Havarikommissionen
Accident Investigation Board Denmark

BULLETIN

Serious incident

20-7-2014

involving

CESSNA 172

OY-AKH

and

BOEING 737 800

SU-GDY

ECCAIRS Release 5

Certain report data are generated via the EC common aviation database

FOREWORD

This bulletin reflects the opinion of the Danish Accident Investigation Board regarding the circumstances of the occurrence and its causes and consequences.

In accordance with the provisions of the Danish Air Navigation Act and pursuant to Annex 13 of the International Civil Aviation Convention, the investigation is of an exclusively technical and operational nature, and its objective is not the assignment of blame or liability.

The investigation was carried out without having necessarily used legal evidence procedures and with no other basic aim than preventing future accidents and serious incidents.

Consequently, any use of this bulletin for purposes other than preventing future accidents and serious incidents may lead to erroneous or misleading interpretations.

A reprint with source reference may be published without separate permit.

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BULLETIN

General

File number:	HCLJ510-2014-273
UTC date:	20-7-2014
UTC time:	13:08
Occurrence class:	Serious incident
Location:	Approximately 2 nm east of Falsterbo (Sweden) within Copenhagen Terminal Control Area (TMA)
Injury level:	None
Classification:	A) Risk of collision

Aircraft A

Aircraft registration:	OY-AKH
Aircraft make/model:	CESSNA 172
Current flight rules:	Visual Flight Rules (VFR)
Operation type:	General Aviation Pleasure Cross-country
Flight phase:	En route
Aircraft category:	Fixed wing Airplane
Last departure point:	Denmark EKRN (RNN): Bornholm/Ronne
Planned destination:	Denmark EKRK (RKE): Kobenhavn/Roskilde
Aircraft damage:	None

Aircraft B

Aircraft registration:	SU-GDY
Aircraft make/model:	BOEING 737 800
Current flight rules:	Instrument Flight Rules (IFR)
Operation type:	Commercial Air Transport Revenue operations Passenger
Flight phase:	Approach
Aircraft category:	Fixed wing Airplane
Last departure point:	Egypt HECA (CAI): Cairo/Intl
Planned destination:	Denmark EKCH (CPH): Kobenhavn/Kastrup
Aircraft damage:	None

SYNOPSIS

Notification

All times in this report are UTC.

The Aviation Unit of the Danish Accident Investigation Board (AIB) was notified of the serious incident by the Area Control Centre at Copenhagen Airport, Kastrup on 20-7-2014 at 14:28 hrs.

The International Civil Aviation Organization (ICAO), the European Aviation Safety Agency (EASA), the Directorate-General for Mobility and Transport (DG MOVE), the National Transportation Safety Board (NTSB USA), the Central Directorate of Aircraft Accident Investigation Ministry of Civil Aviation Egypt and the Danish Transport Authority (DTA) were notified of the serious incident on 20-7-2014 by the AIB.

The Swedish Accident Investigation Authority (Statens haverikommission (SHK)) was notified of the serious incident on 21-7-2014 by the AIB.

The Egyptian and the Swedish investigating authorities both appointed non-travelling accredited representatives to the investigation.

The serious incident occurred within Swedish territory but within airspace controlled by a Danish air traffic control (ATC) unit. For that reason and in agreement with SHK and in accordance with ICAO Annex 13, the AIB was in charge of the safety investigation.

Summary

The pilot’s diverted focus (aircraft A) combined with the lack of Mode C altitude information (aircraft A) resulted in an unauthorized penetration of controlled airspace (Copenhagen TMA).

The lack of Mode C altitude information (aircraft A) reduced the effect of available preventive safety barriers (ATC and Traffic Collision and Avoidance System (TCAS)) and thereby compromised flight safety.

Furthermore, a seemingly misperception by the pilots of aircraft B of the horizontal separation influenced their decision on not making an appropriate avoiding action.

The serious incident occurred during daylight and under visual meteorological conditions (VMC).

The safety investigation did not result in recommendations being made.

FACTUAL INFORMATION

History of the flight

Aircraft A was a privately operated Cessna 172 aircraft with one pilot and one passenger on board, conducting a Visual Flight Rules (VFR) flight from Ronne (EKRN) on the Danish island of Bornholm to Copenhagen Roskilde (EKRK) on the Danish island of Zealand.

Aircraft B was a commercially operated Boeing 737-800 aircraft, conducting a scheduled revenue Instrument Flight Rules (IFR) flight from Cairo International Airport (HECA), Egypt, to Copenhagen Kastrup (EKCH) on the Danish island of Zealand.

Both aircraft passed enroute overhead the southern part of Sweden to their planned destinations.

After departure from EKRN, but prior to reaching Swedish airspace, the pilot of aircraft A contacted Sweden Control (133.800 MHz) at 12:32:23 hours and informed that aircraft A had departed EKRN enroute to EKRK and maintained an altitude of 4,000 feet mean sea level (msl).

The air traffic controller (ATCO) at Sweden Control issued a transponder (squawk) code of 7232 to aircraft A.

The pilot of aircraft A read back the transponder code as 7032, which went unnoticed by the ATCO.

As the transponder reply with the code number 7032, but without altitude (Mode C) readout subsequently was displayed on the radar screen, the ATCO noticed the erroneous code and passed this information to another ATCO, who was about to replace the ATCO at the duty position.

After the duty change, the ATCO at 12:34:48 hours instructed the pilot of aircraft A to change the transponder code to 7232, which the pilot did.

The ATCO had no recall of having received flight altitude information of aircraft A from the pilot of aircraft A or from the ATCO going off duty.

The registration of aircraft A was not coupled to the radar track of aircraft A by the COOPANS system (see “Airspace and ATC information”).

As aircraft A approached Swedish airspace without having requested a permission to enter the controlled airspace of Malmoe TMA, the ATCO presumed that aircraft A was flying below the lower limit of Malmoe TMA, as this was common practise among pilots conducting VFR flights from EKRN to other airports in Denmark.

It was the perception of the pilot of aircraft A, that he had requested and received a permission to enter and cross Malmoe TMA (flying on a westerly course and at an altitude of 4,000 feet msl).

Furthermore, the pilot believed that the altitude of aircraft A was radar presented to the ATCO by the Mode C transponder functionality.

Without further radio communication with Sweden Control, aircraft A continued westbound into and through Malmoe TMA at 4,000 feet msl, and passed just north of the city of Trelleborg at 13:04:02 hours.

At the same time, aircraft B was approaching the southern coastline of Sweden on a west-northwesterly course descending through Flight Level (FL) 082.
See appendix 1.

At 13:04:30 hours, the pilots of aircraft B contacted Copenhagen Approach (124.975 MHz).

The ATCO at Copenhagen Approach informed the pilots of aircraft B that aircraft B was identified (radar presented) and issued an instruction to descend to 4,000 msl on the local barometric pressure of 1015 hectopascal (hPa). The pilots of aircraft B read back the instruction.

Shortly before aircraft A passed the boundary between Malmoe TMA and Copenhagen TMA, the passenger in aircraft A became sick and vomited in the cockpit and on the pilot's tablet. This caused some distress in the cockpit and the pilot's focus diverted from the operation of the aircraft. The pilot pre-planned descent, to an altitude below the lower limit of Copenhagen TMA, was delayed.

At 13:05:48 hours, aircraft A left Malmoe TMA and continued westbound into Copenhagen TMA maintaining an altitude of 4,000 feet msl and with a radar presented groundspeed of 110 knots.

Meanwhile aircraft B was maintaining 4,000 feet msl flying with a radar presented groundspeed of approximately 285 knots. The two aircrafts flew on projected crossing tracks with a converging angle of approximately 25 degrees.

The pilots of aircraft B observed aircraft A at a horizontal distance of 8 nautical miles (nm) in their 2 o'clock position at the same altitude as aircraft B. Subsequently, the pilots of aircraft B had a TCAS TA presentation of aircraft A without altitude indication presented on their navigation displays (ND).

At 13:07:51 hours, aircraft B passed aircraft A at a radar presented horizontal distance of 0.0 nm and seemingly at the same altitude. The position of the serious incident was just west of the Falsterbo canal, on the outskirts of Hoellviken in Sweden.
See appendix 2 and 3.

At 13:08:15 – 13:08:48 hours the radar presented groundspeed of aircraft A increased from 110 knots to 150 knots and then decreased back to 110 knots. During the same time interval and according to the radar presentation, aircraft A turned approximately 30 degrees to the right followed by a similar turn in the opposite direction back to the original course.

At 13:08:27 hours, the pilots of aircraft B reported to Copenhagen Approach that a Cessna 172, flying at the same altitude – 4,000 feet – had passed in front of them at a distance of 2 nm.

The ATCO at Copenhagen Approach replied that a radar track without Mode C presentation on the ATC radar display was presented behind the radar track of aircraft B.

Earlier, the ATCO noticed the track of aircraft A, but the ATCO presumed that the aircraft was an uncontrolled VFR flight flying below Copenhagen TMA (below 2,500 feet).

At 13:08:51 hours, the pilot of aircraft A contacted Sweden Control and informed that he would change frequency and contact Copenhagen Information.

The ATCO at Sweden Control informed the pilot of aircraft A that the frequency was 127.075 MHz, which was read back by the pilot of aircraft A.

At 13:09:21 hours, the ATCO at Copenhagen Approach asked the pilots of aircraft B to confirm that the traffic, which had passed in front of them, was flying at the same altitude as aircraft B.

This was confirmed by the pilots of aircraft B, who also replied that the aircraft was a Cessna 172 and it had passed aircraft B at a horizontal distance of approximately 2 nm.

At 13:09:32 hours, the pilot of aircraft A contacted Copenhagen Information on 127.075 MHz and informed that aircraft A conducted a VFR flight from EKRN to EKRK maintaining an altitude of 4,000 feet and had just passed Falsterbo on a heading towards Stevns (approximately west-southwest).

The Flight Information Service Officer (FISO) at Copenhagen Information instructed the pilot to squawk 4454. The pilot of aircraft A read back the instruction to squawk 4454.

Subsequently, the FISO asked the pilot if he was aware of the requirements and regulation concerning the Copenhagen Area (Copenhagen TMA and CTR and EKRK TMA).

The pilot of aircraft A confirmed that he was aware, and that he would descend to below 2,500 feet before he reached the town of Store Heddinge (on the island of Zealand).

At 13:10:52 hours, the transponder code of aircraft A was presented as 5444 on the radar display of the FISO.

At 13:12:08 hours, the FISO at Copenhagen Information instructed the pilot of aircraft A to squawk 4454. This was read back by the pilot of aircraft A, and subsequently the transponder code of aircraft A was presented on the radar display of the FISO as 4454.

At 13:12:20 hours, the FISO requested the present altitude of aircraft A. The pilot of aircraft A replied that the altitude was 3,000 feet descending to 2,500 feet.

The FISO informed the pilot of aircraft A that the maximum allowable altitude of aircraft A at the present position was 2,500 feet.

At 13:12:45 hours, the pilot of aircraft A reported that his altitude was below 2,500 feet.

At 13:13:41 hours, the FISO informed the pilot of aircraft A, that aircraft A was now radar presented with an altitude readout (Mode C) of 2,000 feet on the radar display of the FISO.

This was acknowledged by the pilot of aircraft A.

For the remaining part of the flight, the altitude of aircraft A was Mode C radar presented.

Personnel information

Aircraft A

The pilot of aircraft A (male, 66 years) was the holder of a valid European Union Private Pilot License (PPL (A)).

The medical certificate (class 2) was valid until 5-5-2015.

The PPL license contained the following ratings:

SEP (land) (valid until 30-4-2016)

Flying experience

	Last 24 hours	Last 90 days	Total
All types (hours)	1	29	52
This type (hours)	1	29	52

Aircraft B

The commander of aircraft B (male, 43 years) was the holder of a valid Egyptian Airline Transport Pilot License (ATPL (A)).

The ATPL license contained the following ratings:

B737 (300-900)
ME/IR
Flying experience

	Last 24 hours	Last 90 days	Total
All types (hours)			12000
This type (hours)			6000

Aircraft information

Aircraft A

Aircraft A was equipped with a Bendix/King KT76A altitude encoding (Mode C) transponder. See picture below.

When the mode selector switch was set to “ON” (Mode A), the transponder code information was transmitted. If the mode selector switch was set to “ALT” (Mode C), the transponder transmitted both transponder code and aircraft altitude information.

The pilot of aircraft A explained to the AIB that the transponder transmitted altitude information to the air traffic services system (ATS) during the previous flight from EKRK to EKRN.

During the serious incident flight, the pilot stated that he operated the transponder according to normal procedure (and in the same way as during the previous flight) and before take-off set the transponder mode control to “ALT” (Mode C activated). The pilot stated that he did not change the setting of the mode control knob throughout the serious incident flight.

In the time period from departure from EKRN until the serious incident had happened, the transponder of aircraft A did not transmit altitude information (Mode C) to the ATS system or to the TCAS system of aircraft B.

Therefore:

- The track label associated to aircraft A did not present any altitude information to the ATCOs.
- Only TCAS lateral information concerning aircraft A was displayed on the ND to the pilots of aircraft B.

The pilot had no explanation for the missing transmission of aircraft A transponder altitude information to the ATS system (ATC radar displays) for the majority of the serious incident flight.

The pilot had no knowledge of any previous or subsequent technical malfunctions of the aircraft transponder.

According to the maintenance facility, which maintained and serviced aircraft A, there were no known faults or remarks regarding the transponder or the altitude encoding capability of aircraft A during the preceding three years.

Aircraft A had no autopilot.

<u>Aircraft B</u>

Aircraft B had a TCAS system.

TCAS interrogates ICAO compliant transponders of all aircraft in the vicinity and based on the replies received, tracks the slant range, altitude (when it is included in the reply message), and relative bearing of surrounding traffic. From several successive replies, TCAS calculates a time to reach the CPA (Closest Point of Approach) with the intruder, by dividing the range by the closure rate. This time value is the main parameter for issuing alerts.

"*Introduction to TCAS II*" Ver. 7, U.S. Department of Transportation, Federal Aviation Administration (FAA)

A TA was presented if the predicted CPA of the intruder was within approximately 40 seconds of a TCAS specified three dimensional collision area around the host aircraft.

An intruder aircraft with an operating transponder without Mode C capability (or Mode C capability de-activated) was TA presented with indicated range and bearing, but no relative altitude of the intruder aircraft.

The TA symbol of the intruder aircraft was presented on the ND in a yellow colour.

Aircraft B had an autopilot installed which was engaged during the sequence of events.

Meteorological information

<u>Aerodrome Forecast (TAF)</u>

Malmoe Sturup (ESMS) and EKCH:

TAF STD esms 201130z 2012/2112 09012kt cavok=
TAF STD ekch 201130z 2012/2112 08012kt cavok=

<u>Aviation Routine Weather Report (METAR)</u>

METAR esms 201250z 09013kt cavok 25/12 q1015=
METAR ekch 201250z 08012kt cavok 26/13 q1015 nosig=

<u>Pilot observation</u>

According to the pilots of aircraft B there were no restrictions in the visibility.

According to the pilot of aircraft A, the visibility was more than 10 kilometres (km), there were no clouds below 5,000 feet, and he experienced light turbulence during the flight.

Navigation

<u>Aids to navigation</u>

The pilot of aircraft A used as main navigation aid an electronic flight planning software program presented on a tablet in a moving map format. The tablet was mounted on the control column in front of the right hand pilot seat, where the passenger was seated.

The pilot had limited experience with the use of the flight planning software program, but was confident with the basic features.

A paper VFR sectional chart was available in the cockpit.

The flight planning software program presentation contained most of the information available in the VFR paper chart. However, the information was in parts presented in a slightly different manner.

This included certain altitude restrictions concerning Malmoe and Copenhagen TMA, Copenhagen Area and the presentation of the FIR boundary between Sweden and Denmark.

In addition to the chart function of the flight planning software program and based on the tablet internal Global Navigation Satellite System (GNSS) receiver the aircraft planned route, present position and altitude were presented to the pilot.

On the basis of the recorded flight planning software program data log files a presentation of the flight of aircraft A was produced.
See appendix 4.

For layout comparison purposes, an extract of the VFR paper chart showing the same area is also presented.
See appendix 5.

<u>Pilot focus</u>

During the time period, when the on-board passenger was sick and while searching for vomit bags, the focus of the pilot of aircraft A diverted from flying the aircraft and keeping a lookout.
The aircraft dived for a short period of time.

<u>Intended flight altitude profile</u>

The pilot of aircraft A stated that he intended to descend to an altitude below 2,500 feet prior to leaving Malmoe TMA - *”..just after Trelleborg..”* - and fly below Copenhagen TMA.

This decent was delayed as a consequence of the passenger’s sickness.

Airspace, Air Traffic Service (ATS) and Rules of the Air

<u>Airspace</u>

Aircraft A and B passed overhead the southern part of Sweden, which was divided into two ATS sectors; the eastern sector was controlled by Swedish ATC and the western sector, still within Swedish airspace, was delegated to Danish ATC.

The Swedish sector comprised:

- Malmoe TMA (airspace class C) where ATC was managed by Sweden Control
- Swedish FIR (airspace class G) below parts of Malmoe TMA, where FIS was provided by Sweden Control on a capacity allowing basis.

The Danish sector comprised:

- Copenhagen TMA (airspace class C) where ATC was managed by Copenhagen Approach/Departure.
- Danish FIR (airspace class G) below parts of Copenhagen TMA, where FIS was provided by Copenhagen Information.

The lower vertical limits of Malmoe and Copenhagen TMAs were changing depending on the distance from the respective aerodromes (ESMS and EKCH).

The serious incident occurred within Copenhagen TMA.

The below, in extract from the Danish Aeronautical Information Publication (AIP), describes operation in class C airspace:

ENR 1.4 ATS Airspace Classification
1. Classification of Airspaces
Class C. IFR and VFR flights are permitted. All flights are subject to air traffic control service and IFR flights are separated from other IFR flights and from VFR flights. VFR flights are separated from IFR flights and receive traffic information in respect of other VFR flights.

Confer the Danish ATS instruction 10, revision 15, chapter 6.2 the required radar separation minimum between aircraft operating in class C airspace was 5 nm or 1,000 feet, respectively.

<u>Swedish ATS</u>

In Sweden, one ATC unit (Sweden Control) handled IFR, controlled VFR and uncontrolled VFR traffic within both Malmoe TMA and within the airspace below Malmoe TMA.

The handling of IFR and controlled VFR traffic within Malmoe TMA had priority comparing to the service provided to uncontrolled VFR traffic within the airspace below Malmoe TMA.

During the flight of aircraft A through Malmoe TMA, the ATCO, handling the position of Sweden Control, was exposed to a high workload. The ATCO had the impression that aircraft A had descended below Malmoe TMA and assigned a lower priority to the handling of aircraft A.

<u>Use of transponder and flight in class C airspace</u>

The below, in extract from the Swedish AIP, stated the requirements and regulations concerning transponders and flight in class C airspace within Sweden Flight Information Region (FIR).

GEN 1.5

3. Requirement for SSR transponder

3.1 Within Sweden FIR, aircraft operating within those airspaces specified in the below table shall be equipped with a serviceable SSR transponder at least as shown in the table, except as specified in 3.2 or 3.3 below.

A	*Mode A required.*
AC	*Mode A and C with automatic pressure-altitude reporting required.*
N	*No transponder requirement.*

	Airspace	***IFR flight***	***VFR flight***
a)	*Control zone (CTR)*	*A*	*A*
b)	*Control area (CTA)*	*AC*	*AC*
c)	*Traffic information zone (TIZ)*	*A*	*N*
d)	*Traffic information area (TIA)*	*AC*	*N*
e)	*Class G airspace above the highest of 3000 ft AGL or 5000 ft MSL*	*AC*	*N*
f)	*Class G airspace except airspace specified in e)*	*N*	*N*

3.5 Unless otherwise instructed or permitted by ATC, an aircraft equipped with a functioning transponder shall operate it in flight, including mode C pressure-altitude reporting as prescribed in table in 3.1 above.

ENR 1.2

1.2 Visual flight rules

2 VFR flight in class C airspace, except CTR

2.1 VFR flight in class C airspace shall be conducted as controlled flight in compliance with applicable rules in Annex 2 and the additional procedures specified below;

a) Flight plan - Prior to flight, a flight plan containing applicable items on the ICAO flight plan form shall be filed with ATS. Requested level, route and entry/exit point shall be specified.

b) An ATC clearance shall be obtained from the appropriate ATC before entering class C airspace. The clearance may be deviated from only in an emergency situation necessitating immediate action, in which event ATC shall be notified as soon as practicable.

c) Two-way radio communication shall be maintained with the appropriate ATC on the prescribed frequency.

d) Position reports - Position and level shall be reported to ATS.

- *Before entering the class C airspace*
- *Over reporting points specified by ATS and when entering and leaving the TMA.*

e) SSR transponder, see GEN 1.5 para 3.

Danish ATS

Flight Information Service (FIS) to uncontrolled VFR traffic within airspace class G below Copenhagen TMA was in Denmark provided by Copenhagen Information.

The primary task of FISOs was to provide traffic information service to VFR flights.

Controlled VFR flights within Copenhagen TMA were controlled by Copenhagen Approach/Departure, which also handled IFR traffic within the same airspace.

A high number of training and privately operated VFR flights from EKRK used the class G airspace below Copenhagen TMA, with or without activated transponder equipment or having established two-way radio communication with an ATS unit, which did not conflict with the rules for operating within class G airspace.

According to the Danish Air navigation Service Provider (ANSP), ATCO's often observed unidentified radar tracks of aircraft – with or without mode C presentation – flying within the lateral limits of Copenhagen TMA. For aircraft using a transponder with Mode C information, both position and altitude were apparent to the ATCO, however for aircraft using a transponder with Mode A information only or no transponder at all it was not known to the ATCO whether the aircraft was within- or outside the TMA in respect of the altitude.

ATCOs had to presume that the aircraft was flying below the lower limit of the TMA, and traffic information regarding these tracks was not always issued to aircraft flying within the TMA.

Use of transponder and flight in class C airspace

The below, in extract from the Danish AIP (VFR Flight Guide), states the requirements and regulations concerning transponders and flight in class C airspace within Danish FIR.

GEN 1.5
2. VFR Flights. SSR Transponder Requirement
2.1 Aircraft performing VFR flights within Danish ATS Air Space classified C shall be equipped with SSR-transponder with 4096 codes in mode A/3 and mode C with automatic transmission of pressure altitude information (Ref. ICAO Annex 10, Volume I).

ENR 1.2 Visual Flight Rules
7. Pilot-in-command carrying out VFR flight, shall
a. when he is flying in airspace classes B, C and D
b. when he is part of aerodrome traffic on controlled aerodromes, or
c. when he is flying Special VFR.

follow the regulations concerning ATC clearances regarding adherence to flight plan, position reports, cease of control and radio communication.

ENR 1.6 Radar services and procedures
2. Secondary Surveillance Radar (SSR)
d. When the aircraft carries serviceable Mode C equipment, the pilot shall continuously operate this mode, unless otherwise directed by ATS.

2.1 Normal operating procedures
a. The provision of ICAO (PANS-OPS, Volume I, Part VIII, Secondary Surveillance Radar (SSR) Transponder Operating Procedures) will apply.

2.5 Code assignment method
b. VFR flights may be assigned an individual SSR code.
Note: Assignment of a discrete SSR code to a VFR flight does not imply that the flight will be continuously monitored by radar or that the flight has been cleared to enter airspace in which VFR flights in accordance with the Rules of the Air, ICAO Annex 2, para 3.6.1.1 shall be operated as controlled flights.

2.6 Flight plan notification
For flights within Copenhagen FIR the SSR capability shall be indicated in item 10 of the flight plan.

CO-OPeration of Air Navigation Service providers (COOPANS)

COOPANS encompasses the upgrading and harmonisation of Swedish, Irish, Austrian, Croatian and Danish ATM systems in a single unified ATM system that uses common software and entails harmonised maintenance processes and operational concepts.

See COOPANS

One feature of the COOPANS system was an automated coupling between the stored ATC flight plan of an aircraft and the radar track of the same aircraft.

At the time of the serious incident, a coupling took place when the preassigned transponder code in the stored ATC flight plan was identical to the transponder code reply presented in the radar track, and the radar track contained a Mode C altitude readout. (Other parameters of the radar reply, like a minimum speed and a position within a specified corridor, must also be fulfilled in order for the automatic coupling to occur).

The aircraft label (registration or call sign) would then be connected to the radar track of the aircraft, indicating to the ATCO that a coupling had occurred.

The ATCO had the possibility to manually perform a coupling between the radar label and the radar track without altitude readout.

<u>Rules of the Air</u>

International rules concerning collision avoidance and right-of-way between aircraft are stated in ICAO Annex 2 “Rules of the Air”, below in extract:

Chapter 3. General Rules

Part 3.2 Avoidance of collisions

Nothing in these rules shall relieve the pilot-in-command of an aircraft from the responsibility of taking such action, including collision avoidance manoeuvres based on resolution advisories provided by ACAS equipment, as will best avert collision.

Note 1.— It is important that vigilance for the purpose of detecting potential collisions be exercised on board an aircraft, regardless of the type of flight or the class of airspace in which the aircraft is operating, and while operating on the movement area of an aerodrome.

Part 3.2.2 Right-of-way

The aircraft that has the right-of-way shall maintain its heading and speed.

3.2.2.1 An aircraft that is obliged by the following rules to keep out of the way of another shall avoid passing over, under or in front of the other, unless it passes well clear and takes into account the effect of aircraft wake turbulence.

3.2.2.3 Converging. When two aircraft are converging at approximately the same level, the aircraft that has the other on its right shall give way

3.2.2.4 Overtaking. An overtaking aircraft is an aircraft that approaches another from the rear on a line forming an angle of less than 70 degrees with the plane of symmetry of the latter, i.e. is in such a position with reference to the other aircraft that at night it should be unable to see either of the aircraft’s left (port) or right (starboard) navigation lights. An aircraft that is being overtaken has the right-of-way and the overtaking aircraft, whether climbing, descending or in horizontal flight, shall keep out of the way of the other aircraft by altering its heading to the right, and no subsequent change in the relative positions of the two aircraft shall absolve the overtaking aircraft from this obligation until it is entirely past and clear.

Separation

To assess the minimum horizontal separation between aircraft A and B during the sequence of events, four different sources of information were available to the AIB:

- The recorded radar presentation of the position of the two aircraft (see appendix 2) indicating a horizontal separation of 0.0 nm.
- The onset of the TA in aircraft B (flight safety report and pilot statement).
- The recorded ATC radio communication indicating a horizontal separation of 2 nm, as reported by the pilots of aircraft B.

- Subsequent information from the pilots of aircraft B indicating a passing separation of 4-6 nm between aircraft A and B (flight safety report and pilot statement).

To assess the minimum vertical separation between aircraft A and B during the sequence of events, five different sources of information were available to AIB:

- The recorded ATC radio communication indicating an altitude of both aircraft A and B of 4,000 feet msl.
- The aircraft A recorded flight planning software program presentation of the flight indicating an altitude of 4,000 feet.
- Subsequent information from the pilot of aircraft A indicating an altitude of 4,000 feet msl (flight safety report and pilot statement).
- Subsequent information from the pilots of aircraft B indicating an altitude of both aircraft A and B of 4,000 feet msl (flight safety report and pilot statement).
- The recorded radar presentation indicating an altitude of 4,000 feet of aircraft B (see appendix 3).

<u>Error sources</u>

Through the various systems, different error sources were introduced which interacted in data processing and presentation of the horizontal and vertical position of aircraft A and B:

- Allowable aircraft altimeter tolerance.
- Transponder altitude increment reporting error.
- ATS radar data acquisition tolerances and limitations.
- ATS radar data presentation tolerances and limitations.
- AIB radar data presentation software tolerances and limitations.
- Aircraft A flight planning software data acquisition and presentation tolerances and limitations.

<u>Visual sighting of aircraft</u>

The pilot of aircraft A informed the AIB, that he observed a large aircraft approximately when aircraft A passed overhead the area of Falsterbo, and approximately at the same time when the pilot contacted Copenhagen information.

The large aircraft was positioned to the right and ahead of aircraft A, at an estimated distance of 6-7 nm and at an estimated altitude of 1,000-1,500 feet above aircraft A, flying away from aircraft A in a northerly direction.

The distance made it impossible for the pilot of aircraft A to identify the aircraft type or the operator of the large aircraft.

It was the perception of the pilot of aircraft A, that the large aircraft overtook aircraft A from a position of 7- 8 o’clock, corresponding to an angle of 30 degrees from behind at the left side.

ANALYSIS

Aircraft A transponder Mode C readout

It was not possible for the AIB to establish whether or not the transponder of aircraft A, for a part of the flight was set to Mode A only, or if the transponder was affected by a periodic failure.

However, the AIB concludes that the radar systems did not receive any Mode C information from aircraft A in the time period from departure at EKRN until after the event had happened.

The Mode C readout on the previous flight and during the latter part of the serious incident flight and the service history of the transponder from the maintenance facility indicated no technical malfunction of the transponder.

Position report and ATC clearance

According to the Swedish and Danish AIP ENR 1.2 a clearance shall be obtained from the appropriate ATC before entering class C airspace. In addition, position and level (altitude) shall be reported to ATC when entering and leaving the TMA.

During the flight at initial radio communication with Sweden Control, the pilot of aircraft A was of the opinion that he received a clearance to enter the Swedish TMA.
No subsequent position report was made by the pilot, when aircraft A entered Malmoe TMA.

The position report made by the pilot at 13:08:51 hours to Sweden Control after leaving Malmoe TMA was incomplete, as neither position nor level (altitude) was stated by the pilot.

This report was made approximately 3 minutes or 6 nm after leaving Malmoe TMA.

The transmission made by the pilot at 13:09:21 hours was sent to Copenhagen Information but should have been sent to Copenhagen Approach as aircraft A was within airspace class C controlled by Copenhagen Approach.

This transmission took place approximately 3½ minutes or 7 nm after aircraft A had entered Copenhagen TMA.

ATCO (Sweden Control)

The incorrect setting of the transponder code by the pilot of aircraft A following the initial radio call to Sweden control, may have contributed to a loss of information exchange between the ATCOs during the subsequent duty change.

As the ATCO going on duty only recalled having received information of the incorrect transponder setting of aircraft A, and not of the pilot reported altitude of aircraft A, the ATCO’s perception of the intention of the pilot of aircraft A might have been influenced.

In the opinion of the AIB, the following aspects also contributed to the ATCO’s perception of aircraft A descending and flying below the lower vertical limit of Malmoe TMA:

- No coupling of the stored ATC flight plan and the radar track occurred (connecting the aircraft label to the radar track of aircraft A).
- No Mode C readout in the radar presented track of aircraft A.
- A typical altitude profile followed by other VFR flights on a similar route.
- No position report was received from the pilot, when aircraft A entered Malmoe TMA.
- Incomplete and late position report from the pilot, when aircraft A left Malmoe TMA.

To the ATCO, aircraft A was operating as an uncontrolled VFR flight, flying below Malmoe TMA in class G airspace.

The perceived high work load by the ATCO might have necessitated a prioritising of ATC to IFR and Controlled VFR traffic comparing to ATS to uncontrolled VFR traffic.

For that reason, the ATCO did not challenge the actual operation of aircraft A.

<u>ATCO (Copenhagen Approach)</u>

No warnings of aircraft A entering Copenhagen TMA were presented to the ATCO:

- No handover from Sweden Control took place.
- No radio transmission or position report was received from the pilot of aircraft A.
- No Mode C readout in the radar presented track of aircraft A.

Even though the track of aircraft A had been observed, the ATCO perceived aircraft A to be an uncontrolled VFR flight flying below Copenhagen TMA. For that reason, no issuance of preventive traffic information concerning aircraft A was relayed to the pilots of aircraft B.

<u>FISO (Copenhagen Information)</u>

When the FISO received the initial radio call from the pilot of aircraft A, the serious incident had already occurred and no other radar presented traffic was in the vicinity of aircraft A.

The instruction from the FISO on a new transponder code and the conversation regarding the rules and regulations concerning the Copenhagen Area did not impact the sequence of events.

However to the AIB, the pilot's decision to contact Copenhagen Information instead of Copenhagen Approach indicated a lack of situational awareness.

Altitude of aircraft A

Several recorded radio transmissions to ATC (Sweden Control and Copenhagen Approach) and FIS (Copenhagen Information) and subsequent statements by the pilots of both aircraft A and B, confirmed in the opinion of the AIB that aircraft A was flying at or close to an altitude of 4,000 feet msl at the time of the serious incident.

The flight planning software program presented aircraft A at an altitude of 4,000 feet at the time of the serious incident.
See appendix 4.

Certain altitude spikes seemed to be exaggerated, whenever the aircraft changed altitude.

During the portion of the flight, where the aircraft altitude was presented as level (maintaining same altitude), the credibility of the presentation increased and held in the opinion of the AIB a higher validity to support other altitude data sources.

However, the suspected dive initiated at 13:08:15 (see "Speed change of aircraft A" below) is hardly presented, which decreases the credibility of the presentation.

Altitude deviance

Although both aircraft A and B apparently were maintaining an altitude of 4.000 feet msl during the sequence of events, an undefined altitude deviance might have been introduced through a number of sources:

- Aircraft altimeter system tolerance (aircraft A and B)
- Autopilot system tolerance (aircraft B)
- Pilot manual flight control tolerance (aircraft A)

The magnitude of altitude deviation that was, or might have been, introduced through the above sources is unknown to the AIB.

However, it seems likely that the pilot manual flight control of aircraft A might have been influenced by the pilot's diverted focus in combination with the reported light turbulence conditions that prevailed during the flight.

In the opinion of the AIB, aircraft A more likely deviated from 4.000 feet msl and to a larger extent, than aircraft B which was controlled by the autopilot.

Horizontal separation between aircraft A and B during the sequence of events

The pilots of aircraft B reported to ATC, shortly after the serious incident, a minimum horizontal separation of 2 nm between aircraft A and B.

In the subsequent statements from the pilots of aircraft B, the minimum horizontal separation was reported to be 4-6 nm.

The AIB has no explanation for the discrepancy of the reported separation distances by the pilots of aircraft B.

The TCAS TA, which was presented to the pilots of aircraft B, did in the opinion of the AIB occur, when aircraft B was approximately 2 nm behind aircraft A.

At that moment, aircraft B was overtaking aircraft A almost directly from behind with approximately 175 knots.

With a speed of 175 knots, it took approximately 40 seconds for aircraft B to overtake aircraft A, which corresponded to the time period used by the TCAS logic in TA assessments (predicted CPA within 40 seconds).

From a position of 40 seconds of flight time before the two aircraft radar presented flight tracks crossed, both aircraft flight tracks were steady and converging at an angle of approximately 25 degrees towards a position approximately 3 nm miles ahead of aircraft B.

The radar presented horizontal position of Aircraft A relative to aircraft B during 13:07:15 – 13:07:43 hours, was 14 degrees (+/- 1 degree) to the right of the track of aircraft B.

This made aircraft A appear as an almost static object in the horizontal plane as observed from aircraft B.

As a static object is harder to detect for the human eye than a moving object, a pilot, who loses visual contact with a "static" aircraft, usually finds it harder to re-establish visual contact with such an aircraft than with a "moving" aircraft.

The AIB radar data software presented horizontal separation between aircraft A and B of 0.0 nm (Appendix 2) indicated a separation of less than 0.05 nm, as a separation of 0.05 nm to 0.149 nm would have been presented as 0.1 nm.

The ATC radar horizontal presentation (Appendix 3) showed a partial overlap of the aircraft.

Total separation during the sequence of events

The AIB finds it likely that aircraft A and B passed each other in close proximity and with a risk of collision.

Even though, the objective data (radar presentation and TCAS TA) in the opinion of the AIB had a higher credibility than the subjective data (pilot perception of distance and altitude), the different sources of possible deviance in objective data acquisition and processing, and in aircraft control (human and autopilot) must be taken into account.

It was not possible for the AIB to estimate the magnitude of introduced deviance, as the different sources in relation to each other might either have increased or decreased the total separation between aircraft A and B.

Pilots of aircraft B

According to the "Rules of the Air" described in ICAO Annex II, aircraft B should give way to aircraft A, and if necessary take avoiding action.

No avoiding action was taken by the pilots of aircraft B, which might have been caused by:

- The pilots of aircraft B did not expect the presence of uncontrolled VFR traffic within the TMA.
- The object that the pilots of aircraft B initially visually identified as aircraft A, at a distance of 8 nm, might have been another aircraft invisible to the ATC radar, and not aircraft A.
- Aircraft B overtook aircraft A almost directly from behind. The size of aircraft A might have been difficult to assess until the two aircraft were very close to each other.
- For reasons unknown to the AIB, the pilots of aircraft B lost sight of aircraft A during the sequence of events – and were unable to re-establish visual contact with aircraft A, possibly due to the "static" appearance of aircraft A.

On the basis of the available data, which were partly contradictory, the AIB cannot conclude with certainty, why the pilots of aircraft B did not make an avoiding action. Taking into consideration the likely initial sighting of aircraft A at a distance of 8 nm flying at the same altitude as aircraft B and the subsequent TA, an avoiding action seemed appropriate.

However, it is possible that the pilots lost sight of aircraft A during the sequence of events and subsequently were unable to re-establish visual contact with aircraft A in time to take avoiding action.

Pilot of aircraft A

The less than optimum situational awareness of the pilot of aircraft A might be linked to the pilot's limited total flying experience of 52 hours of flight time.

To the AIB, this influenced the sequence of events at two specific points of the flight:

- The pilot's perception of the radio communication with Sweden Control, incorrectly led him to believe that he had received a clearance to enter Malmoe TMA at 4,000 feet.

  Even though, the radio communication seemed unambiguous to the AIB, and did not include "request", "clearance", "transition", "Malmoe" or "TMA" the pilot of aircraft A most likely anticipated that he would receive a clearance before he contacted Sweden Control.

  The issuance of a transponder code, in addition to the anticipated transmission of altitude information by the aircraft transponder, was in the opinion of the AIB an unconsciously valid substitute for a correctly phrased clearance to the pilot.

- The mental workload of dealing with a sick passenger and flying the aircraft safely was higher than the pilot was able to handle simultaneously. As a consequence, the attention of the pilot was not focused on the primary tasks of flying (navigating and communicating).

Additionally, the pilot's experience with the flight planning software program was limited. This might have influenced the pilot's cognitive capability in regard to extracting navigational information.

The pilot of aircraft A did not observe aircraft B until after the sequence of events.

This might be due to:

- The ambient noise level inside the cockpit of aircraft A.
- The confusion in the cockpit of aircraft A due to the passenger being sick.
- The pilot of aircraft A was looking inside and downwards in the cockpit.
- A larger horizontal separation between aircraft A and B than presented in Appendix 2 and 3, as a result of radar data system acquisition and processing introduced errors.
- An aircraft altimeter and autopilot system tolerance introduced an unknown altitude difference between aircraft A and B.
- An unnoticed pilot induced altitude deviation from 4.000 feet msl.
- The light turbulence "blanked out" any disturbance caused by the passage of aircraft B, e.g. wake turbulence.
- A combination of some or all of the above.

Speed change of aircraft A

The increase in speed from 110 knots to 150 knots initiated at13:08:15 hours seemed to be the outcome of a rather abrupt dive of aircraft A, as such a speed was unattainable in level flight.

This coincided with the pilot's statement regarding the circumstances.

It was not possible for the AIB to establish whether or not the passage of aircraft B influenced the dive.

The estimated position and altitude of the visually sighted large aircraft in relation to aircraft A by the pilot of aircraft A, did in the opinion of the AIB make it highly likely that the large aircraft was identical to aircraft B. No other aircraft was ATS radar presented in the area in a radius of up to 10 nm around Falsterbo at the time of observation.

Meteorological conditions

The forecasted and reported visibility did in the opinion of the AIB not have any negative influence on the sequence of events.

Airspace

The airspace structure surrounding the airports of Copenhagen and Malmoe was complex, and the frequency of VFR flights in and around the area was high.

The differences in provided ATS by Sweden Control, Copenhagen Approach/Departure and Copenhagen Information might not have been transparent to all VFR pilots, taking into account the different experience levels of these pilots.

The dual function of Sweden Control (ATC and FIS), compared with the single function of Copenhagen Approach/Departure (ATC) and Copenhagen Information (FIS), may in the opinion of the AIB have presented an unfamiliar and in-transparent ATS environment to the pilot of aircraft A.

This might have led to a misperception of the level of provided ATS for the pilot of aircraft A.

However, in the opinion of the AIB, neither the dual function of Sweden Control nor the single functions of Copenhagen Approach/Departure or Copenhagen Information were safety issues.

CONCLUSIONS

Findings

1. During the sequence of events, ATC and TCAS of aircraft B did not receive Mode C information from the transponder of aircraft A.
2. The total flying experience of the pilot of aircraft A was low.
3. The pilot of aircraft A perceived that he had received a clearance to enter and cross Malmoe TMA at 4,000 feet msl.
4. The pilot of aircraft A did not transmit position reports to ATC in accordance with the Swedish and Danish AIP ENR 1.2.
5. The airspace structure surrounding the airports of Copenhagen and Malmoe airports was complex.
6. The dual functions of Sweden Control (ATC and FIS) compared to the single functions of Copenhagen Approach/Departure (ATC) and Copenhagen Information (FIS) presented an unfamiliar ATS setup to the pilot of aircraft A.
7. Due to the passenger becoming sick, the focus of the pilot of aircraft A was diverted from flying the aircraft.
8. The confusion in the cockpit of aircraft A delayed the pilot's execution of the planned descent and flight below Copenhagen TMA.
9. Unauthorised, Aircraft A penetrated Copenhagen TMA.
10. A seemingly misperception by the pilots of aircraft B of the horizontal separation influenced their decision on not making an appropriate avoiding action.
11. In regard to aircraft A, the high frequency of unidentified VFR flights within the lateral limits of Copenhagen and Malmoe TMA, influenced the decision making of the ATCOs in Sweden Control and Copenhagen Approach/Departure.

Factors

1. During the sequence of events, ATC and TCAS of aircraft B did not receive mode C information from the transponder of aircraft A.
2. Due to the passenger becoming sick, the focus of the pilot of aircraft A was diverted from flying the aircraft.
3. Unauthorised, aircraft A penetrated Copenhagen TMA.
4. A seemingly misperception by the pilots of aircraft B of the horizontal separation influenced their decision on not making an appropriate avoiding action.

Summary

The pilot's diverted focus (aircraft A) combined with the lack of mode C altitude information (aircraft A) resulted in an unauthorized penetration of controlled airspace (Copenhagen TMA).

The lack of mode C altitude information (aircraft A) reduced the effect of available preventive safety barriers (ATC and TCAS) and thereby compromised flight safety.

A seemingly misperception by the pilots of aircraft B of the horizontal separation influenced their decision on not making an appropriate avoiding action.

<u>Preventive actions</u>

As a result of the serious incident the below listed preventive actions have been introduced:

- The Danish and Swedish ANSPs introduced the Prefix speed “N” in the ATCO presented radar label of aircraft using Mode A transponder function only, in order to prevent that the aircraft altitude indication was mistaken for the aircraft speed indication.
- The Danish and Swedish ANSPs and the joint subsidiary of the Danish and Swedish ANSPs met with the Swedish Transport Agency and the Danish Transport Authority in order to conduct an information campaign regarding airspace rules and regulations for VFR pilots.
- The joint subsidiary of the Danish and Swedish ANSPs reviewed the EUROCONTROL initiative “European Action Plan for Airspace Infringement Risk Reduction”, in order to secure that “Best Practices” were adhered to.
- The Danish and Swedish ANSPs implemented Airspace Intrusion Warning (AIW) on January 22nd 2015 which was a ground (radar) based tool, with the purpose to warn the controller about an unauthorized penetration of a defined airspace volume. One critical input to this system was the aircraft transponder transmitting Mode C information. If the system predicted an eminent threat of intrusion or an actual intrusion was detected, an alarm was presented to the controller.

<u>Suggestions by the AIB</u>

The investigation of the serious incident did not result in any recommendations being made by the AIB.

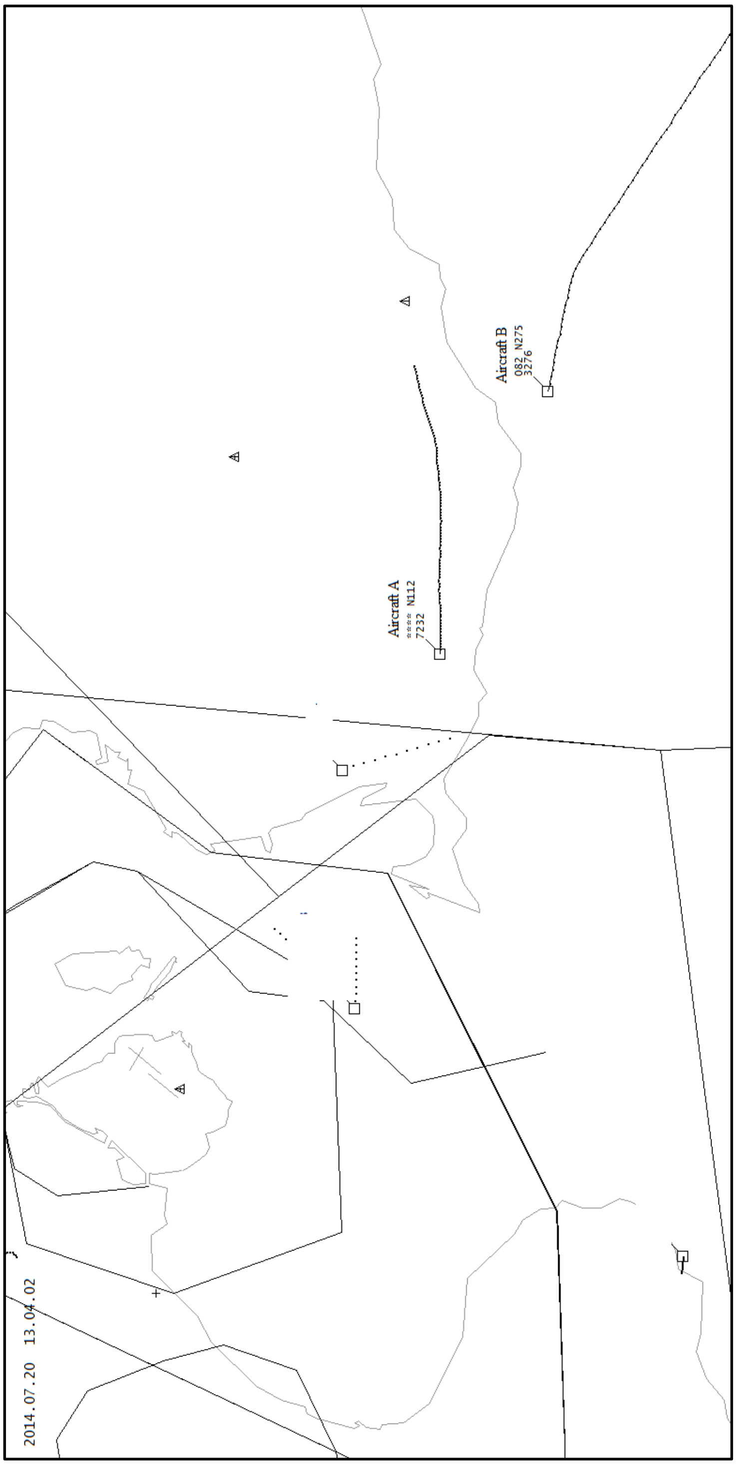
However, the AIB would like to encourage:

- VFR pilots to conduct the enroute part of their flight according to published VFR cruising levels, e.g. 3.500 or 4.500 feet, even when flying below transition altitude (TA).
- VFR pilots to at any time during flight activate the Mode C function of the aircraft transponder (if so equipped).
- All pilots to take into account the ICAO *“Rules of the air”, Chapter 3 “General Rules”* during all phases of flight.

APPENDICES

Appendix 1

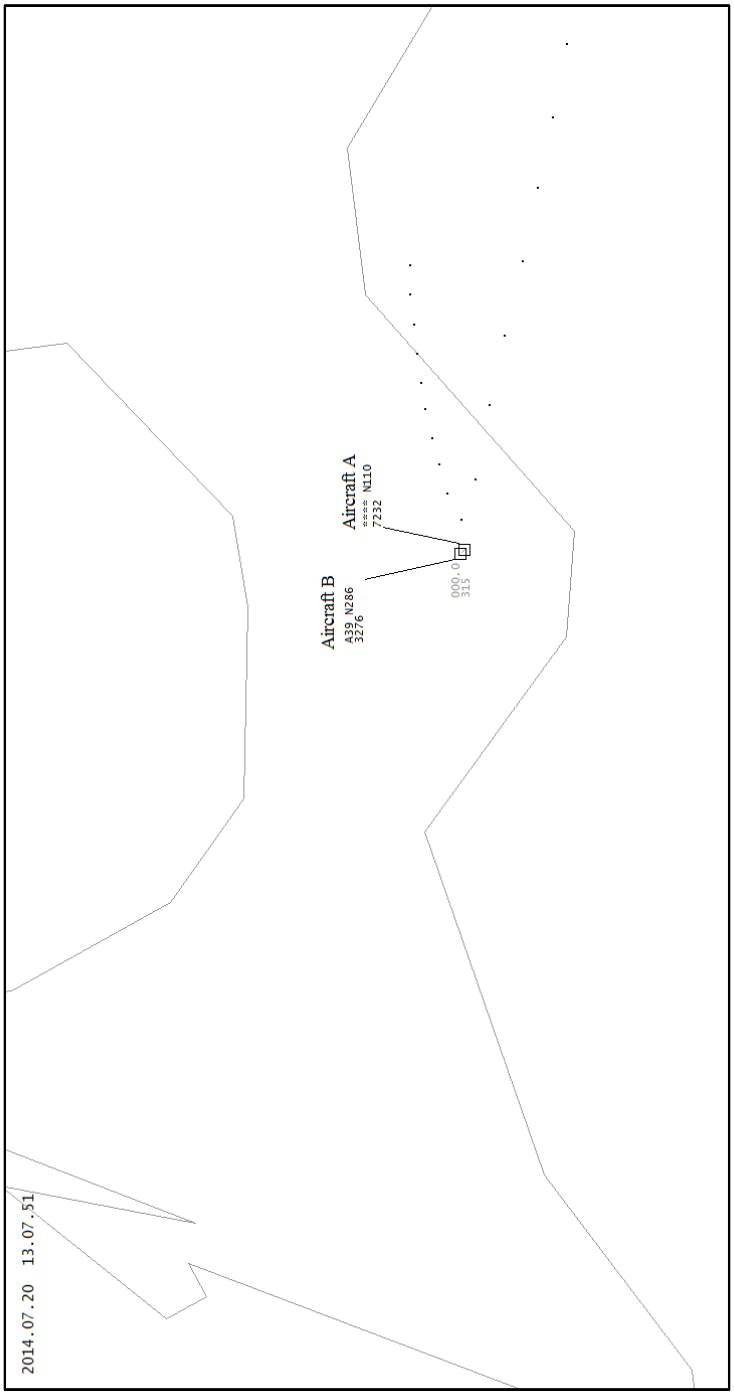
Radar presentation 13:04:02 UTC (AIB software generated presentation).



<u>Appendix 2</u>

Radar presentation 13:07:51 UTC “Horizontal separation” (AIB software generated presentation).

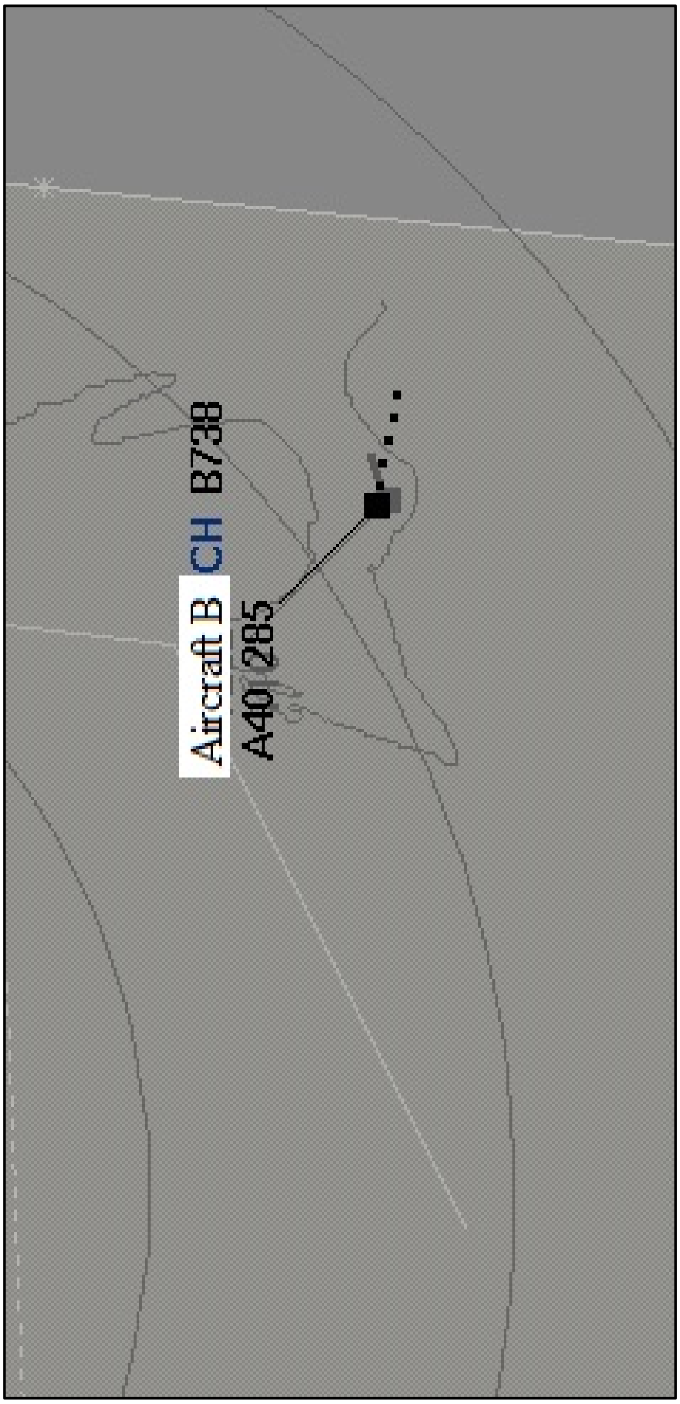
The radar presented horizontal separation and position of aircraft A and B were valid.
However, due to a technical feature of the software used by the AIB for the presentation, the altitude of Aircraft B is indicated as A39 and not A40.



Appendix 3

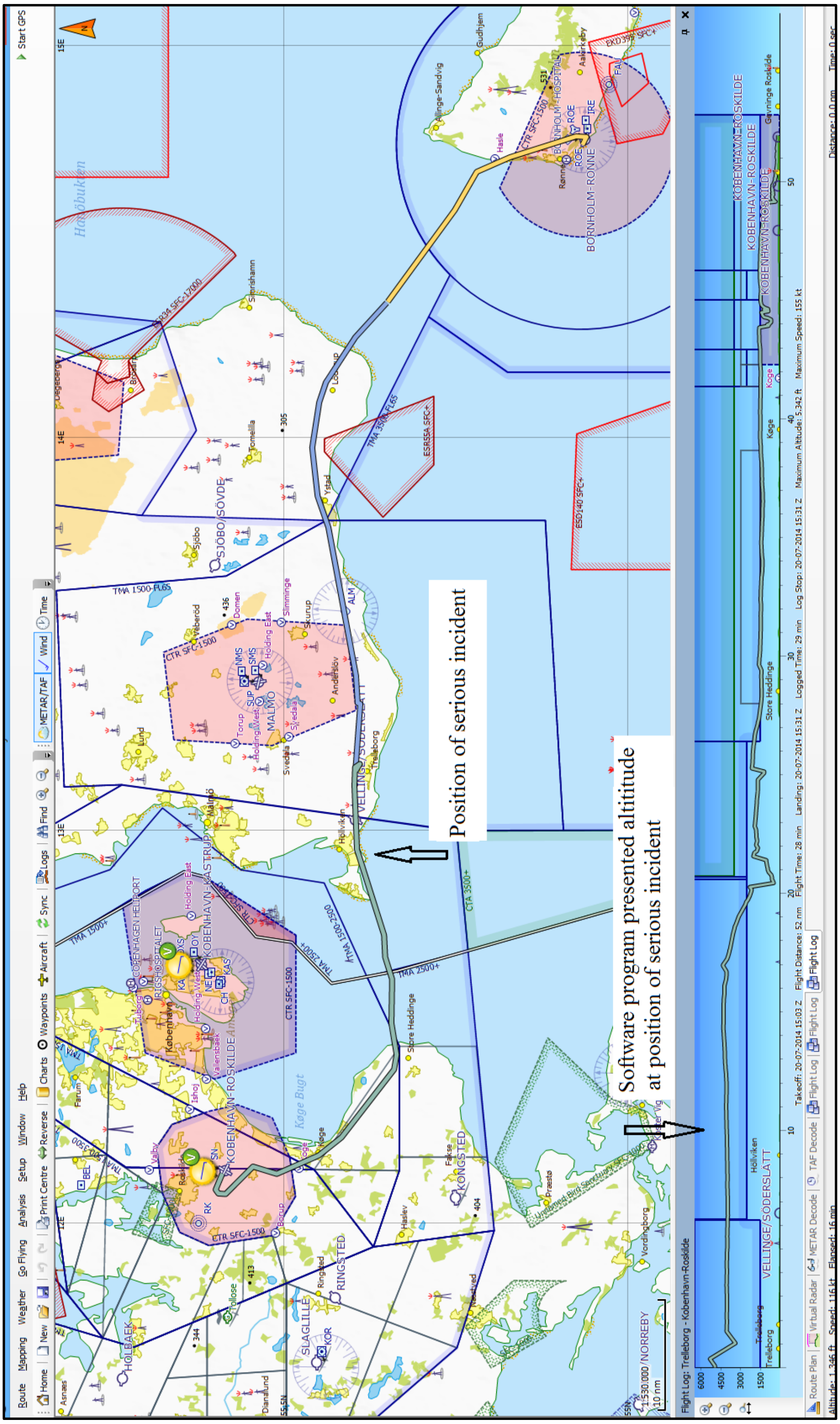
Radar presentation 13:07:50 UTC “Altitude of Aircraft B”.

The radar presentation is identical to the actual ATCO radar presentation at Copenhagen approach. The altitude of Aircraft B was presented as A40.



Appendix 4

Flight planning software program presentation of track and altitude of Aircraft A



Appendix 5

VFR Aeronautical Chart (“Paper chart”)