Statens haverikommission
Swedish Accident Investigation Authority

ISSN 1400-5719

***Final report RL 2013:11e***

# Serious incident involving the aircraft PH-DCI and SE-MDC in the airspace north-east of Jönköping, Östergötland county, on 20 June 2012.

Ref no L-53/12
2013-06-11

---



The report is also available on our web site: www.havkom.se

This document is a translation of the original Swedish report. In case of discrepancies between this translation and the Swedish original text, the Swedish text shall prevail in the interpretation of the report.

---

| *Postadress/Postal address* | *Besöksadress/Visitors* | *Telefon/Phone* | *Fax/Facsimile* | *E-post/E-mail* | *Internet* |
|---|---|---|---|---|---|
| P.O. Box 12538<br>SE-102 29 Stockholm<br>Sweden | Sveavägen 151<br>Stockholm | +46 8 508 862 00 | +46 8 508 862 90 | info@havkom.se | www.havkom.se |

Statens haverikommission
Swedish Accident Investigation Authority

1. The Swedish Transport Agency
   Civil Aviation and Maritime Department

**Final report RL 2013:11e**

The Swedish Accident Investigation Authority (Statens haverikommission, SHK) has investigated a serious incident that occurred on 20 June 2012 in the airspace north-east of Jönköping, Östergötland county, involving two aircraft with the registrations PH-DCI and SE-MDC.

SHK hereby submits under the Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation, a final report on the investigation.

The Swedish Accident Investigation Authority respectfully requests to receive, by 10 September 2013 at the latest, information regarding measures taken in response to the recommendations included in this report.

This document is a translation of the original Swedish report.

On behalf of the Swedish Accident Investigation Authority,

Mikael Karanikas Nicolas Seger

## Contents

## General points of departure and limitations

The Swedish Accident Investigation Authority (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended to clarify, as far as possible, the sequence of events and their causes, as well as damages and other consequences. The results of an investigation shall provide the basis for decisions aiming at preventing a similar event from occurring again, or limiting the effects of such an event. The investigation shall also provide a basis for assessment of the performance of rescue services and, when appropriate, for improvements to these rescue services.

SHK accident investigations thus aim at answering three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any supervisory role and its investigations do not deal with issues of guilt, blame or liability for damages. Therefore, accidents and incidents are neither investigated nor described in the report from any such perspective. These issues are, when appropriate, dealt with by judicial authorities or e.g. by insurance companies.

The task of SHK also does not include investigating how persons affected by an accident or incident have been cared for by hospital services, once an emergency operation has been concluded. Measures in support of such individuals by the social services, for example in the form of post crisis management, also are not the subject of the investigation.

Investigations of aviation incidents are governed mainly by Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation. The investigation is carried out in accordance with Annex 13 of the Chicago Convention.

## The investigation

SHK was notified on 21 June 2012 that a separation minima infringement between two aircraft with the registrations PH-DCI and SE-MDC had occurred at an altitude of approximately 4300 metres north-east of Jönköping, Östergötland county, on 20 June 2012 at 16.50 hrs.

The incident has been investigated by SHK as represented by Mr Mikael Karanikas, Chairperson, and Mr Nicolas Seger, Investigator in Charge.

The investigation team of SHK was assisted by Mr Lars-Olof Ek as an expert in Air Traffic Control, Ms Gerd Svensson as an expert in behavioural science and Mr Christer Magnusson as a sound expert.

The investigation was followed by Ms Lotta Landqvist Jacobsen of the Swedish Transport Agency.

## Abbreviations and explanations

| | | |
|---|---|---|
| ACC | Area Control Centre | |
| ANS | Air Navigation Services | |
| AIP-ENR | Aeronautical Information Publication-En Route | |
| Assume | Assume | Confirm radar label and the assuming of control for the aircraft |
| ATCC | Air Traffic Control Centre | |
| ATS | Air Traffic Service | |
| CARD | Conflict And Risk Display | |
| CTA | Control Area | |
| E | Executive Controller | Air traffic controller in E position (chief position) in ACC sector |
| FIR | Flight Information Region | |
| FLEG | Flight Leg | |
| Flygnivå | FL Flight Level | Altitude in hundreds of feet above the reference pressure level 1013.2 hPa |
| IFR | Instrument Flight Rules | |
| LFV | LFV | A public service company which operates air traffic services in Sweden |
| MTCD | Medium Term Conflict Detection | |
| P | Planner Controller | Air traffic controller in P position |
| PRL | Prediction Line | |
| RA | Resolution Advisory | Message from TCAS representing a manoeuvre command |
| SEP tool | Separation Tool | |
| STCA | Short Term Conflict Alert | Warning function based on radar data in the short term |
| TA | Traffic Advisory | Traffic information from TCAS |
| TCAS | Traffic alert and Collision Avoidance System | Airborne collision warning system |
| TMC | Terminal Control | |
| TS-A | Tactical Supervisor ACC | |
| UIR | Upper Flight Information Region | |
| VFR | Visual Flight Rules | |
| WS | Watch Supervisor | |

**Report RL 2013:11e**

| | |
|---|---|
| Aircraft A; registration and type | SE-MDC, ATR 72 |
| Aircraft B; registration and type | PH-DCI, Jetstream Series 3 200 |
| Class/Airworthiness | Normal, Certificate of Airworthiness and valid Airworthiness Review Certificate (ARC) |
| Owner/Operator | A: Golden Air<br>B: AIS Airlines |
| Time of occurrence | 20-06-2012, 16.50 hrs in daylight<br>Note: All times are given in Swedish daylight saving time (UTC[1] + 2 hrs) |
| Place | North-east of Jönköping, Östergötland county,<br>(pos. 58°02′N 015°13′E; 4 300 m above sea level) |
| Type of flight | Commercial aviation |
| Weather | According to SMHI's analysis: wind 260 degrees 30-40 knots, visibility >10 km, no clouds |
| | |
| Persons on board aircraft A | |
| Crew members | 4 |
| Passengers | 72 |
| | |
| Persons on board aircraft B | |
| Crew members | 2 |
| Passengers | 19 |
| | |
| Injuries to persons | None |
| Damage to aircraft | None |
| Other damage | None |
| | |
| Commander aircraft A | |
| Age, licence | 44 years, ATPL[2] |
| Total flying hours | 10,000 hours, no information for type |
| Flying hours previous 90 days | 171 hours, all on type |
| Number of landings previous 90 days | 136 |
| Co-pilot aircraft A | |
| Age, licence | 23 years, CPL[3] |
| Total flying hours | 780 hours, of which 510 hours on type |
| Flying hours previous 90 days | 175 hours, all on type |
| Number of landings previous 90 days | 148 |
| | |
| Cabin crew members aircraft A | 2 persons |

[1] UTC - Universal Time Coordinated is a reference for the exact time anywhere in the world.
[2] ATPL (Airline Transport Pilot Licence).
[3] CPL (Commercial Pilot Licence).

| | |
|---|---|
| Commander aircraft B | |
| Age, licence | 49 years, CPL |
| Total flying hours | 10,000 hours, of which 2,000 hours on type |
| Flying hours previous 90 days | 143 hours, all on type |
| Number of landings previous 90 days | 172 |
| Co-pilot aircraft B | |
| Age, licence | 20 years, CPL |
| Total flying hours | 442 hours, of which 235 hours on type |
| Flying hours previous 90 days | 166 hours, of which 143 hours on type |
| Number of landings previous 90 days | 187 |
| Cabin crew members aircraft B | none |

## Summary

Golden (GAO) 551 with the registration SE-MDC was en route south from Bromma to Ängelholm at Flight Level 140. Approximately 30 nautical miles north-east of Jönköping, a meeting occurred with an aircraft with the registration PH-DCI that had taken off from Jönköping en route to Bromma on a north-easterly heading and that was climbing to Flight Level 150.

During the meeting, there was a separation minima infringement upon which both aircraft's collision warning systems were activated. The crews of both aircraft performed evasive manoeuvres in accordance with the collision warning systems' instructions.

Air traffic control did not clearly perceive the TCAS alarm and attempted to modify the aircraft flight paths.

The serious incident was caused by the following factors:

- The air traffic controller's focus was on an early handover of flights to another sector.
- Air traffic control's aids for noticing the conflict were not capable of breaking the mental picture that the controller had of the situation in the sector.

## Recommendations

The Swedish Transport Agency is recommended to improve the training at suppliers of Air Traffic Services with respect to procedures for TCAS RAs. *(RL 2013:11 R1)*

# 1. FACTUAL INFORMATION

## 1.1 History of the flight

Golden (GAO) 551 with the registration SE-MDC was en route south from Bromma to Ängelholm at Flight Level 140. Approximately 30 nautical miles north-east of Jönköping, a meeting occurred with an aircraft with the registration PH-DCI that had taken off from Jönköping en route to Bromma on a north-easterly heading and that was climbing to Flight Level 150.

During the meeting, there was a separation minima infringement upon which both aircraft's collision warning systems were activated. The crews of both aircraft performed evasive manoeuvres in accordance with the collision warning systems' instructions.

The least vertical distance between the aircraft was 300 feet at a horizontal distance of 3.24 nautical miles (nm). The least horizontal distance was 1.75 nm with an altitude difference of 800 feet, see Fig. 1.

During the entire event, both aircraft were in contact with the air traffic controller in the combined sectors 1 and 9 (1/9) at Stockholm Air Traffic Control Centre. On two occasions, the controller received "white values"[4], i.e., silent coordination, for Golden (GAO) 551 from sector 7. The first time at 16:27 hrs, this related to a new flight level and/or route, namely, Flight Level 160 to the point ELPAX. The second time, at 16:30 hrs, it concerned Flight Level 140. Both times, the controller accepted the "white values" on a list of incoming flights to the sector.

At 16.33.50 hrs, Golden (GAO) 551 announced itself on the controller's frequency and was instructed to fly directly towards the point TOKSI. Thereafter, the controller's attention was turned towards aircraft in another part of sector 1/9. One of these was another aircraft with the call sign Golden (GAO) 552 en route to Bromma via the point MIKNA at Flight Level 190.

At 16.41.41 hrs, PHDCI announced itself on the controller's frequency. The controller confirmed its radar label by performing what is known as an "Assume"[5], upon which the cleared route in question was illuminated for a few seconds. PHDCI was then at Flight Level 60 climbing to 90 and received further clearance to the desired altitude, Flight Level 150. One of the air traffic control tools used to see a flight's coming flight path, Conflict And Risk Display (CARD), showed a red marking for the coming conflict.

PHDCI and Golden (GAO) 552 were going to Bromma and were almost coincident. The controller performed what is known as a "Force"[6] on Golden (GAO) 552 and somewhat later also on PHDCI to make controllers in sector 2 aware of these aircraft earlier than the Eurocat system automatically does via preset parameters.

---

[4] White value/silent coordination - An electronic, non-verbal coordination between sectors with a question that can be accepted or rejected with the commands Accept or Reject.
[5] Assume - Confirm radar label and the assuming of control for the aircraft.
[6] Force/Force ACT - A manual transmission of ACT (Activate Message), including estimated time over a certain point, before the parameter set time, when ACT is transmitted automatically.

At 16.50.39 hrs, Golden (GAO) 551 reported that the warning system TCAS had given the command “TCAS climb”. The controller heard the alert in the aircraft cockpit and then saw on the radar screen that STCA was activated.

Golden (GAO 551) left Flight Level 140 and climbed to Flight Level 146. The controller attempted to guide this aircraft away and provide traffic information to it as well as terminate the second aircraft's climb. PHDCI, which terminated its climb at Flight Level 137 and had commenced descent, reported to the controller that it was already in “TCAS descent”, that is descent commanded by TCAS.

The incident occurred at position 58°02′N 015°13′E; 4300 metres above sea level.


Fig. 1. Radar tracks with the minimum vertical distance of 300 feet at a horizontal distance of 3.24 nm.

## 1.2 Injuries to persons

None.

## 1.3 Damage to the aircraft

None.

## 1.4 Other damage

None.

## 1.5 Personnel information (aircraft and ATS)

### *1.5.1 Commander aircraft A*

The commander was 44 years old at the time and had a valid ATPL.

| Flying hours | | | | |
|---|---|---|---|---|
| Latest | 24 hours | 7 days | 90 days | Total |
| All types | 5 | 17 | 171 | 10,000 |
| This type | 5 | 17 | 171 | No information |

Number of landings previous 90 days: 136.
Type rating concluded on 20 July 2010.
Latest PC (Proficiency Check) carried out on 13 June 2012 on ATR 72.

### *1.5.2 Co-pilot aircraft A*

The co-pilot was 23 years old at the time and had a valid CPL.

| Flying hours | | | | |
|---|---|---|---|---|
| Latest | 24 hours | 7 days | 90 days | Total |
| All types | 5 | 17 | 175 | 780 |
| This type | 5 | 17 | 175 | 510 |

Number of landings previous 90 days: 148.
Type rating concluded on 31 July 2011.
Latest PC was conducted on 13 June 2012 on ATR 72.

### *1.5.3 Commander aircraft B*

The commander was 49 years old at the time and had a valid CPL.

| Flying hours | | | | |
|---|---|---|---|---|
| Latest | 24 hours | 7 days | 90 days | Total |
| All types | 5 | 19 | 143 | 10,000 |
| This type | 5 | 19 | 143 | 2,000 |

Number of landings previous 90 days: 172.
Type rating concluded on 01 May 2011.
Latest PC (Proficiency Check) carried out on 20 December 2011 on Bae Jetstream 32.

### *1.5.4 Co-pilot aircraft B*

The co-pilot was 20 years old at the time and had a valid CPL.

| Flying hours | | | | |
|---|---|---|---|---|
| Latest | 24 hours | 7 days | 90 days | Total |
| All types | 5 | 15 | 166 | 442 |
| This type | 5 | 15 | 143 | 235 |

Number of landings previous 90 days: 187.
Type rating concluded on 01 February 2012.
Latest PC was conducted on 16 January 2012.

### *1.5.5 The pilots' duty schedule*

The pilots' hours of duty were within permitted limits.

### *1.5.6 The air traffic controller's duty schedule*

The controller had a long history of experience and Y-authorisation, which means qualification for sectors 1, 2, 7 and 9 at Stockholm ACC.

The controller began her afternoon watch at 14.30 hrs and worked as Planner in sector 2 (P2) until 15.28 hrs. After a break, the controller relieved the Executive Controller in sector 1 and 9 (E1) at 16.19 hrs.

The watch in question was preceded by a morning watch the previous day from 06.30 hrs to 14.30 hrs and an afternoon watch before that from 14.30 hrs to 22.30 hrs. The controller was off-duty for three days prior to the working week in question.

Sleep the night before the day in question, according to the controller, amounted to about six hours and was not uninterrupted. The night after the working week's first afternoon watch, the controller slept in an overnight room at the place of employment for about six to seven hours.

Six to seven hours' sleep was, according to the controller, a normal amount of sleep. The controller usually woke up early and experienced difficulties sleeping at a stretch, which according to him had formed over the many years of shift work. This could sometimes result in the controller feeling very tired, but on the day in question, the controller felt focused and alert.

At the time of the incident, there had been no overtime so far this year.

## 1.6 Aircraft information

### *1.6.1 Airworthiness and maintenance*

| **Aircraft A** | |
|---|---|
| TC-holder | ATR – GIE Avions de Transport Régional |
| Model | ATR 72-212A |
| Serial number | 894 |
| Year of manufacture | 2009 |

| **Aircraft B** | |
|---|---|
| TC-holder | Bae Systems |
| Model | Bae Jetstream 32 |
| Serial number | 916 |
| Year of manufacture | 1992 |

The aircraft had both a Certificate of Airworthiness and a valid ARC[7].

[7] ARC - Airworthiness Review Certificate

The ATR 72 is a twin-engine turboprop-powered aircraft with a capacity of 74 passengers.

The Jetstream 32 is a twin-engine turboprop-powered aircraft with a capacity of 19 passengers.

### *1.6.2 Description of parts or systems related to the incident*

Not applicable.

### *1.6.3 Availability and serviceableness of TCAS*

Both aircraft were equipped with a collision warning system called TCAS. The system is airborne and functions completely without ground stations.

TCAS operates so that a transponder in the aircraft transmits an interrogating signal to all aircraft in the vicinity. Aircraft that have a transponder receive the interrogating and respond with a signal that is received by directional antennas at the interrogator. Guided by this, the system then calculates the distance and relative bearing to the responding aircraft and, if altitude information has been received, relative altitude.

The information received is then presented to the recipient on a display in the cockpit. The system also calculates how close a passage that will take place between the various aircraft and indicates with a Traffic Advisory (TA) which might become a threat. If a potential threat continues to approach according to certain specific criteria, TCAS issues a manoeuvre command, a Resolution Advisory (RA). These manoeuvre commands act vertically, that is, the pilot receives commands to manoeuvre vertically (see principle outline, Fig. 2 below).

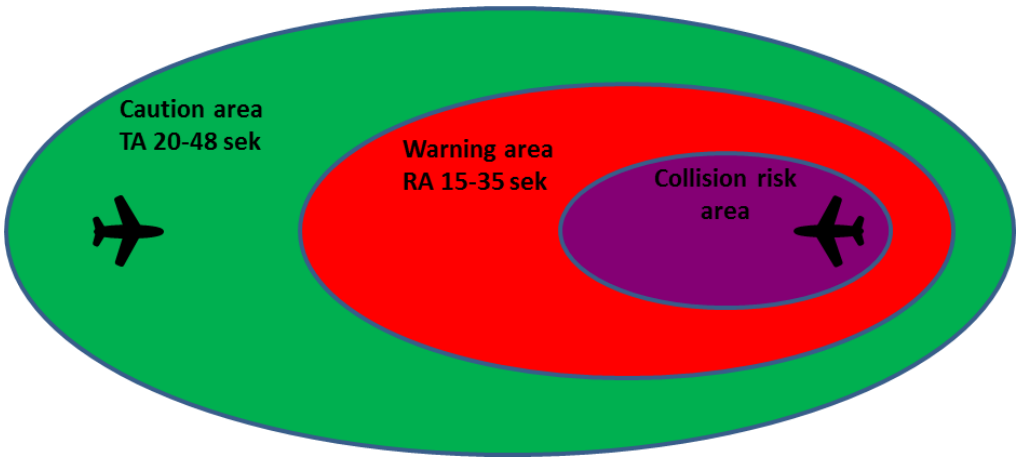


Fig. 2. TCAS TA/RA areas.

RAs from TCAS have direct consequences for the tasks of both the crew and the controller. The crew is required to immediately manoeuvre according to RAs, even if the RAs are contrary to air traffic control clearances or instructions. As soon as the workload in the cockpit allows, the pilot is required to notify air traffic control that an RA has been received, including the deviation from received clearance. The controller may not attempt to modify the aircraft flight path until the flight crew reports returning to previous clearance.

Drozdowski et al.[8] has pointed out that RAs in the cockpit represent a fundamental change of the controller's task. In normal conditions, the controller's foremost task is to ensure separation, if required, by actively modifying aircraft flight paths. With an RA, the controller should no longer actively try to ensure separation of the affected aircraft. It is only if and when the crew informs the controller that the latter becomes aware that an RA has occurred. It happens that crews give late notification and that the information is incomplete or incorrect. As mentioned by the authors, a study by the Swiss Aircraft Accident Investigation Bureau shows that only 28% of RAs are reported correctly and in a timely manner. The foremost cause of unreliable reporting was assessed to be the high level of stress and workload in the cockpit when an RA is received. The reporting of RAs also has lower priority than other RA-related tasks in the cockpit, in particular that of manoeuvring according to RAs and avoiding a potential collision.

Drozdowski et al. argues that if a controller is not aware of an RA, the controller is also not aware of the change in his/her task, that is, a shift from active control to merely monitoring the conflicting aircraft. In the absence of quick information from a crew, it may be that the controller issues an instruction to an aircraft with an RA. In the worst case, the crew may be instructed to manoeuvre contrary to the RA. Although the crew should not comply with air traffic control instructions, this has occurred.

On 1 July 2002, two aircraft collided with each other over Überlingen[9]. Both were equipped with the TCAS collision warning system. The crew of one of the aircraft complied with the manoeuvre command issued by TCAS. The crew of the other aircraft complied with the controller's instructions, which were contrary to the manoeuvre command that TCAS had issued. At the time the controller in the Überlingen accident issued his instructions, he was not aware that both aircraft had received RAs.

## 1.7 Meteorological information

The weather according to SMHI's analysis:
Wind 260 degrees 30-40 knots, visibility >10 km, no clouds, nil significant weather.

## 1.8 Aids to navigation

Not applicable.

[8] Drozdowski S.,Dehn M.D.,Teutsch J.& Lorenz B. Operational impact of RA Downlink: Results of a real-time simulation. Paper presented at the 7th USA/Europe ATM & R&D Seminar 2-5 July 2007, Barcelona.
[9] Investigation Report AX001-1-2/02 May 2004, German Federal Bureau of Aircraft Accident Investigation.

## 1.9 Radio communications

Audio transcript of ATC information concerning traffic to which the controller (E1) devoted attention ahead of the coming handover from sector 1/9 to sector 2 on 20 June 2012:

| Time | From | |
|---|---|---|
| 16.33.50 | GAO551 | Sweden god eftermiddag [good afternoon], Golden 551 140 inbound ELPAX. |
| 16.33.54 | E1 | Golden 551, Sweden, radar contact. Proceed direct TOKSI. |
| 16.33.58 | GAO551 | Direct TOKSI, Golden 551. |
| 16.38.52 | GAO552 | Sweden, hello, Golden 552 approaching 190 inbound MIKNA. |
| | E1 | Golden 552, Sweden, radar contact. After MIKNA TROSA, TROSA5Y runway 30. |
| | GAO552 | After MIKNA TROSA, TROSA5Y runway 30, Golden 552. |
| 16.40.59 | JTG9744 | Sweden, god eftermiddag igen [good afternoon again] JTG9744, we are passing Flight Level 65 climbing Flight Level 90 inbound TROSA. |
| | E1 | JetTime 9744, Sweden, radar contact. Climb to Flight Level 180. |
| | JTG9744 | Climbing Flight Level 180, JetTime 9744. |
| 16.41.41 | PHDCI | Sweden Control, "god middag" ["good afternoon"], PHDCI out of Jönköping passing Flight Level 60. |
| 16.41.47 | E1 | PHDCI, Sweden, radar contact. Climb to Flight Level 150. |
| 16.41.53 | PHDCI | Flight Level 150, PHDCI. |
| 16.43.10 | E1 | JetTime 9744, climb to Flight Level 270. |
| | JTG9744 | Climb Flight Level 270, JetTime 9744, tack for det [thanks for that]. |
| 16.44.49 | Int | E1 receives a coordination/revision from sector K in Malmö for a NTJ207 at Flight Level 150. |
| 16.45.35 | NTJ207 | Å [Oh] Sweden god eftermiddag [good afternoon] Nextjet 207, 136 climbing 150. |
| | E1 | Nextjet 207, Sweden, radar contact. After MIKNA TROSA, TROSA3T runway 26. |
| | NTJ207 | After MIKNA TROSA, TROSA3T for runway 26, Nextjet 207. |
| | E1 | JetTime 9744 you are cleared TROSA3T runway 26. |
| | JTG9744 | TROSA3T runway 26, JetTime 9744, thank you. |
| 16.50.39 | GAO551 | Golden 551 TCAS climb. (Alert signal in the back-ground) |
| 16.50.42 | E1 | Golden 551…turn right heading…ja [yes] you have traf-fic at your one o'clock, distance 2. |
| 16.50.53 | E1 | PCI stop climb Flight Level 135, descend to Flight Level 130. |
| 16.50.58 | PHDCI | We are already in a TCAS descent, ma'am. |
| | E1 | Roger. |
| 16.51.12 | E1 | Å [Oh], Golden 551 clear of conflict. |

| | | |
|---|---|---|
| 16.51.15 | E1 | Golden 551, I will file a report of course of this. |
| 16.51.19 | GAO551 | Yeah, we will descend back to 140. |
| 16.51.21 | E1 | Golden 551. |
| 16.51.23 | E1 | PCI climb to Flight Level 150 again, free from traffic. |
| 16.51.29 | PHDCI | Roger, cleared Flight level 150, PCI. |

Legend to table:

| | |
|---|---|
| E1: | Air traffic controller |
| Int: | Interphone communication |
| GAO551: | Golden Air Flight 551 |
| GAO 552: | Golden Air Flight 552 |
| JTG9744: | JetTime 9744 |
| NTJ207: | Nextjet 207 |
| PHDCI: | AIS Airlines Jetstream 32 |

## 1.10 Aerodrome information

Not applicable.

## 1.11 Flight recorders

Not applicable.

## 1.12 Site of occurrence

### *1.12.1 Site of occurrence*

The separation minima infringement occurred in controlled airspace approximately 30 nautical miles north-east of Jönköping.

### *1.12.2 Airspace classification and separation rules*

Airspace within Sweden's flight information region (FIR/UIR) is divided into controlled and uncontrolled airspace. Controlled airspace is a delimited airspace in which all air traffic must follow controllers' instructions regarding altitudes, headings, separations and so on. The tasks of air traffic control include preventing collisions between aircraft, promoting orderly air traffic and providing advice and information for the safety and efficiency of air traffic.

This incident took place in controlled airspace in the control area SUECIA CTA. Swedish airspace is also divided into airspace classes, see Fig. 3. This incident took place in airspace class C, in which all aircraft flying in accordance with instrument flight rules (IFR) shall be separated from each other. Both aircraft were flying in accordance with IFR. The required separation is 5 nautical miles horizontally or 1000 feet vertically.

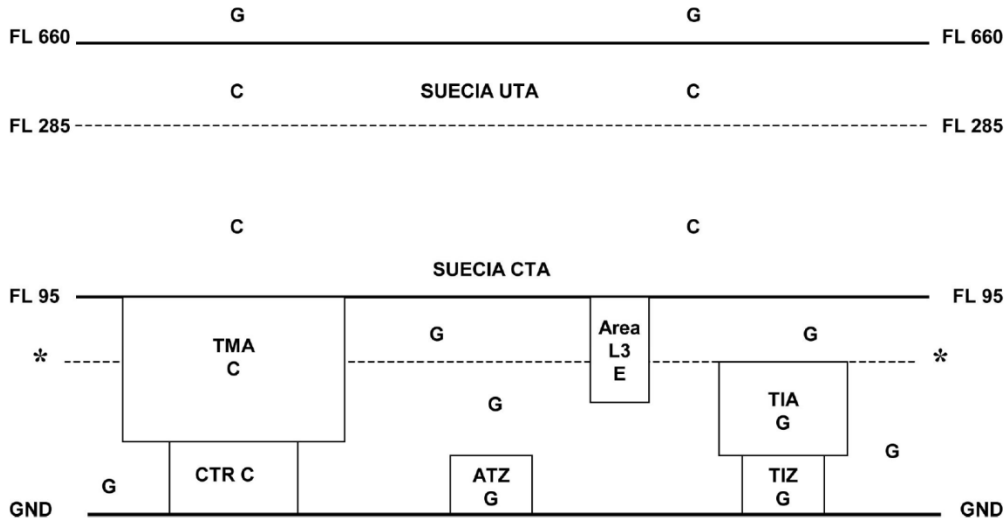


Fig. 3. Airspace classification (AIP Sweden).

### *1.12.3 Responsibilities and regulations in the airspace in question*

Air traffic control at ATCC Stockholm was responsible for air traffic control services in the area with the help of radar. The incident occurred in sector 1, which during the watch was combined with sector 9. The combined sector 1/9 was monitored by Stockholm ACC (see Fig. 4).

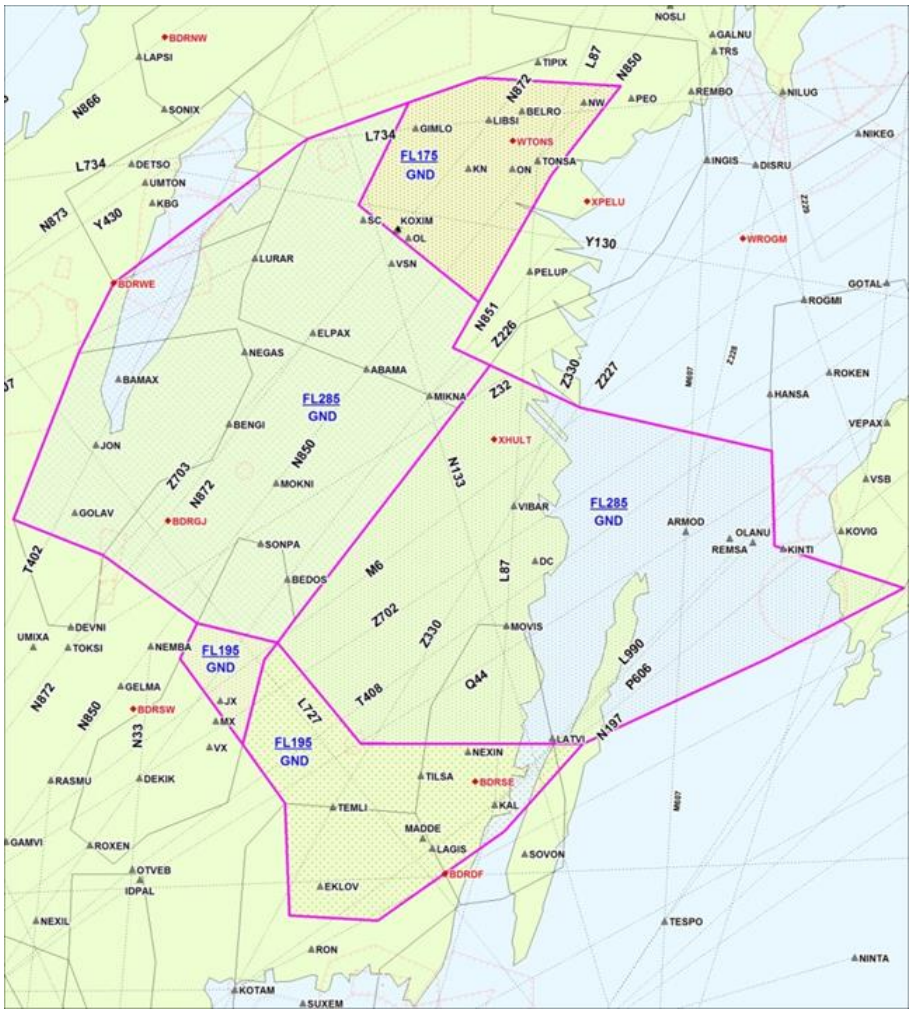


Fig. 4. Sector 1/9.

## 1.13 Medical information

Nothing indicates that the mental and physical condition of the pilots or the controller were impaired before or during the incident.

## 1.14 Fire

Not applicable.

## 1.15 Survival aspects

Not applicable.

## 1.16 Tests and research

### *1.16.1 Interview with the air traffic controller*

The interview with the controller was conducted on 5 July 2012. In the interview, the following emerged:

The P1 position was closed at the time of relief, since there was no military activity and traffic was moderate. The controller and the relieved controller looked at the chart with the flight-planned traffic load level and assessed that the P1 position could be closed for about another hour. According to the controller, the staff situation was such that it was possible to open the P position, but the controller himself considered that there was very little to do in sectors 1 and 9. The two sectors were combined during the watch, which was also normally the case.

After a while, a "white value" was received, that is, a silent coordination, from sector 7, that Golden 551 which had taken off from Bromma was incoming on Flight Level 160 towards the point ELPAX. A little later, a further "white value" was received from sector 7 regarding Golden 551, which the controller noted. According to the controller the aircraft was probably at Flight Level 140 at that time. When Golden 551 was en route into sector 1, the crew called the controller via radio and received the instruction to fly directly towards the point TOKSI. After this, Golden 551 was, according to the controller, as good as gone from her consciousness.

The controller went on to work with flights in another part of the sector, down by Kronoberg. There were Golden 552 that was going towards Bromma via the point MIKNA at Flight Level 190 and JetTime 9744 that was going towards Arlanda. JetTime 9744 requested Flight Level 270. The controller used the separation tool SEP tool and initially assigned JetTime 9744 a safe intermediate altitude, Flight Level 180, since Golden 552 was en route towards Bromma at Flight Level 190.

The controller also received from air traffic control in Jönköping a "white value" regarding PHDCI which was taking off from Jönköping with the request to fly directly towards Trosa. The request was rejected because PHDCI would

then block any take offs from the Östergötland area during its climb. Instead, the controller assigned the normal route towards PELUP. When the pilot called the controller, the latter immediately issued the requested cruising altitude, Flight Level 150, without a thought for Golden 551 that was coming from the north at Flight Level 140.

According to the controller, 140 is a rather unusual flight level for air traffic from the north. Normally, aircraft in the category in question (turboprop, max 50 seats) are at Flight Level 160 or higher.

The controller felt that there was very little to do. The focus was on handing over Golden 552 and PHDCI to sector 2, as sector 1 usually roughly separates traffic to sector 2. By plotting a Prediction Line (PRL), such things as speed comparisons between the aircraft were made. The controller performed a "Force" on Golden 552 and PHDCI to hand them over to sector 2 in a good manner at an early stage.

In order to verbally coordinate the incoming Bromma traffic directly with the controller in the P position in sector 2, the controller in sector 1/9 turned around. Verbal coordination without using the interphone is sometimes performed, according to the controller, when it is quiet and there is not much to do. And in the controller's mental picture of the situation, there were no conflicts.

However, the controllers in sector 2 were occupied with other things, for which reason the controller awaited a suitable occasion to verbally coordinate the traffic. According to information, the controller in the meantime turned around to the radar screen several times and looked at the two flights that were to be verbally coordinated with sector 2, but without noticing the situation of Golden 551.

Suddenly, the controller heard in his headset a pilot say something about warning signals in the aircraft cockpit. The controller then turned around to his radar screen, saw that STCA was activated, went to the radio frequency and tried agitatedly to do something and provide traffic information. The controller did not remember what was said, only that an altitude was given to one of the aircraft.

According to the controller, CARD displays so many conflicts that are not correct, for which reason it is not used.

The controller said he always scanned the radar screen and worked with altitude restrictions, that is, safe intermediate altitudes, against conflicting traffic and for monitoring clearances. Furthermore, the controller, primarily in times of peak traffic, used to scan lists to gain an overview and search for potential conflicts.

### *1.16.2 Description of the air traffic control system*

Eurocat 2000E (E2kE) is an air traffic control system that was being used in Swedish airspace at the time of the incident. The system includes monitoring aids, tools, safety nets and functions. Below is a description of the parts of the

system that are directly related to the incident and that are used and presented in the controllers' work position.

The tools Medium Term Conflict Detection (MTCD) and Flight Leg (FLEG) help the controller to see a flight's route in advance, also in relation to other flights. The controller can use the information to make decisions about future clearances. Conflict And Risk Display (CARD) is information on the radar screen that shows MTCD conflicts and risks depending on what is selected. The radar screen displays a red box. To see which aircraft are involved, the pointer icon is moved over the red box. MTCD, FLEG and CARD are based on updated flight plan data.

When the controller performs “Assume”, a FLEG comes up showing the aircraft's route. By doing a “click and hold” on the middle mouse button, a FLEG is obtained as well as the FLEGs of all the others with which this flight has conflicts. FLEGs are marked in green, yellow and red.

The safety nets are based on data from the monitoring equipment and give an alert when these fall below certain values. One of the safety nets is called Short Term Conflict Alert (STCA), which is based on radar data. STCA is a warning to the controller of the risk that a separation will be infringed. The conflict between two radar tracks is detected, provided that one of the tracks is correlated. The STCA function looks forward and gives a warning 90 seconds before a potential conflict. The warning is displayed as a red frame around the radar labels for the affected flights and as a red background behind the call signs in all lists on which the flights are represented.

A function called SEP tool can be used to show minimum distances between two tracks with respect to position, heading and speed. Prediction Line (PRL) is another function that can be used to display the predicted tracks of aircraft.

### *1.16.3 TCAS training programme for air traffic controllers*

ICAO has published guidelines for controller training on TCAS[10]. According to the guidelines, training should include both theoretical elements and practical exercises. Practical exercises may, for example, be done in simulators so that controllers are not surprised by a TCAS event in their operational environment. TCAS elements should also be integrated into recurrent training.

Initial training of controllers at Entry Point North includes a lesson of about 100 minutes on TCAS and how crew and controller are to act in the event of an RA, according to information from a representative of Entry Point North. The training has so far been theoretical because of difficulties in logically and credibly creating situations that generate TCAS alerts.

During the controller's local training – “On the job training” – there are an additional two days of emergency training in which TCAS is included as a minor part. The annual competence assurance of controllers includes some form of emergency training. According to information provided by Team Manager Stockholm Training, the emergency training in 2011 consisted of various emergency situations in which Eurocontrol's checklist for how to manage

[10] Controller training guidelines, ACAS Manual, Chapter 6, ICAO Doc 9863. 2006/2012.

TCAS RAs was reviewed. There was no practical training for the same reasons stated above.

The theoretical verification consisted of a written test without aids. Before this test, reading instructions were issued which recommended the controllers to read, for example, the ANS Operations Manual regarding TCAS. The test included a question on the subject. The controller in question underwent this training on 18 May 2011 and passed the test.

### *1.16.4 Studies regarding disturbed sleep and fatigue*

The main problem with shift work is disturbed sleep and fatigue, as found by Kecklund et al. in a report summarising the state of research on working hours, health and safety. Seven to eight hours' sleep is, according to the authors, the minimum for recovery, health and safety[11]. There has been discussion about whether shift work leads to a permanent sleep disturbance, but based on research so far, there is nothing that supports the notion that shift workers have a chronic lack of sleep or chronic sleep disturbance. However, there are individual differences.

Fatigue in shift work is highest in connection with night shifts and early morning shifts, mainly during the second half of the night shift due to natural human circadian rhythm. Circadian rhythm also gives rise to a certain decrease in the afternoon between around 15.00 hrs and 17.00 hrs, when the effects of disturbed sleep or lack of sleep may manifest themselves. The exact times will vary from person to person[12]. Fatigue due to lack of sleep and sleep disturbance, i.e., insufficient recovery, can impair performance, such as that of memory, reaction time and attention.

## 1.17 Organisational and management information

### *1.17.1 LFV*

LFV is a public service company which conducts air traffic services for civilian and military clients in Sweden. At the time of the incident, the business area Production En Route was operating activities primarily at the control centres, ATCC (Air Traffic Control Centre) Malmö and ATCC Stockholm.

On 1 July 2012, NUAC HB (Nordic Unified Air Traffic Control) took over operations of the three control centres in Copenhagen, Malmö and Stockholm and performs air traffic services en route, that is, the part of airspace where flights are en route, as a subcontractor to LFV and its Danish counterpart, Naviair.

### *1.17.2 Air Traffic Control Centre (ATCC Stockholm)*

ATCC Stockholm consists of two parts, an ACC (Area Control Centre) and a TMC (Terminal Control Centre).

---

[11] Kecklund G., Ingre M. & Åkerstedt T. Arbetstider, hälsa och säkerhet – en uppdatering av aktuell forskning. Stressforskningsrapporter nr 322, Stockholm 2010.
[12] See e.g. Fatigue Risk Management Systems Manual for Regulators. ICAO Doc 9966, 2012 Edition.

### *1.17.3 Operations manuals*

Manning of positions

According to the local operations manual for ATCC Stockholm (Section 1, Chapter 3), the E position is opened first. The P position and/or additional sectors are opened upon an established traffic load level or in accordance with TS-A or the assessment of E. However, TS-A can always order an opening. The closing of the P position, or combining of sectors, may be proposed by the controller, but is decided by TS-A.

TS-A retrieves/updates data for traffic load. The recommended level for opening a controller position is marked in red on a bar chart. The traffic bars present the number of movements for continuous hours at 20-minute intervals. At traffic load level 18 for the combined sector 1/9, it is recommended that the P position or an additional E position be open.

Position P1 is to be open on ordinary Mondays to Thursdays from 08.30 hrs to 16.30 hrs local time and ordinary Fridays from 08.30 hrs to 12.00 hrs local time. During specific events that reduce demand during a watch in progress, deviations may be made, as judged by WS/TS.

On Wednesday 20 June 2012, the traffic load level for sector 1/9 was over the level marked in red from 15.00 hrs to 15.20 hrs, and from 15.20 hrs to 17.00 hrs was between 15 and 17, that is, under the level marked in red.

Working methodology

The local operations manual also contains comprehensive working instructions for E and P, and specifies the following[13]:

> *By way of deviation from the central regulations, the E position is the main position in the ACC sectors. If during low traffic intensity it is decided to cut down to single manning in a sector, the P position is closed. In the case of single manning, P's duties and responsibilities are transferred to E.*

E is responsible for the performance of traffic control services within his own and other sectors transferred to that position. E shall be responsible for flights and the updating of flight plan data in E2kE for traffic taken over (Sector state Assume) as well as a number of additional tasks. PC is responsible for flights and updating flight plan data in E2kE for traffic that has been coordinated (Sector State Coordinated) and that is in the process of ongoing coordination (On-going coordination). In addition, P shall search for conflicts using MTCD and make E aware of conflicts that require action and respond to and rectify system coordinations in Sector State Coordinated and On-going coordination.

According to the Central Operations Manual (Part 3, Section 2, Chapter 3, Point 2.4) the following methodology is applicable for air traffic control upon the report of a TCAS alert:

> *If an aircraft in controlled flight reports that it is executing an evasive manoeuvre in accordance with an RA ("resolution advisory"), the controller*

[13] ATS Operations Manual, Part 3 Section 2 - Chapter 1 Points 2, 3 and 4, 22-03-2012.

*shall not attempt to modify the aircraft flight path until the flight crew reports "CLEAR OF CONFLICT". Traffic information shall only be provided upon request from the aircraft.*

### *1.17.4 The air traffic controller's workplace*

An operating position consists of a workplace with three screens, a communications station, computer mouse, keyboard and headsets. The radar screen is positioned in the centre. The other two screens display information about weather and lists with information indicating when aircraft will enter the sector, among other things (see Fig. 5).

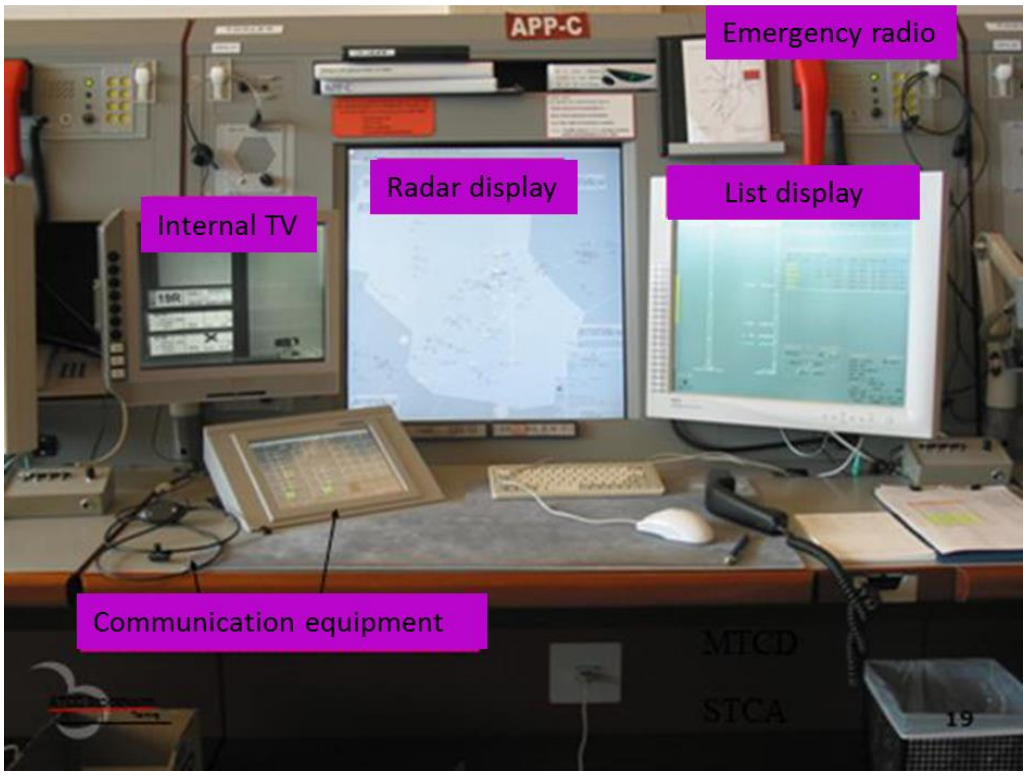


Fig. 5. An air traffic controller's workplace.

The distance between the E position in sector 1 (E1) and the P position in sector 2 (P2) is between 3.5 and 4 metres. P2 is located to the left of E1, and between the two positions is an unmanned position in sector 1 (P1), see Fig. 6 below. The screen with "Approach Sector List" at E1's workplace is located to the right of his radar screen.

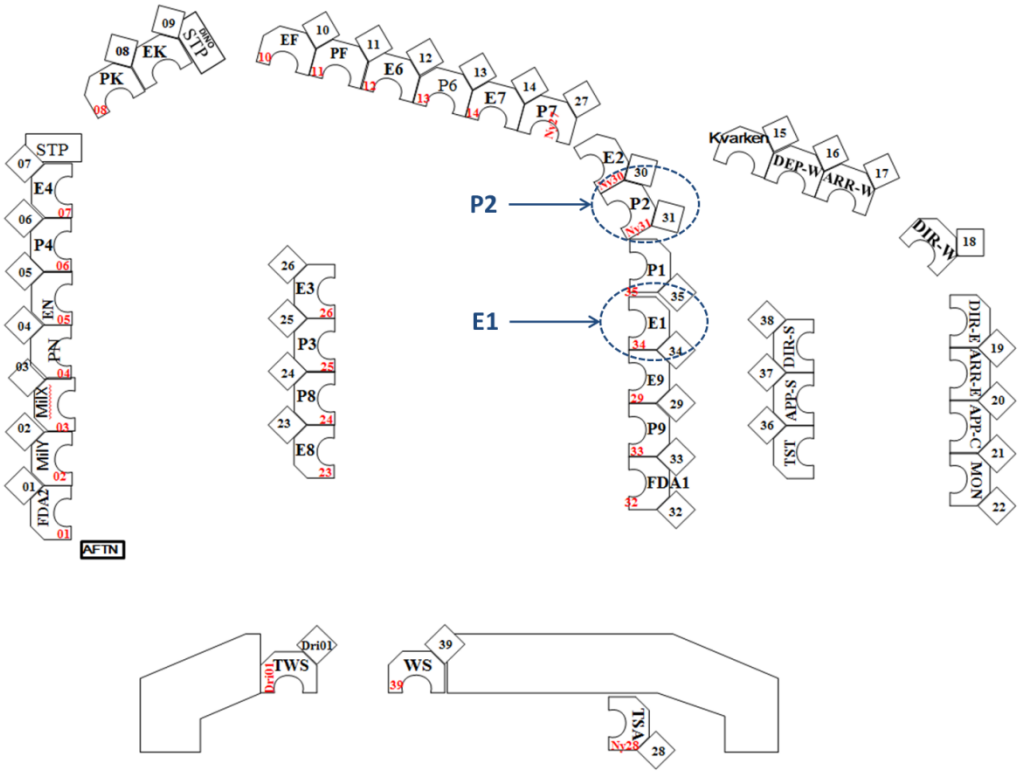


Fig. 6. The operating work positions E1 and P2 are marked in blue.

## 1.18 Additional information

### *1.18.1 Gender equality issues*

The investigation of the event in question has also been treated from a gender equality perspective, that is, against the background of the issue of whether there are circumstances to suggest that the event in question or its effects were caused or influenced by the women and men concerned not having the same opportunities, rights and obligations in various respects. No such circumstances have been found.

### *1.18.2 Previous incidents at the air traffic control centre*

On 2 July 2010, a separation minima infringement occurred between two aircraft in the airspace south-west of Östersund. The aids, functions, tools and safety nets of air traffic control were not used and were not noticed in time. The airborne collision warning systems were activated, upon which the pilots in each aircraft performed evasive manoeuvres.
The investigation conducted by SHK, RL 2012:01[14], found that

- CARD was thought to display too much irrelevant information and was therefore not utilised to full extent, according to interviews with controllers, and that
- STCA alarms had not been noticed on several occasions according to interviews with controllers, inspectors at the Swedish Transport Agency and LFV's own investigation.

[14] Serious incident between two aircraft LN-RRN and OH-LBT in the airspace southwest of Östersund, Jämtland county, on 2 July 2010. Swedish Accident Investigation Authority, RL 2012:01.

SHK's assessment was that several factors had contributed to the incident, namely irregular cruising level, divided attention and focus on information in the second of the two combined sectors, single manning and the culture around single manning, fatigue, forgetfulness, the design and placement of CARD and weaknesses in the application of the safety management system.

The design of the STCA alarm was assessed to be a risk factor as it was not immediately capable of catching the attention of the operator and only made use of the sense of sight.

No recommendations were given, because LFV had announced that the decision had been made to adjust the opening hours of positions in the group and deploy a new air traffic control system in 2012, including a modified visual presentation of STCA and a sound warning.

Furthermore, in May 2011, the supervisory authority, the Swedish Transport Agency had requested a statement from LFV on the measures taken as a result of several incidents in which STCA alarms had not been immediately noticed. In an audit of LFV in August 2011, the Swedish Transport Agency had also found shortcomings in systems and traceability in respect of how proposed measures from investigations into reported incidents were dealt with.

### *1.18.3 Measures taken after the previous incident*

According to an interview with a group manager at ATCC Stockholm in July 2012, a traffic control system had been deployed in Malmo. Changes had been made that were stated to mean that a large part of the false alarms in CARD and FLEG will disappear. It was also mentioned that work was in progress on the presentation of STCA, since the introduction of a sound warning places specific requirements on parameterisation so that the warning will be effective and not give rise to many false alarms and thereby risk inuring the controllers.

The opening hours of the P position were said to have been set right to some extent in order to reduce instances of relieving and improve aviation safety. In sector K, the P position was to be open during times of military activity. In sectors 1, 2 and 3, the control of the P position's opening hours was regulated to times during ordinary weekdays. During specific events that reduce demand during a watch in progress, the Watch Supervisor or tactical watch supervisor could decide to make deviations, something which was usually said to be done in consultation with the operator.

Sound warning for STCA has been introduced at ATCC Malmö (February 2013) and ATCC Stockholm (April 2013).

### *1.18.4 Environmental aspects*

Not applicable.

## 1.19 Special or effective methods of investigation

Not applicable.

# 2. ANALYSIS

## 2.1 Introduction

The event has been analysed from the perspective of Human and Organisational Factors and their interaction. The purpose of the analysis was to identify conditions that influenced the sequence of events and the system's safety barriers or safety nets. Barriers/safety nets denote the technical, administrative and human arrangements intended to stop a sequence of events so that an accident does not occur. These conditions are presented below.

## 2.2 Factors contributing to Golden 551 not being noticed

Earlier during the controller's watch, the traffic situation had been more intensive. The workload during the watch in question was assessed by the controller to be low. The time from which Golden 551 announced itself until the time that the next flight, Golden 552, announced itself was five minutes. It is known that memory lapses, unlike other operational errors, increase significantly in situations with a rapidly decreasing mental workload[15]. The relatively rapidly decreased mental workload can thus be a factor that contributed to Golden 551 no longer being in the controller's mental picture of the flight situation.

In the mental picture of the flight situation that the controller had, there was no flight that PHDCI could be in conflict with, for which reason PHDCI was allowed to climb directly from Flight Level 60 to its cleared flight level, that is, without receiving a safe intermediate altitude. Flights such as Golden 551 were usually performed at higher flight levels. Even if the controller had accepted the lower flight level, there may have been an unconscious expectation/notion that the flight was being performed at the higher flight level.

At the time in question, the controller's focus was on Golden 552 and flights in another part of the sector with potential conflicts and needs for action. The controller was thus working actively with searching for conflicts between GAO552 and another flight. Furthermore, the controller was working actively with planning how GAO552 and PHDCI were to be handed over to sector 2. The concentration and focus on this work thereby contributed further to the thought of a potential conflict with GAO551 not being prompted. As pointed out by Endsley and Smolensky[16], goals and plans affect the aspects that are mainly noticed in the development of situation awareness.

Furthermore, it cannot be ruled out completely that the controller's trouble sleeping may have affected his attention capacity and working memory at the time in question, as it is natural for there to be some reduction in the level of alertness.

---

[15] Endsley M.R. & Smolensky M.W. Situation awareness in air traffic control: The picture. I M.W. Smolensky & E.S. Stein (Eds.) Human factors in air traffic control. London: Academic Press Ltd, 1998.
[16] See previous footnote.

## 2.3 Barriers/safety nets

Controllers have several tools for searching for conflicts and for being made aware of potential separation minima infringements. Why did these not function so that the sequence of events could be stopped and the separation minima infringement avoided?

The conflict was displayed on MTCD FLEG when the controller confirmed the radar label for PHDCI. As mentioned in Section 1.16.2, the FLEG and all other FLEGs with which the flight has conflicts are displayed if the controller does a "click and hold" on the middle mouse button. The controller did not do this. One reason for this may be that the controller assessed that there was no potential conflict and that she had full control of the situation. An additional factor is considered to be the fact that in sector 1/9 a large number of potential conflicts are usually obtained on FLEG that can be demanding to analyse, for which reason controllers might not make use of that tool, even during low traffic intensity.

The conflict was displayed in MTCD CARD but was not noticed by the controller. The fact that CARD is not used has previously been found in internal investigations and in SHK's previous investigation RL 2012:01. There it emerged that controllers do not consider the tool to be user-friendly, as traffic in the sector is often such that CARD gives alerts for an excessive number of flights that do not constitute real conflict threats. This happens especially in times of peak traffic and may result in controllers also not using CARD during low traffic intensity in the sector.

Ninety seconds before the separation minima infringement, STCA was activated, but was not noticed. The reason for this was that the controller was facing sector 2, which meant that attention and gaze were not turned towards the screens displaying the STCA alarm. Since the alarm was visual, it was unable to catch the attention of the controller. The fact that STCA alarms are not always perceived in a timely manner has also emerged in previous investigations.

From time to time, the controller had a quick look at the radar screen while awaiting a suitable occasion to give sector 2 information. The fact that the conflict was not detected at that point can be explained by there being no conflict in the controller's mental picture of the traffic situation. STCA, which was displayed with a red frame around the two flights' radar labels, was thus not capable of breaking the controller's mental picture of what he expected to see. The controller also did not notice the STCA alarm image on the screen to the right of the radar screen because he was facing the left and had his attention in that direction.

Occasionally scanning the lists of information on the sector's flights is a procedure that the controller usually applied to gain an overview of the traffic and to discover possible conflicts. The procedure was used in times of peak traffic, but not when traffic was assessed to be low as in the present situation.

The working methodology for TCAS alerts was not used in that the controller attempted to guide this aircraft away, provide traffic information and terminate the second aircraft's climb before the crew had stated "Clear of conflict" and without the crew having requested traffic information.

This may be explained by the controller being in a situation involving high stress levels and by her not having had practical exercises in handling this type of conflict during his training. The controller did not clearly perceive that it was a TCAS alert.

According to information obtained, the reason no practical exercises take place during initial training or local training is that there are difficulties in logically and credibly creating situations that generate TCAS alerts. However, ICAO's guidelines on training in this regard recommend that practical exercises be carried out and have thus not identified such difficulties that it would not be considered useful to have practical exercises for this, for example, in a simulator. According to SHK, recurrent practical training of situations with TCAS alerts would probably increase the chances of correct actions under operational conditions. As demonstrated in the Überlingen accident, for example, deviations from applicable procedures in the handling of TCAS alarms by controllers and pilots can have very serious consequences. The possibilities for introducing practical exercises of this nature should therefore be reconsidered with a view to improving training in this regard.

When the separation minima infringement occurred, the airborne collision warning systems, TCAS, activated a manoeuvre command both on board Golden 551 and PHDCI. The pilots managed the TCAS alerts in an appropriate manner.

# 3 CONCLUSIONS

## 3.1 Findings

*a)* The pilots were qualified to perform the flight.
*b)* The aircraft had both a valid Certificate of Airworthiness and valid Airworthiness Review Certificate.
*c)* The air traffic controller was fully qualified for the sector in question.
*d)* The air traffic controller was performing both E's and P's tasks in the combined sector.
*e)* GAO551 had Flight Level 160 planned, which was revised to Flight Level 140.
*f)* PHDCI received clearance to Flight Level 150 without the conflict with GAO551 being noticed.
*g)* PHDCI and GAO552 were sequenced manually before handover of the flights to sector 2.
*h)* The air traffic controller turned towards sector 2 in order to verbally, without the interphone, discuss the coordination of the traffic.
*i)* MTCD and STCA were not noticed.
*j)* The air traffic controller attempted to modify the aircraft flight paths during the TCAS alert.

## 3.2 Factors as to cause

- The air traffic controller's focus was on an early handover of flights to another sector.

- Air traffic control's aids for noticing the conflict were not capable of breaking the mental picture that the controller had of the situation in the sector.

### 3.3 Factors as to risk

- Air traffic control attempted to modify the aircraft flight paths during the TCAS alert.

## 4. RECOMMENDATIONS

The Swedish Transport Agency is recommended to improve the training at suppliers of Air Traffic Services with respect to procedures for TCAS RAs. (RL *2013: 11 R1).*