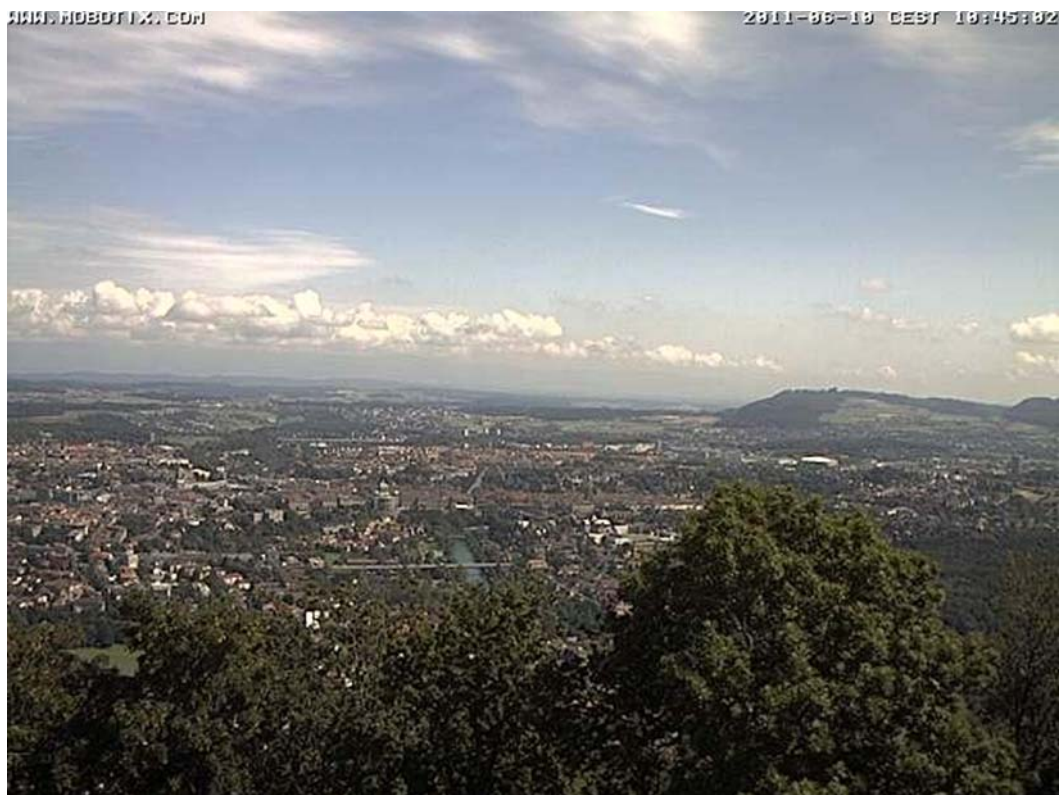


Figure 4: Bern-Gurten webcam, north view, 08:45 UTC.

1.5 Communications

According to information from the crew of HHN 201, they attempted even before the TCAS TA was triggered to inform air traffic control of the closing of an aircraft from above and from the left which they had observed on their NAV display. Because of the high frequency occupancy they were not able to transmit this message.

According to the recording of the Swiss Radar Geneva Sector INSE radio frequency, between the triggering of the first TCAS RA in their aircraft at 08:36:59 UTC and the “*clear of conflict*” message issued by the TCAS at 08:37:39 UTC, the crew of HHN201 read back air traffic control instructions four times. Two of these read-backs took place between 08:37:06 UTC and 08:37:22 UTC, while the TCAS on HHN201 was issuing a resolution advisory. During none of these read backs did the crew of HHN 201 mention that a TCAS RA was active. At 08:37:23 UTC the air traffic controller, in view of the convergence of the two aircraft and on the basis of a TCAS RA, gave the instruction “*two zero one, follow TCAS, opposite traffic one mile, follow TCAS*”, though the crew of HHN201 had not reported a TCAS RA beforehand.

From 08:36:55 to 08:37:12 UTC the frequency was occupied with radio messages.

1.6 Procedures

According to the letter of agreement (LoA) between Geneva ACC and Zurich ACC, flights with destination Stuttgart had to be handed over at waypoint KORED at FL 280.

1.7 Airspace information

The serious incident took place in class C airspace.

The Swiss Air Force was carrying out flights at the time of serious incident. For civil air traffic control, this meant that they had to manage traffic within the airspace assigned to them.

1.7.1 Geneva ACC airspace

For civil air traffic control, the use of the airspace assigned to it by the Air Force meant that south of waypoints MOLUS - KORED no direct flight paths, which contribute substantially to the deconcentration of traffic, were available. The entire volume of traffic had to be handled within a defined corridor with a width of 15 NM. Below FL 250, the corridor in this configuration has a width of 8 NM, corresponding to less than half of the normal width.

At this time, the Air Force air traffic control centre was carrying out an exercise which simulated a restricted representation of the air situation as a so-called degraded air picture. This had the effect that transponder codes which are normally hidden for civil air traffic control were being displayed on the radar screen (cf. figures 5 and 6). Hence the radar picture was encumbered with information which was not necessary for traffic management, and this made readability more difficult for the air traffic controller.



Figure 5: Radar image of Sector L12 in Geneva ACC at the time of the first radio contact with GWI 2529 at 08:33:40 UTC. The blue circle shows the area in which additional transponder codes or symbols of aircraft are shown which are normally suppressed.

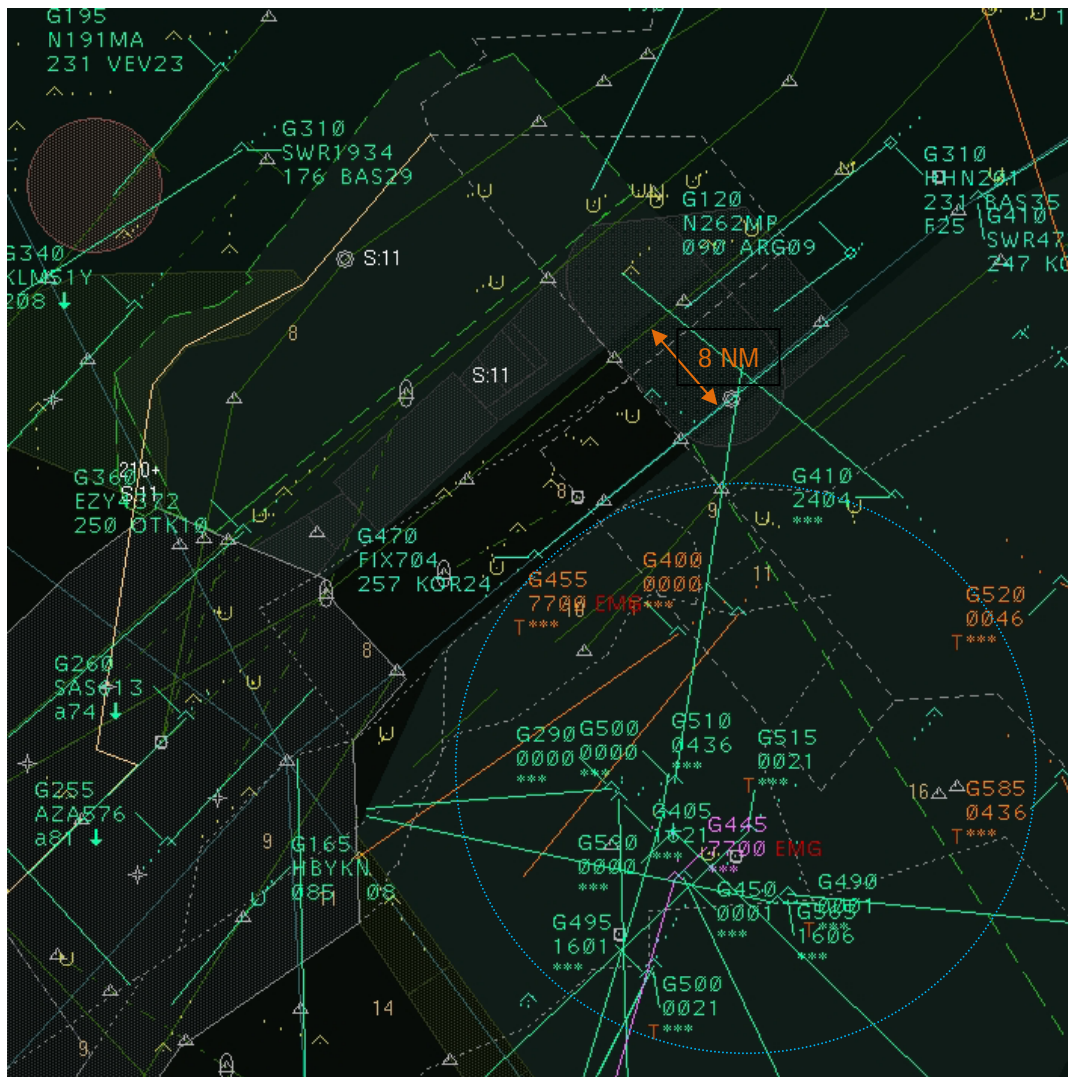


Figure 6: Radar image of Sector INSE in Geneva ACC at 08:34:00 UTC. The blue circle shows the area with additional radar symbols and transponder codes which complicated the overall view. Aircraft GWI 2529 was not shown in this sector because its entry into this sector was not envisaged.

1.7.2 Zurich ACC airspace

The above-mentioned airspace restrictions also applied to the adjacent western part of Zurich ACC.

Aircraft GWI 2529 was flying on a north-easterly radar heading in order to ensure horizontal separation from flight FIX 704, which was climbing (see figure 7). The possibility of achieving separation on an easterly heading, and therefore avoiding crossings with flights on an opposite heading, did not exist, as the Air Force was using this airspace. This had the effect that flights GWI 2529 and HHN 201 could only be separated vertically.



Figure 7: Radar image of the western part of Sector M2 in Zurich ACC at the time of the first radio contact with GWI 2529, at 08:35:18 UTC.

1.8 Flight recorders

No data from flight data recorders was analysed. The data from the TCAS computer on GWI 2529 was analysed.

1.8.1 Mode S downlink

Transponder data from the TCAS computers of both aircraft was transmitted via mode S downlink to the air traffic control radar stations. The recorded data was used for the investigation.

1.9 Organisational and management information

1.9.1 Hahn Air aviation company

1.9.1.1 General

At the time of the serious incident, Hahn Air Lines was a scheduled airline certificated by the IATA on the basis of several implemented IOSA audits and licensed by the German Federal Aviation Office (LBA); it also provided charter services. In addition, Hahn Air was active in the business of electronic airline ticketing. Hahn Air Lines employed some 15 full-time and part-time pilots.

The crew of HHN 201 consisted of two pilots, who were both qualified to operate as flight commander on the RA390. Both of them were in possession of a 'right hand seat qualification', i.e. they were also authorised to act as copilot from the right-hand seat.

Both pilots performed management functions within the company.

1.9.1.2 Flight Operations Manual

The operator laid down the organisation, the procedures to be applied, etc. in the Operation Manuals (OM) A, B, C and D, among other things.

Chapter 8 of the Hahn Air OM A sets out the workings of flight operations as well as the procedures to be applied.

On the subject of ACAS - TCAS, the Hahn Air OM A states the following:

“TCAS II provides collision avoidance manoeuvre advice in the vertical plane, in either of two forms:

- Traffic Advisories (TA's), which indicate the approximate position relative to the subject aeroplane, either in azimuth only, or azimuth and altitude, of nearby transponding aircraft which may become a threat;
- Resolution Advisories (RA's) which recommend manoeuvres or manoeuvre restrictions in the vertical plane to resolve conflicts with aircraft transponding SSR Mode C altitude.

If a TA or RA is received, the following action should be taken :

- TA – a TA is intended to alert the crew that an RA, requiring a change in flight path, may follow. A visual search should immediately be concentrated on that part of the sky where the TA indicates the conflicting traffic to be. If the potential threat cannot be seen and gives cause for concern, air traffic control assistance should be requested in deciding whether a change of flight path is required. If the potential threat is seen, and considered to pose a definite risk of collision, the pilot should manoeuvre his aeroplane as necessary to avoid it making sure that the area into which he is manoeuvring is clear. Once clear of the potential threat, and any other subsequent conflicts, the pilot should resume his previously cleared flight path and advise ATC of any deviation from his clearance.
- RA – an RA is intended to advise pilots on the manoeuvre they must carry out in order to achieve or maintain adequate separation from an established threat. The required manoeuvre should be initiated immediately, and crew members not involved in its execution should ensure that the sky ahead is clear of other traffic and continue the visual search for the established threat. Once the TCAS II indicates that adequate separation has been achieved, or visual acquisition or ATC information shows that there is no longer a conflict, the aeroplane should be promptly returned to its intended flight path and ATC informed.

NOTES :

- An RA MAY NOT BE DISREGARDED if the pilot visually identifies the potentially conflicting traffic and might decide that no deviation from the current flight path is necessary.

- Manoeuvres should never be made in a direction opposite to that given in an RA.

- if an instruction to manoeuvre is received simultaneously from an RA and from ATC, and the instructions conflict, the advice given by the RA should be followed.
- in case of TCAS alert the PNF should observe the airspace for conflicting traffic and should call ATC with the phrase 'TCAS RA'. For further procedures refer to Eurocontrol ACAS safety bulletin 7."

Section 8 of the Hahn Air OM A, revision 6 dated 15 April 2011, also deals with the collision of a B757 and a TU154 near Überlingen in 2002. An excerpt from the ACAS II Bulletin no. 5 of Eurocontrol was inserted into the OM A. (Annex 1)

The following four text boxes were reproduced in the Hahn Air OM A from the Eurocontrol ACAS II bulletin:

"Pilots shall respond immediately by following the RA as indicated, unless doing so would jeopardise the safety of the aeroplane"

"Pilots shall follow the RA even if there is a conflict between the RA and an ATC instruction to manoeuvre"
"Pilots shall not manoeuvre in the opposite sense of an RA"

"Note 2.— Visually acquired traffic may not be the same traffic causing an RA. Visual perception of an encounter may be misleading, particularly at night."

"Pilots shall, as soon as permitted by flight crew workload, notify the appropriate ATC unit of the RA, including the direction of any deviation from the current ATC instruction or clearance"

1.9.1.3 Training Manual

The training required for the acquisition of the RA390 type rating is defined in the Hahn Air OM D. This training is subdivided into a Module A, consisting of 5 8-hour days of classroom instruction, plus a Module B, consisting of 6 exercises on a level C/D simulator, plus as a 7th exercise the Licence Skill Test.

Module A

According to the syllabus, Module A, which extends over 5 days, covers the topic of 'Navigation Instruments, TCAS', for two hours on the third day.

Module B

Module B, which includes 6 exercises on a Level C/D simulator and as a 7th exercise the License Skill Test, includes practical TCAS exercises.

According to information from the Flight Safety International Hawker Beechcraft Learning Center, Wichita, Kansas, USA on 28 July 2009 and on 10 November 2009, the crew were faced with a TCAS scenario as part of recurrent training. This simulated dangerous traffic in the departure procedure after take-off. Between 31 March and 2 April 2011, the crew completed a Premier recurrent

course at the same training centre during which TCAS training was also completed.

1.9.2 Skyguide air navigation services

1.9.2.1 Working procedures when entering cleared flight levels

In a working environment in which flight data is recorded on a control strip, the principle has always been “write as you speak”, in order to ensure that the current information status at any time is documented and therefore retrievable. This working principle was also transferred to the input of cleared flight levels using a mouse; in this context, reference is made to “click as you speak”. The difference is that the information is displayed directly in the radar 'label' of the corresponding flight and the current information status is in the direct field of vision of the radar executive (RE) and radar planner (RP). The cleared flight level transmitted by radio is introduced by mouse-click into the label by the RE without delay and displayed immediately. There is no prescription ruling the sequence of the introduction and transmission event and air traffic controllers handle it indistinctly. The avoidance of the constant change of focus between the perception of the situation on the radar screen and the writing on the control strip has led to a significant increase in efficiency given the same workload.

1.9.2.2 Standards regarding phraseology

In relation to standard phraseology, the ATMM Switzerland Section 7, 1.1 and 1.4, states the following, inter alia:

“1 ATC CLEARANCES

1.1 ISSUANCE OF ATC CLEARANCE

An ATC clearance specifies the conditions under which a given controlled flight may be conducted.

Issue an ATC clearance to each controlled flight (or portion of controlled flight).

Controlled flights comprise:

- a) IFR and VFR flights in airspaces class C and D;*
- b) IFR flights in airspace class E; and*
- c) aerodrome traffic at controlled aerodromes without aerodrome control zones.*

Phrase ATC clearances in a clear, positive and concise manner.”

“1.4 CONTENTS

1.4.1 GENERAL

Clearances shall contain the following items in the order listed:

- a) aircraft identification;*
- b) clearance limit;*
- c) route of flight (e.g. SID, ATS routes, STAR);*
- d) level(s); and*
- e) any necessary instruction or information (e.g. SSR transponder code, approach or departure manoeuvres, speed restrictions, vertical speed control instructions, time of expiry of the clearance)*

Phraseology:

- CLEARED TO (clearance limit) VIA (route description or FLIGHT PLANNED ROUTE) (level) (restrictions)”*

In relation to standard phraseology for an initial radio contact between an aircraft and an air traffic control centre, the following stipulations applied, among others (extract from the ATMM Geneva ACC, General ACC procedures ENR A-3):

"A.2.1 ATC CLEARANCE

An ATC clearance does not include a clearance limit, except in the case of a special event (restrictions, traffic congestion etc.). However, the route clearance should include the first reporting point of the receiving FIR/UIR.

ATC clearance format:

- *Aircraft call sign*
- *"Identified"*
- *Route*
- *Flight level*

Examples:

"SPEEDWAY FIVE ONE TWO, IDENTIFIED, CLEARED (VIA) MILPA – MEDAM – TORINO, (MAINTAIN) FLIGHT LEVEL THREE THREE ZERO".

No information is present in this connection in the ATMM Zurich ACC Volume 2.

1.10 Safety nets

1.10.1 Enhanced surveillance

The transponder in "mode S enhanced surveillance (EHS)" transmits a number of aircraft parameters - "downlink aircraft parameters" (DAP) - to the air traffic control radar stations. One of these parameters is the respective altitude selected in the flight management system (selected altitude).

In an air traffic management (ATM) system with an appropriate technical configuration, this data can be analysed and used to eliminate sources of error. To this end, the values in the flight management system of an aircraft are compared with the corresponding values in the ATM system and an alarm is triggered in the event of a difference.

Systems of this type are operationally available in a few European countries and in Switzerland they are at an advanced planning stage.

1.10.2 Airborne collision avoidance system¹

Since 1 January 2000 it has been mandatory in Europe for commercial flights by turbine-engined aircraft with a maximum permitted take-off mass in excess of 15,000 kg or with more than 30 seats to carry a collision avoidance system conforming to the ACAS II standard.

Since 1 January 2005 it has also been mandatory for aircraft with a maximum permitted take-off mass in excess of 5700 kg or with more than 19 seats to carry a collision avoidance system conforming to the ACAS II standard.

- a) An airborne collision avoidance system (ACAS) is a system permanently installed in the aircraft which is based on secondary radar transponder signals and which works independently of ground-based systems. It issues advisories and avoidance commands to the pilot, in order to avoid possible conflicts with other aircraft which are also equipped with secondary radar transponders.
- b) ACAS II is an airborne collision avoidance system which in addition to traffic advisories also issues vertical avoidance commands (resolution advisories).

¹ The designation of the basic concept of this collision prevention system is an airborne collision avoidance system (ACAS). The International Civil Aviation Organization (ICAO) uses this term when drawing up the standards with which the system must comply. The traffic alert and collision avoidance system (TCAS) is a concrete implementation of this concept.

- c) A “resolution advisory” (RA) is an instruction to the crew to climb or descend with the purpose of establishing adequate separation from aircraft which are dangerously close or to carry out a climb, descent or level flight so that a specific vertical separation is achieved.
- d) A “traffic advisory” (TA) is an indication intended to make the crew aware that an aircraft is in the vicinity could pose a possible risk.

1.10.3 Air traffic control conflict alert system

In the event that the flight paths of two or more aircraft lead to a violation of the minimum separations, there exists in air traffic control a conflict alert system (short term conflict alert - STCA). This warns the air traffic controller and, where appropriate, requires his or her intervention.

The conflict alert systems of the Geneva and Zurich area control centres use different parameters for triggering an alert. This explains why in the case in question the systems did not respond at the same time.

2 Analysis

2.1 Technical aspects

There are no indications of any pre-existing technical faults which might have influenced the serious incident.

In the case of vertical convergences, the air traffic control conflict alert system (short term conflict alert - STCA) constitutes a safety net of only very limited effectiveness. In the present serious incident, the first warning in Sector M2 in Zurich occurred at 08:36:52 UTC and in Sectors INSE and L12 in Geneva it occurred at 08:36:59 UTC, i.e. some 35 seconds and 28 seconds respectively before the dangerous convergence. From 08:36:57 UTC the TCAS on GWI was generating resolution advisories. At 08:36:59 UTC the TCAS on HHN 201 began to issue resolution advisories. Thus the STCA alert occurred almost at the same time as the resolution advisories from the last safety net (TCAS). The air traffic controllers therefore had no time to effectively resolve the impending dangerous convergence.

Early detection of the impending conflict was also made more difficult by the fact that the two aircraft were being handled by different sectors on different frequencies. In addition, coordination and the general overview were adversely affected because the two aircraft were only partially displayed in the different sectors.

The two flights were displayed only on the radar displays of Sectors L12 and M2 for the following reasons:

- In Sector WEST, HHN 201 left the vertical area of responsibility after passing FL 245 and was no longer displayed.
- In Sector M2 both GWI 2529 and HHN 201 were displayed. The routes of both flights passed through its area of responsibility. The serious incident took place within Sector M2.
- In Sector INSE only HHN 201 was displayed. Although the aircraft was above this sector prematurely, the flight was assigned to this sector on the basis of the specified procedure. Only when the STCA alert was triggered was GWI 2529 also displayed.
- Both flights were displayed in Sector L12. However, because of the chronological sequence the flights crossed outside this sector.

At the time of the serious incident, Geneva area control centre was technically not in a position to compare the selected flight level 250 as transmitted by the transponder in mode S EHS on GWI 2529 with the flight level 280 entered in the ATM system. In the present case, this difference which occurred would have caused an alarm to trigger more than three minutes before the serious incident. This alarm would very probably have enabled the air traffic controllers to intervene at an early stage and resolve the impending conflict at an early stage. Thus, an important safety net in air traffic control was missing; this contributed to the occurrence of the hazardous convergence.

The benefits of such a safety net are recognised at the international level as an important future tool in the detection of incorrect inputs and thus in the prevention of such incidents. In Europe, its development is at an advanced stage and the implementation phase has begun in individual area control and approach control centres. Since 2012, the Swiss air traffic control features on all sectors the parameters transmitted by Transponder Mode S EHS.

2.2 Human and operational aspects

2.2.1 Air traffic control

2.2.1.1 Sector L12 of Geneva Area Control Centre

Owing to an impending separation problem in Sector M2 of Zurich ACC, the radar planner coordinated with Sector L12 in Geneva a heading change of 15 degrees to the left for GWI 2529, which was flying in a north-easterly direction and descending. This brought the aircraft into the section of the airspace in which traffic flying in a south-westerly direction is generally managed. In view of the airspace restrictions due to the activity of the Air Force, this was an obvious solution, but one which increased the complexity of the traffic situation as well as necessary coordination.

The RE controller for Sector L12 in Geneva handed over GWI 2529 to Sector M2 in Zurich, after he had cleared it to descend to FL 250 while it was still within his area of responsibility. He did not realise that at the same time as he issued clearance to FL 250 to the crew of GWI 2529 he had entered flight level FL 280 in the radar system. The air traffic controller could not subsequently explain why he had cleared GWI 2529 to FL 250. This flight level did not comply with the arrangement (letter of agreement) between the Geneva and Zurich area control centres and according to this agreement it would have required prior coordination with Zurich.

For reasons of traffic organisation, maximum flight levels for handovers between sectors and area control centres are agreed for flights which are nearing their destinations and which must therefore begin their descent. In order to limit the number of coordinations, as far as possible the lowest flight levels within the respective area of responsibility of the transferring sector are agreed. In the combined Sector L12, this corresponds to flight level FL 250 and a large proportion of descending flights exit the sector at this flight level. In this context, the flight level FL 280 as an exit flight level represents an exception. However, this does correspond to the flight level generally agreed between Geneva and Zurich for flights with Stuttgart as their destination airport.

One possible explanation stems from the question of whether temporarily effective conditioning had occurred to the air traffic controller due to a repetitive process. This would mean specifically that the repeated utterance or hearing of the expression "FL250" led to an automatic response. In many cases such a response results in an efficiency and productivity advantage as cognitive resources are available for other tasks and the load of the working memory is held at a low level.

Generally it can be said in this regard that the simultaneous presence of automated routine processes and conscious reflection are part of the day-to-day activity of air traffic controllers. In the interests of economy and flexibility, in the course of professional experience there arises a style of working tailored to these requirements; it exhibits individual nuances within the given framework.

With regard to the above-mentioned error, this possible explanation leads to the actual result that the air traffic controller committed an error caused by the fact that in his conscious awareness of the moment the specific event was out of focus. According to our hypothesis the subsequent consequence was the unintentional uttering of FL 250 used several times beforehand in a kind of repetitive pattern.

On the assumption of a general professional routine behaviour resulting in a partially automated behaviour, the consequence on the sensomotoric level was a

correct result whereas on the verbal level the result was deviated and incorrect caused by a short termed overlaying erroneous automatism.

It would also be conceivable that the focus of the attention was set on the introduction of FL 280, whereas the verbal level was faded out. This favoured the effect of the repetitive inadequate automatism.

A further possible explanation for this behaviour derives from the psychoanalytical theory which states that the unintentional mentioning of an incorrect expression or even a wrong numerical value is not a matter of chance. Sometimes it reveals a suppressed secondary consideration, though this is not apparent in the case of the Sector L12 RE controller.

Therefore, the application of a psychoanalytical interviewing technique would be required in order to understand the unconscious reason for inaccurate speech. This would relate not only to the error itself, but also specifically to why it was precisely this flight level which was mistakenly cited. Assuming that such questioning was successful, this would give an insight into what led in the present case to a discrepancy between conscious and unconscious intentions. Additional findings would not, however, be expected, so such questioning was not considered as part of the investigation.

Psychological and mental coordination can be affected by factors such as fatigue or stress and increase the risk of errors and incorrect actions. Also, perturbation of mental equilibrium consumes energy, thereby reducing the flexibility needed for demanding coordination performances. The investigation of the serious incident revealed no evidence that would indicate a deterioration in mental equilibrium.

Finally, even a simple ergonomic reason for this error in the work of the air traffic controller can be given: essentially, people's ability to carry out several activities at the same time is limited. When looked at in detail, it is impossible to deal with more than one ~~two~~ operation simultaneously in a focused manner. Multitask capability is characterized by individual differences depending on personality and is generally known to be of limited extent. Since it is necessary to resort to procedures which have been trained for and which have become routine when several activities are being carried out simultaneously, in such phases the risk of routine errors also increases. Whenever possible, therefore, activities should be carried out at slightly staggered times. In the management of modern commercial aircraft, ergonomic principles which aim to reduce errors have long been consistently integrated into the design of work processes. Thus, for example, the crew of such an aircraft are instructed and trained, after receiving clearance from air traffic control, to enter this instruction in the flight management system and only then to actively read back the numerical value which is then displayed by the system in order to confirm the clearance from air traffic control. This implements a method of working which ensures that an instruction is not merely read back routinely from memory; on the contrary, a 'closed loop' is created which helps to eliminate the majority of incorrect inputs before they occur. However, the method of working implemented by air traffic control - entering a cleared flight level into the radar display using a mouse and transmitting it to the crew by radio at the same time ("*click as you speak*") neglects such simple ergonomic principles and offers only limited possibilities of identifying at an early stage a simple working error. These processes therefore represent a systemic contributing factor to this serious incident.

At the time of the incident, the Air Force was carrying out an exercise which simulated a restricted perception of the air situation, a so-called degraded air picture. This had the effect that transponder codes which are normally hidden for civil air

traffic control were being displayed on the radar screen. The radar image therefore included information which was not necessary for traffic management. Consequently, the burden on the RE's concentration and as a result his workload increased.

For the two air traffic controllers, the RP coach and trainee, there was no possibility for them to become visually aware of the difference between the clearance given and the entry into the radar system. They were also busy with coordination tasks in connection with the Air Force exercise and therefore did not hear the actual clearance to descend to FL 250 given by the RE controller. The configuration with dual occupancy of the RP workstation may appear on the one hand as an advantage, as an extra person can monitor the radio conversations; on the other hand it must be taken into account that the trainee is on a learning curve and therefore the coordinations which arise take slightly longer and in some cases have to be discussed with the coach.

2.2.1.2 Sector M2 of the Zurich Area Control Centre

At the time of the first radio call by the crew of GWI 2529 to Sector M2 in Zurich, the RE controller did not realise that the crew of GWI 2529 were reporting a descent to FL 250, not the flight level FL 280 envisaged for the handover. The current flight level of just over FL 300 shown on the radar display at this time was within the expected range. As a result of the previous coordination, she expected that the crew of GWI 2529 would as normal report during the initial contact the cleared flight level and in particular the heading change to the left. However, the message included only the cleared flight level, causing the ATCO to make a corresponding enquiry concerning the change in heading. This focus on one partial aspect of the radio conversation may have meant that she did not take in the reported flight level and therefore did not notice the difference between the coordinated level and the cleared level. Another possible explanation is the expectation that GWI 2529 would descend to flight level FL 280, which might result in her not noticing the erroneous clearance to FL 250 issued by the previous sector on the initial call of the crew.

In addition, it should be noted that the Sector M2 RE air traffic controller did not apply the procedures of the air traffic control company regarding standard phraseology. Thus the ATMM Switzerland generally maintains that an air traffic control clearance must also include the cleared flight level, among other things. The Geneva ACC ATMM likewise states this, though it specifies therein that this should take place in particular when a clearance is given after an initial radio call. Regulations to this effect are not included in the Zurich ACC ATMM. Even if it seems strange that such fundamental processes are regulated differently in the two air traffic control area centres, the absence of corresponding regulations in the Zurich ACC ATMM alone does not explain the behaviour of the Sector M2 RE controller. Rather, the reason should probably be sought in the fact that in air traffic control it has become common practice to omit certain parts of a standard clearance in order to reduce occupancy of the frequency. In the present case, however, that an additional possibility of correcting the working error which had occurred in the Geneva ACC by issuing a complete and correct clearance, was lost.

When the radar display subsequently indicated a flight level of FL 272, the Sector M2 RE controller noticed for the first time that the descending GWI 2529 was already below FL 280. She was aware at this time of HHN 201; the flight was under the jurisdiction of her sector and was shown on the radar display. The Sector M2 RE controller immediately realised the conflict between the two flights and tried reflexively to halt GWI 2529's descent at FL 270. This intuitive reaction of the air

traffic controller is understandable. What made things more difficult was that HHN 201 was not on her frequency. She did not know the flight level to which HHN 201 had been cleared. Since GWI 2529 would normally have to descend to flight level FL 280, she assumed that HHN 201 would climb to FL 270 as a maximum and would continue climbing after crossing GWI 2529.

There was not much time to find a solution. The aircraft were closing at approximately 13.5 NM per minute over a distance of some 10 NM. The Sector M2 RP controller became aware of the conflict as a result of a call from Geneva Sector L12. The latter informed him that HHN 201 was climbing to FL 270. Together, they agreed to resolve the conflict somewhat by making both GWI2529 and HHN 201 turn left in their respective direction of flight. During the telephone call, the Sector M2 RP controller informed the Sector M2 RE controller about the conversation, whereupon the latter gave an instruction to GWI 2529 to initiate a left turn. This instruction caused GWI 2529 to initiate a left turn some eight seconds before the crossing. In Geneva, however, Sector L12 was not in contact with HHN 201; Sector INSE in Geneva ACC was in contact with it. In order to get HHN 201 to also turn left in its direction of flight, Sector L12 had to inform Sector INSE of this arrangement; this took place at 08:36:59 UTC. Subsequently, the arrangement could evidently no longer be transmitted by the Sector INSE RP controller to the RE controller, so the latter, on the basis of his own assessment of the situation of HHN 201, gave an instruction to turn right at 08:37:16 UTC, which tended to exacerbate the convergence.

2.2.1.3 Zurich Area Control Centre Sector West

HHN 201 was approximately to the north of beacon WIL when the crew reported they would soon be reaching flight level FL 230. Sector West in Zurich then handed over the aircraft to Geneva Sector INSE so that the crew could continue their climb as soon as possible. This procedure was in compliance with the current practice and was often used in the border area of competencies.

2.2.1.4 Geneva Area Control Centre Sector INSE

The Sector INSE controllers had the task of allowing flight HHN 201, which had taken off from Zurich, to climb through their sector towards its cruising altitude. As they did so, among other things they had to ensure separation between a flight with destination Geneva airport and a flight which had taken off from Geneva. To this end, coordinations had taken place which allowed flight HHN 201 to climb within the altitude and competency zone of Geneva air traffic control centre Sector L12 above it. Since the flight level of FL 280 entered in the ATM system for the descending GWI 2529 and that for the climbing HHN 201 did not represent a conflict, no alert was triggered by the system. This separation of the two flights was correctly planned by means of the above-mentioned electronic and telephone coordination by the Sector L12 ATCOs, whose area of responsibility included the cleared flight levels.

Since GWI 2529 was not expected to fly into Sector INSE, the latter had no knowledge of its flight data, because of the system, and the flight was also not therefore displayed on the radar screens either. When an STCA alert suddenly triggered, the ATCOs realised that there was a conflict between HHN 201, of which they were aware, and a hitherto unknown flight which now appeared on their radar screens as GWI 2529 and with which they had no radio contact. The only possibility of intervening to resolve the hazardous convergence was to give HHN 201 appropriate instructions, which then happened immediately. Since GWI 2529 was at this time still above HHN 201, it was appropriate to give it an instruction to descend immediately, followed by a change in heading to the right as an

additional measure. The Sector INSE was informed as described above of the coordination of the evasive manoeuvre between Sectors L12 and M2. For time reasons, however, these planned measures could no longer be implemented by the Sector INSE RE controller.

In view of the short notice and the rapid sequence of events, the Sector INSE RE controller finally decided to give no further instructions to HHN 201 and to urge it to follow the instructions of the TCAS. In this context it must be added that he could only guess at such TCAS instructions; hitherto the crew of HHN 201 had not provided him with any information about the existence of such instructions.

2.2.2 Flight crews

2.2.2.1 Crew of GWI 2529

The first call from GWI 2529 on the frequency of the combined M2 Sectors took place at 08:35:18 UTC, i.e. one minute and 26 seconds before the TCAS on GWI 2529 triggered a TCAS traffic advisory. On the occasion of this first call from GWI 2529 the crew should have reported their current magnetic heading in addition to their cleared altitude, but they failed to do so. According to the air traffic controller this was possibly the reason that she concentrated on the unreported heading and didn't perceive the reported altitude. From 08:36:42 UTC a high workload arose within a very short time in the cockpit of GWI 2529 due to the following events:

- At 08:36:42 UTC the instruction from Sector M2 was given: *“resume own navigation to ARSUT”*.
- At 08:36:44 UTC, while transmission of the *“resume own navigation to ARSUT”* instruction was still being given, the TCAS traffic advisory was triggered. The crew of GWI 2529 responded to this instruction at 08:36:48 UTC with the radio message *“stand-by”*.
- Five seconds later, at 08:36:49 UTC, there followed the question from the M2 radar executive *“please ah confirm maintain level two seven zero?”* For the crew, this instruction was unexpected, because it did not correspond to the current cleared flight level of FL 250. In addition, this instruction was posed in the form of a question but was actually an instruction and was understood as such by the crew. The radio message required interpretation by the crew, i.e. a conscious thought process in order to understand what was actually required of them in this situation. This circumstance, together with the required heading change after waypoint ARSUT plus the simultaneous active TCAS traffic advisory, led to a high workload. The copilot acting as pilot flying switched off the autopilot and flew the aircraft manually in level flight at FL 270. Switching off the autopilot to bring the aircraft to level flight as quickly as possible indicates that the crew were coping with the situation and were able to take appropriate measures.
- At 08:36:55 UTC the crew of GWI 2529 confirmed *“maintaining level two seven zero”*. While this confirmation was being transmitted and before the autopilot could be re-engaged, the situation escalated further: at 08:36:57 UTC the M2 radar executive gave the instruction *“turn left by three zero degrees, due to traffic”* and at the same time the TCAS on GWI 2529 issued a resolution advisory *“maintain vertical speed, crossing, maintain”*.
- A few seconds later, at 08:37:07 UTC, the M2 radar executive repeated the instruction once more *“turn left immediately!”*. At this point in time he was not aware that GWI 2529 was following the TCAS resolution advisory, probably because, among other things, the crew up to this time, i.e. 10 seconds after

the triggering of the resolution advisory, had not made the “TCAS RA” radio report necessary to notify air traffic control. This delay is understandable, given the crew's high workload. At this time the crew of GWI 2529 were setting priorities in accordance with the accepted principle of flying “fly - navigate - communicate”.

- At 08:37:12 UTC the crew of GWI 2529 confirmed “*turning left, ah, we have a TCAS RA*” thereby using the confirmation of this instruction to report an active resolution advisory. This informed the M2 radar executive of this significant fact and he subsequently refrained from giving any further instructions until the hazardous convergence had been resolved.
- At 08:37:25 UTC, i.e. 28 seconds after the triggering of the first TCAS resolution advisory, the type of the resolution advisory changed to “*increase descent, increase descent!*”. The crew followed this TCAS instruction accordingly.
- At 08:37:31 UTC, the TCAS on GWI 2529 ordered a mode reversal, i.e. the reversal of the direction of avoidance. After the “*increase descent!*” there now followed a resolution advisory ‘*climb climb now, climb now!*’. At about this time, the two aircraft crossed the closest point of approach. In the course of the transition to a climb, at 08:37:39 UTC the TCAS issued the message “*clear of conflict*”, i.e. the distance between the two aircraft was again increasing.

In summary it can be stated that the crew of flight GWI 2529 were appropriately skilled and trained and were able to adopt and implement the patterns of behaviour required by TCAS immediately. They followed the TCAS resolution advisories without delay and to the required extent.

2.2.2.2 Crew of HHN 201

The crew of HHN 201 consisted of two pilots who had both trained as flight commanders.

According to the crew's statement, they noticed a converging aircraft on their TCAS display and wanted to inform air traffic control, but this was not possible owing to the high occupancy of the frequency. An analysis of the frequency occupancy, however, indicates that the Sector INSE frequency was occupied for less than half the time in the two minutes before the serious incident. Such a report from crew would have been unusual and would not have been required by any procedure. A crew generally does not know the altitude at which an aircraft shown on the TCAS display is cleared to and whether it is transitioning to level flight 1000 ft or more above or below the flight level cleared for their own aircraft.

When the TCAS on HHN 201 issued a traffic advisory, the crew switched off the autopilot. A traffic advisory is intended to alert the crew that they should prepare for an active evasive manoeuvre. Switching off the autopilot in response to a traffic advisory alone unnecessarily increases the crew's workload and therefore is inconsistent with prudent and safety-conscious flight management.

At 08:36:59 UTC, when the TCAS on HHN 201 issued a resolution advisory “*climb crossing climb, climb crossing climb*”, the crew of HHN 201 followed this instruction, but, according to their statement, at the same time they initiated a left turn on the basis of the TCAS display, which would have brought the aircraft onto a heading changed by 20 degrees. The immediate compliance with the resolution advisory in the vertical axis was correct and constitutes the basis of the fundamental concept of TCAS. However, flying additional lateral evasive manoeuvres contradicts the basic concept of TCAS, as this system is designed, as a last safety net, to prevent a collision by means of coordinated evasive manoeuvres in

the vertical plane. However, the radar recordings indicate no such change in heading.

At 08:37:06 UTC, i.e. seven seconds after the triggering of the first TCAS resolution advisory, the Geneva Sector INSE radar executive ordered HHN 201 to descend immediately, by instructing them: “*descend immediately to flight level two six zero, descend immediately to flight level two six zero*”, which was confirmed by the crew. The crew of HHN201 aborted their climb of 1500 - 2000 ft/min, which the TCAS continued to demand and which was shown optically on the vertical speed indicator and initiated a descent. The resolution advisory requiring a climb was still active until 08:37:31 UTC, i.e. the crew of HHN 201, from the air traffic control instruction to descend at 08:37:06 UTC, flew for 25 seconds contrary to the TCAS resolution advisory, whilst the display of the vertical speed indicator in the red zone provided an additional warning. As a result of this behaviour - flying the aircraft in accordance with the instructions of the air traffic controller and contrary to a TCAS resolution advisory - the crew of HHN 201 *de facto* excluded TCAS as the last safety net, and this resulted in the two aircraft, at their closest point of approach, to have a vertical separation which was significantly less than that used by the TCAS concept as a minimum.

The TCAS concept also assumes that from the triggering of a TCAS resolution advisory, the TCAS computers on the aircraft involved coordinate with each other to resolve the problem, i.e. the respective vertical evasive direction and the extent of the vertical evasive manoeuvre, via the mode S datalink, and that air traffic control, as soon as they have been informed of the activation of an evasive resolution advisory, take no further part. In the period from when the TCAS resolution advisory was triggered at 08:36:59 UTC, the crew of HHN 201 twice confirmed instructions from air traffic control, which on the one hand went contrary to the TCAS resolution advisory and on the other hand would have provided an opportunity to make the comment “*TCAS RA*”, thereby making air traffic control aware that the responsibility of assuring separation had now been passed to the flight crews and that the latter were in the process of following the TCAS instructions.

Remarkably, during their descent, which was made contrary to an active resolution advisory which required a climb, the crew of HHN 201 dropped below the altitude of FL 260 instructed by the Geneva Sector INSE radar executive by some 400 ft.

From 08:37:31 UTC, the time of the mode reversal, the TCAS on HHN 201 ordered it by means of an RA of the “*monitor vertical speed*” type to continue to descend at its current rate of descent; the crew, which had already initiated the descent, did so.

At 08:37:38 UTC, the TCAS on HHN 201 indicated “*clear of conflict*” and at 08:37:43 UTC the crew reported to air traffic control “*now at level 250, request further*”.

The crew of HHN 201 consisted of two members of the management of the Hahn Air company who were responsible, among other things, for producing and implementing the procedures such as, for example the OM A. This OM A includes extensive sections which regulate the use of TCAS in the form of extracts from ACAS II Bulletin no. 5 of the European air traffic control organisation Eurocontrol documents (Annex 1 and Section 1, 1.9.1 2). This bulletin addresses the collision of two aircraft over Überlingen/Germany in 2002. Among other things, what led to this accident was the fact that one of the crews involved did not follow a TCAS resolution advisory but followed the contrary instructions of air traffic control.

With regard to their responsibility concerning this important operation manual, it can certainly be assumed that at the time of the hazardous convergence the flight crew members were at least mentally aware of the relevant text boxes in the OM A

- *“Pilots shall follow the RA even if there is a conflict between the RA and an ATC instruction to manoeuvre”*

and

- *“Pilots shall not manoeuvre in the opposite sense of an RA”*

Nevertheless, the serious incident clearly indicates that they were not able to access this knowledge and convert it into appropriate actions. The reason for this inability cannot lie in a moment of surprise or inadequate mental preparation, because these simple response patterns are designed precisely to allow them to be invoked reliably and in good time following the surprise. Rather, everything indicates that the crew of HHN 201 was essentially not sufficiently familiar with dealing with TCAS.

Even if the training centre used for the periodic performance checks certified that the crew of HHN 201 had been confronted several times in the simulator with TCAS scenarios, this training proved to be ineffective in the light of this serious incident.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- Both aircraft were licensed for IFR transport.
- The investigation produced no indications of any pre-existing technical faults which might have caused or influenced the incident.

3.1.2 Crew

- The pilots were in possession of the necessary licences for the flight.
- There are no indications of the pilots suffering health problems during the flight involved in the incident.
- At no time did the crew of GWI 2529 have visual contact with HHN 201
- The crew of HHN 201 were able to identify GWI 2529 crossing from left to right and from above them to below

3.1.3 Air traffic control personnel

- The air traffic controllers were in possession of the licences necessary to exercise their activities.
- There are no indications of the air traffic controllers suffering health problems at the time of the serious incident.

3.1.4 History of the flight

- Between 08:33:45 UTC and 08:36:19 UTC, HHN 201 received successive clearances to climb to FL 270 in Sector INSE.
- At 08:34:10 UTC, GWI 2529 in Sector L12 in Geneva received clearance to descend from FL 320 to FL 250.
- At 08:34:19 UTC, flight level FL 250 was entered into the flight management system of the Airbus A319 aircraft, flight number GWI 2529.
- At 08:35:01 UTC, GWI 2529 was instructed to report on the Sector M2 frequency of Zurich ACC.
- At 08:35:18 UTC, GWI 2529 reported for the first time in Zurich Sector M2 with the message: "... *descending level two five zero*".
- At 08:36:47 UTC the Sector L12 RP controller in Geneva requested the M2 Sector RP controller in Zurich to stop the descent of GWI 2529: "*Stop the Germanwings two five two niner, our hotel hotel november is going to 270*". The Sector M2 RP controller then informed the Sector L12 RP controller in Geneva that ACC Zurich wanted to turn GWI 2529 to the left.
- At 08:36:49 UTC, the Sector M2 RE controller called GWI 2529 with the question: "...*confirm maintain level two seven zero?*"
- At 08:36:52 UTC, the STCA in Zurich triggered an alert.
- At 08:36:57 UTC, the TCAS on GWI 2529 triggered a corrective resolution advisory.
- At 08:36:57 UTC, the Sector M2 RE controller instructed GWI 2529 to change its heading by 30° degrees to the left. There was no response from the crew of GWI 2529.

- At 08:36:59 UTC, the STCA in Sectors INSE and L12 in Geneva triggered an alert.
- At 08:36:59 UTC, the TCAS on HHN 201 triggered a corrective resolution advisory.
- At 08:36:59 UTC, the Sector L12 RP controller telephoned the Sector INSE RP controller and requested him to turn HHN 201 immediately to the left: *"Hotel, hotel, november, left, left, immediately!"*
- At 08:37:07 UTC the Sector M2 RE controller again gave the instruction to GWI 2529 to turn away to the left: *"Germanwings two five two niner turn left immediately"*.
- At 08:37:08 UTC, HHN 201 received from the Sector INSE RE controller the instruction to descend immediately to FL 260.
- The crew of HHN 201 initiated a descent to FL 260, during which the TCAS resolution advisory *"Climb, crossing, climb"* was still active.
- At 08:37:12 UTC the crew of GWI 2529 confirmed the initiation of a left turn *"Turning left, ah, we have a TCAS RA, Germanwings two five two niner"* and informed Zurich ACC Sector M2 air traffic control that they were following a TCAS resolution advisory *"...we have a TCAS RA,..."*.
- At 08:37:18 UTC, HHN 201 received from the Sector INSE RE controller an instruction to change their heading to the right onto 320°.
- At 08:37:25 UTC, HHN 201 received from the Sector INSE RE controller the instruction to follow the TCAS instructions.
- At 08:37:31 UTC, the TCAS computers on the two aircraft involved changed the evasion directions.
- At 08:37:39 UTC, the TCAS computers on the two aircraft involved issued the *"clear of conflict"* message.

3.1.5 General conditions

- At the time of serious incident, the Air Force was carrying out an exercise which led to restrictions and an increased workload for civil air traffic control.
- The weather conditions had no influence on the serious incident.

3.2 Causes

The serious incident is attributable to the fact that air traffic control gave clearance to an aircraft which led to a hazardous convergence with another aircraft. The fact that one of the flight crews then followed the resolution advisories of the traffic alert and collision avoidance systems (TCAS) only initially and instead followed the instructions of air traffic control meant that the convergence involved had a high risk of collision.

The following factors have been identified as causative for the serious incident:

- The air traffic controller entered the flight level prescribed for this flight as a clearance into the air traffic control system, but gave a different clearance to descend by radio.
- None of the five air traffic controllers who were involved in managing the aircraft concerned noticed the discrepancy between the descent clearance in the system and the altitude transmitted by radio.
- The crew of the aircraft followed the instructions of air traffic control instead of continuing to follow the diverging resolution advisory of the TCAS.

The following factors contributed to the genesis of the serious incident:

- An Air Force exercise led to an increased workload and a more difficult overview for civil air traffic control.
- The use of a non-standard phraseology by air traffic control.

The following factors contributed systemically to the occurrence of the serious incident:

- Air traffic control had no technical safety net at their disposal which would have been able to detect the working error of an air traffic controller at an early stage.
- Working processes in air traffic control which made it difficult to detect working errors favoured by routine.

4 Safety recommendations and measures taken since the serious incident

According to the provisions of Annex 13 of the ICAO, all safety recommendations listed in this report are intended for the supervisory authority of the competent state, which has to decide on the extent to which these recommendations are to be implemented. Nonetheless, any agency, establishment or individual is invited to strive to improve aviation safety in the spirit of the safety recommendations pronounced.

In the Ordinance on the Investigation of Aircraft Accidents and Serious Incidents (OIAASI), the Swiss legislation provides for the following regulation regarding implementation:

“Art. 32 Safety recommendations

¹ DETEC, on the basis of the safety recommendations in the SAIB reports and in the foreign reports, shall address implementation orders or recommendations to the FOCA.

² The FOCA shall inform DETEC periodically about the implementation of the orders or recommendations pronounced.

³ DETEC shall inform the SAIB at least twice a year on the state of implementation by the FOCA.”

4.1 Safety recommendations

4.1.1 Safety deficit

An air traffic controller in the Geneva area control centre cleared the crew of a flight at FL 320 under his control to descend to FL 250. At the same time, he entered FL 280 into his system, which corresponded to the transfer flight level coordinated between the area control centres. Neither he nor his colleagues in the sector noticed the discrepancy between the flight level assigned on the radio and the one entered into the system. The crew correctly entered the clearance they had been given into their system and shortly afterwards reported to the Zurich area control centre as they descended to FL 250. The two air traffic controllers in Zurich expected the flight at flight level FL 280 and did not notice that the crew reported FL 250. As a result, a dangerous convergence occurred with a flight which was climbing to FL 270 in the opposite direction.

Both aircraft were equipped with a transponder, which among other things transmitted the flight level set in the aircraft's system to the radar stations. However, for technical reasons this data cannot currently be used by Swiss air traffic control to compare the altitude clearance entered in the air traffic control system with those entered in the aircraft's system and trigger an alert in the event of any discrepancy.

4.1.2 Safety recommendation no. 462

The Federal Office of Civil Aviation should ensure that within Swiss air traffic control a system is implemented which is able, in the event of a discrepancy between the air traffic control altitude clearance (cleared flight level) and the setting in the aircraft (selected altitude), to trigger an alarm.

4.2 Measures taken since the serious incident

4.2.1 Dealing with employees after a serious incident

Immediately after the serious incident the Sector L12 air traffic controller was replaced and subsequently suspended from duty until 5 July 2011. During this time,

he took leave which was already scheduled. After his return, he resumed work on 6 July 2011 with a coach and worked for three days before he completed a performance review on 9 July 2011, which he failed because of safety-related events. Subsequently, the air traffic controller concerned was retrained and reinstated in his original function after passing the relevant performance review. As part of the investigation of the serious incident of 15 March 2011 it had been established that Skyguide's processes for dealing with employees involved in accidents and serious incidents exhibited safety-critical defects, so the SAIB found itself compelled to issue a safety recommendation in this regard (see final report no. 2136). In the present case, the procedure adopted since then was applied as a trial for the first time and the impression is that it enabled an improvement to be achieved compared.

4.2.2 Safety nets

The Swiss air navigation services company Skyguide is in the advanced stage of a project with the aim of implementing mode S Enhanced Surveillance. A first step to that was the introduction of the monitoring aid, in the course of 2012, which displays the flight level set in the aircraft in the corresponding label on the radar screen.

Payerne, 17 July 2013

Swiss Accident Investigation Board

This final report was approved by the management of the Swiss Accident Investigation Board SAIB (Art. 3 para. 4g of the Ordinance on the Organisation of the Swiss Accident Investigation Board of 23 March 2011).

Berne, 17 October 2013

Annexes

Annex 1: Extract from 'ACAS Bulletin no.5' dated October 2004



Event 1: Mid-air collision near Überlingen

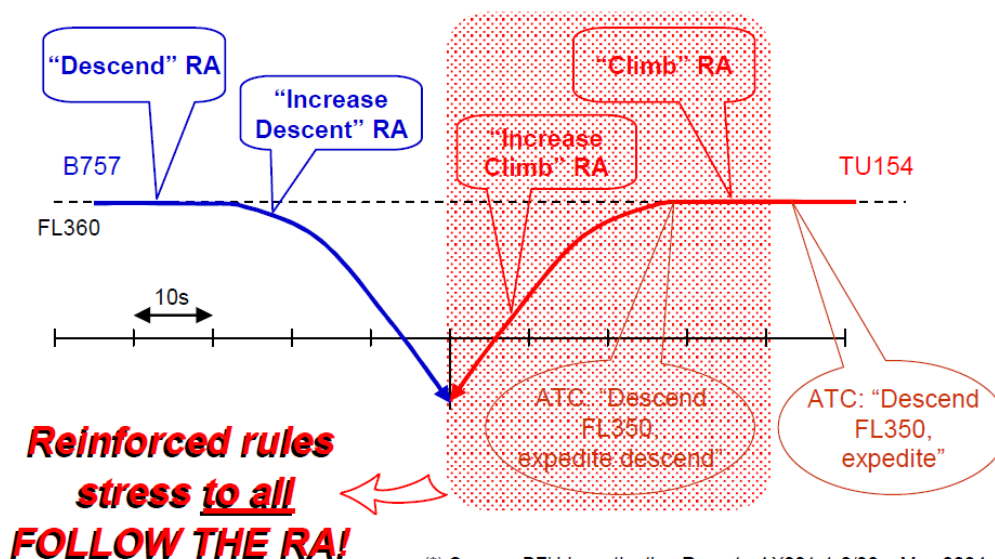
A B757, heading North, and a TU154, heading West, are level at FL360 in conflict on crossing tracks.

The controller instructs, late, the TU154 to expedite descent to FL350. As the flight crew starts to descend, a "Climb" RA is triggered by TCAS II. **Despite the "Climb" RA, the TU154 flight crew continues to descend** in accordance with their operations manual (the TCAS description wording was such that ATC instruction had the highest priority in collision avoidance).

A coordinated "Descend" RA is generated in the B757. The flight crew responds correctly and follows the RA. As the descent starts, the B757 TCAS strengthens to an "Increase Descent" RA, which is also correctly followed by the flight crew.

Because the TU154 flight crew has not acknowledged his instruction, **the controller repeats the instruction to expedite descent to FL350**. This time, the flight crew acknowledges and increases the rate of descent. **Despite an "Increase Climb" RA, the TU154 flight crew continues to descend** and the aircraft collide at 34890 ft.

The investigation of the accident by BFU (*) concluded that **one of the two immediate causes is that the TU154 flight crew manoeuvred in the opposite sense of the TCAS "Climb" RA** as they descended in response to the controller instruction. This is shown in the diagram below.



(*) Source: BFU Investigation Report - AX001-1-2/02 – May 2004

Annex 1, continued

Editorial

Recent experience, including the lessons from the Überlingen mid-air collision, confirms that ICAO standard ACAS operational procedures needed to be reinforced. Revised ACAS procedures and pilot training guidelines are now included in ICAO PANS-OPS Doc 8168. Other ICAO documentation, including PANS-ATM Doc 4444, is also being reviewed to ensure consistency and completeness.

In Europe, complementary action is being taken by JAA to ensure that JAR-OPS ACAS provisions and associated guidance material are in line. Furthermore, the Strategic Safety Action Plan (SSAP) requires, as a high priority, action to be taken by aviation regulatory authorities, air navigation service providers, and airspace users to confirm that these ACAS regulations and procedures are correctly implemented and applied. IATA and other airspace user organisations support these initiatives. Every effort must be made to ensure that the relevant operations manuals include up-to-date ACAS procedures, and that appropriate training is provided to ensure that pilots and controllers are able to apply these standard ACAS procedures consistently.

The ACAS II equipment, known as TCAS II, is an independent airborne safety net. Nevertheless, to ensure that its operational effectiveness is maximised, both pilots and controllers need to understand ACAS II operational principles, and correctly apply the standard operational procedures.

*John Law
Acting Mode S and ACAS
Programme Manager,
EUROCONTROL
October 2004*

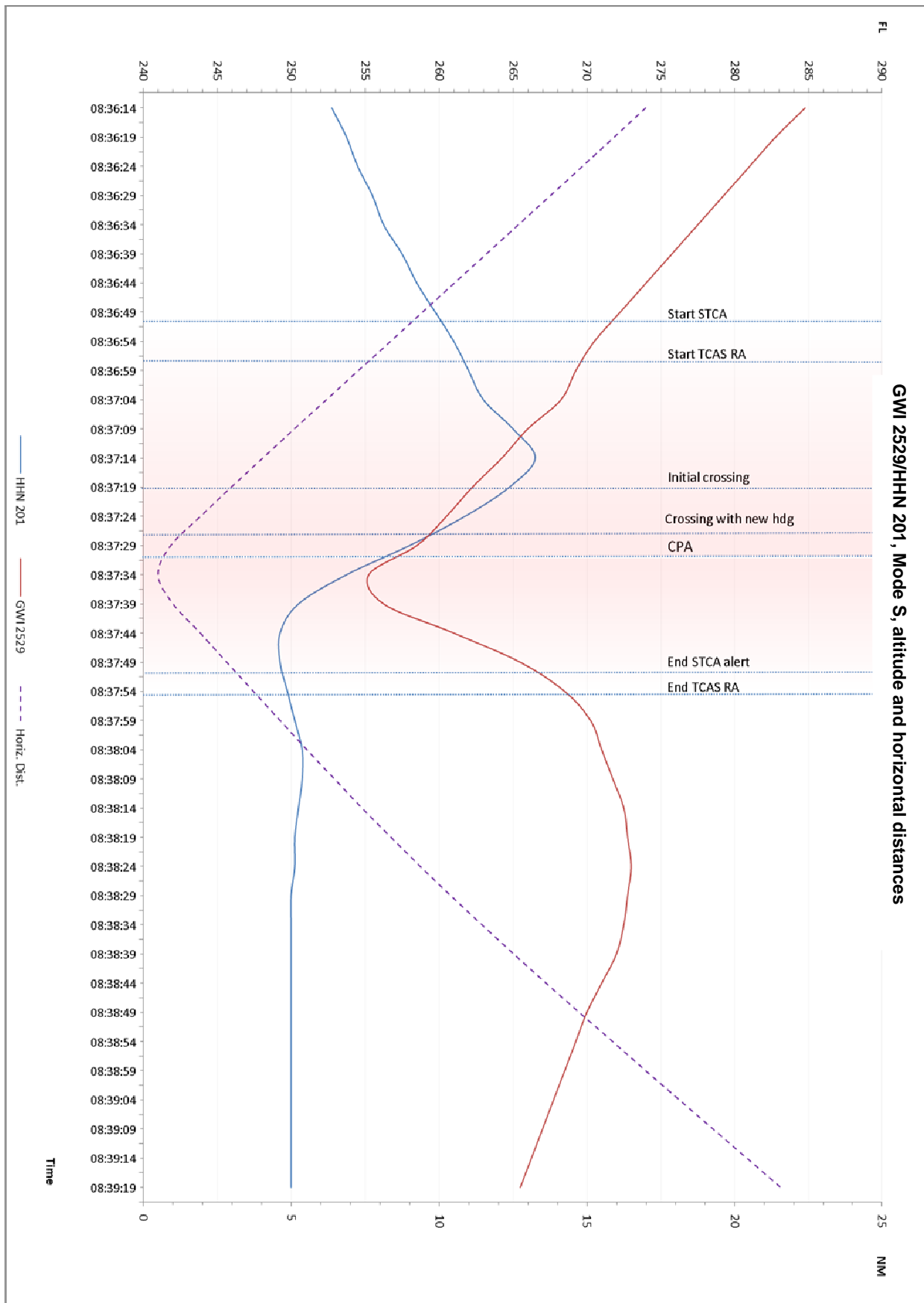
Regulation context for the RA procedure

Following a near accident in Japan, ICAO took action to revise PANS-OPS; at the time of the Überlingen accident, this work was in progress.

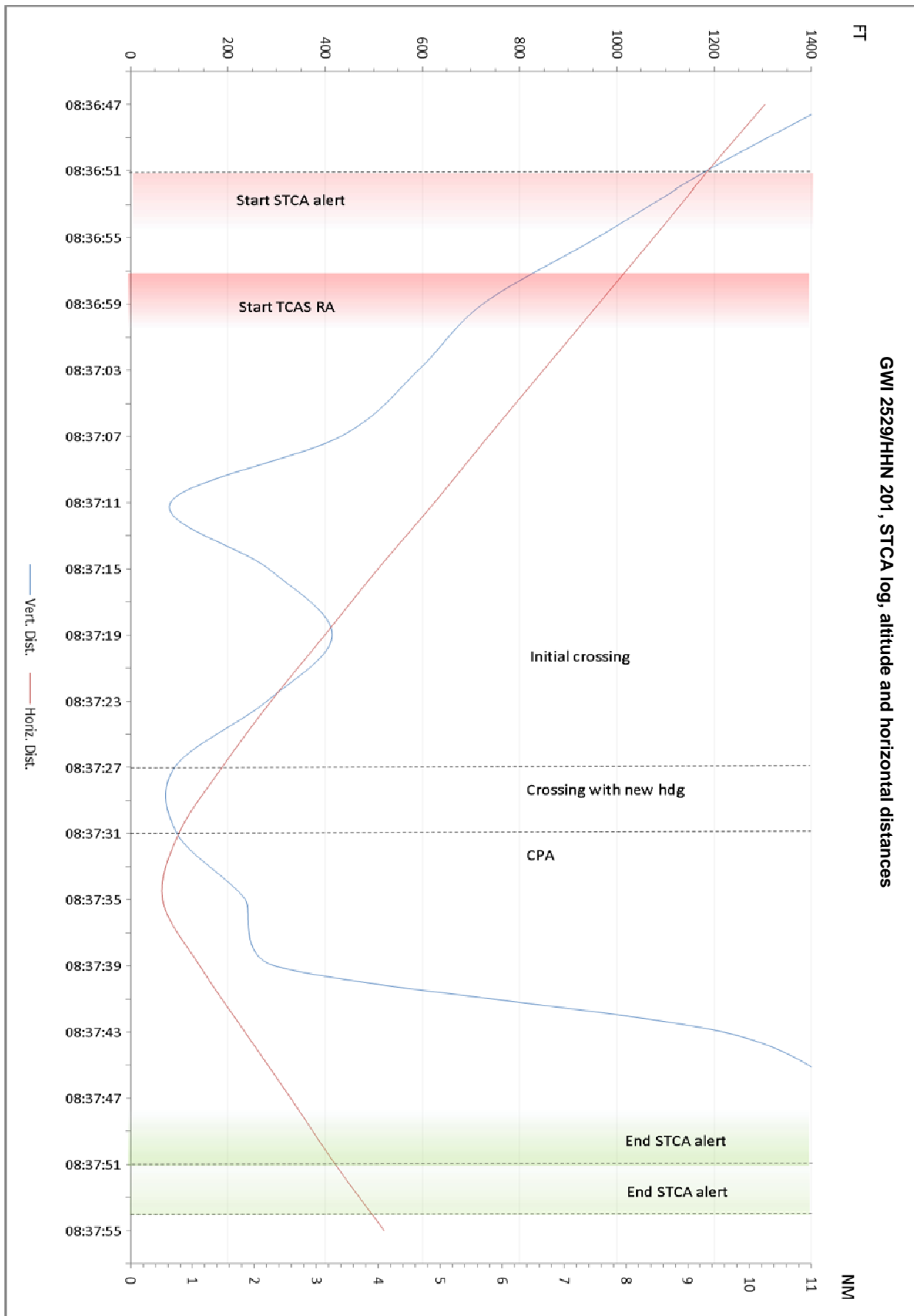
In late 2003, a revised version of the PANS-OPS - Doc 8168 was published. It strengthens and clarifies provisions in ICAO documentation concerning the operation of ACAS II, particularly provisions on pilot responses to RAs.

The only correct way to implement this new regulation is through training. Therefore, it is imperative that the ACAS training of both controllers and pilots is made a priority.

Annex 2: Mode S, altitude and horizontal distances



Annex 3: STCA log, vertical and horizontal distances



Annex 4: Timeline

