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Swedish Accident Investigation Board

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Serious incident between two aircraft LN-RRN and OH-LBT in the airspace southwest of Östersund, Jämtland county, on 2 July 2010

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

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Statens haverikommission
Swedish Accident Investigation Board

Swedish Transport Agency

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Final report RL 2012: 01e

The Swedish Accident Investigation Board (Statens Haverikommission – SHK) has investigated an incident that occurred on 2 July 2010 in the air-space southwest of Östersund, Jämtland county, between two aircraft with the registrations LN-RRN and OH-LBT.

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

On behalf of the Board

Göran Rosvall	Nicolas Seger
Chairperson	Investigator in Charge

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APPENDIX

1 Visualization ATV3D.

SHK. RL 2012_01 bilaga 1.mp4.mp4

General

The Swedish Accident Investigation Board (SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended so far as possible to determine both the sequence of events and the cause of the events, along with the damage and effects in general. An investigation shall provide the basis for decisions which are aimed at preventing similar events from occurring again, or to limit the effects of such an event. At the same time, the investigation provides a basis for an assessment of the operations performed by the public emergency services in respect of the event and, if there is a need for them, improvements to the emergency services.

SHK accident investigations try to come to conclusions in respect of three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any inspection remit, nor is any part of its task to apportion blame or liability concerning damages. This means that issues concerning liability are neither investigated nor described in association with its investigations. Issues concerning blame, responsibility and damages are dealt with by the judicial system or, for example, by insurance companies.

The task of SHK does not either include as a side issue of the investigation that concerns emergency actions an investigation into how people transported to hospital have been treated there. Nor are included public actions in the form of social care or crisis management after the event.

The investigation of aviation incidents is primarily governed by the 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 to the Chicago Convention.

The investigation

SHK was notified on 2 July 2010 of a loss of separation between two aircraft with registrations LN-RRN and OH-LBT that occurred at about 11,000 metres altitude southwest of Östersund, Jämtland county, on the same day at 12:15 hrs.

The incident has been investigated by SHK as represented by Ms Åsa Kastman Heuman, Chairperson until 11 January 2011 and thereafter Mr Göran Rosvall; Mr Stefan Christensen, investigator in charge until 15 August 2011, and thereafter Mr Nicolas Seger and Ms Pia Jacobsson, Human and Organizational Factors (HOF) analyst.

SHK has been assisted by Ms Gerd Svensson as HOF expert from 10 March 2011 and by Mr Lars Hedlund as expert in the field of air traffic control until 25 September 2011 and thereafter Mr Bengt Persson.

The investigation has been followed by the Swedish Transport Agency through Mr Lars Hedblom until 30 March 2011 and Ms Liselotte Landqvist Jacobsen from 19 August 2011.

Abbreviations and explanations

ACC	Area Control Center
AIP-ENR	Aeronautical Information Publication-En Route
ANS	Air Navigation Services
AOR	Area Of Responsability
Assume	Assume
ATCC	Air Traffic Control Centre
ATPL	Airline Transport Pilot License
ATS	Air Traffic Service
CARD	Conflict And Risk Display
EC	Executive Controller
ESOS	Air Traffic Control's designator for Stockholm ATCC
FIR	Flight Information Region
FLEG	Flight Leg
Flygnivå	FL Flight Level
IFR	Instrument Flight Rules
Irregular	Irregular
LFV	LFV
MTCD	Medium Term Conflict Detection
HOF	Human Organizational Factors
PC	Planner Controller
PRL	Prediction Line
RA	Resolution Advisory
SEP tool	Separation Tool
STCA	Short Term Conflict Alert
TA	Traffic Advisory
TCAS	Traffic alert and Collision Avoidance System
TMC	Terminal Control
TS-A	Tactical Supervisor ACC
UIR	Upper Information Region
UTA	Upper Control Area
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

Aircraft: registration, type	SAS 4083: LN-RRN, B737-700 FIN 2414: OH-LBT, B757-200
Class	Both normal
Operator	SAS 4083: SAS FIN 2414: Finnair
Time of occurrence	02/07/2010,12.15 in daylight Note: All times refer to Swedish summer time (UTC+ 2 hours)
Place	Airspace approximately 60 nm southwest of Östersund, Jämtland County, (position 6231N 01249E; 11,000 m above sea level)
Type of flight	Commercial scheduled flight
Weather	VMC, good visibility
Persons onboard LN-RRN:	
crewmembers	5
passengers	152
Persons onboard OH-LBT:	
crewmembers	7
passengers	220
Injuries to persons	None
Damage to aircraft	No damage
Other damage	No damage
Crew LN-RRN	
Commander LN-RRN:	
Age, licence	45, ATPL
Total flying time	14,560 hours, of which 4,460 hours on type
Flying hours previous 90 days	197 hours, all on type
Number of landings previous 90 days	65
Co-pilot LN-RRN:	
Age, licence	45, ATPL
Total flying time	11,000 hours, of which 2,100 hours on type
Flying hours previous 90 days	160 hours, all on type
Number of landings previous 90 days	90
Crew OH-LBT	
Commander OH-LBT:	
Age, licence	43, ATPL
Total flying time	12,642 hours, of which 2,692 hours on type
Flying hours previous 90 days	121 hours, all on type
Number of landings previous 90 days	11
Co-pilot OH-LBT:	
Age, licence	44, ATPL
Total flying time	5,428 hours, of which 1,884 hours on type
Flying hours previous 90 days	101 hours, all on type
Number of landings previous 90 days	11

Summary

The flights SAS 4083 and FIN 2014 were cruising on intersecting tracks at the same flight level southwest of Östersund. The air traffic controls monitoring aids, functions, tools and safety nets were not used and noticed in due time, which led to a loss of separation between the aircraft. The onboard based collision warning systems were activated and the crews in respective aircraft performed avoidance manoeuvres.

LFV, which is the public entity in charge of the air traffic control in the area, has taken actions after the serious incident which includes future changes in the air traffic control system with a more pronounced safety net and certain reinforcements in the manning of air traffic controllers in the current area.

Recommendations

None.

1. FACTUAL INFORMATION

1.1 History of the flights

Scandinavian (SAS) 4083 with registration LN-RRN was en route from Evenes to Oslo, both in Norway. The aircraft had a heading of 200 degrees at flight level 360, equivalent to approximately 11, 000 metres. Finnair (FIN) 2014 with registration OH-LBT had started in Toronto, Canada, and was en route to Helsinki, Finland, at the same altitude with a heading of 100 degrees.

During the incident both aircraft were in contact with the air traffic controller in sector N/K of the Stockholm air traffic control centre (ESOS ATCC). The working position had been handed over about ten minutes before the incident. The previous air traffic controller had been informed by air traffic control in Bodö that Finnair had been cleared to point TOGMI at flight level 360, which is an irregular cruising altitude for the magnetic track in question. The air traffic controller who took over responsibility for sector N/K was informed about the traffic situation by the colleague who was replacing him, and the overall assessment was that the aircraft would not come into conflict with each other. When the handover was completed the radar label for FIN 2014 was correlated with its radar symbol. There was no marking or note made that the aircraft was on the wrong semicircular level.

At 12:11:43 the air traffic controller confirmed radar contact with FIN and confirmed its radar label by performing an "assume". One of the air traffic control tools used to view a flight’s future flight path, conflict and risk display (CARD), showed a red mark for the anticipated conflict. At 12:14:50 the ATC radar database warning system (STCA) alerted the conflict, which means that a red frame was lit around the labels of the two aircraft on the radar screen. Approximately 30 seconds later the air traffic controller called FIN with instructions to immediately descend to a lower flight level, which was not answered. At 12:15:30 SAS was called with the instruction to climb to flight level 370, which was answered immediately.

At 12:15:56 the TCAS warning system activated a control command (RA) in both aircraft. The crews followed the instructions, which meant that SAS continued the initiated climb and FIN descended. The least separation between the two aircraft was 4.9 nautical miles (nm) and 500 feet, 4 nm and 900 feet and 3.1 nm and 1000 feet.

The incident occurred at position 6231N 01249E at 11,000 m above sea level.

1.2 Injuries to persons

None.

1.3 Damage to aircraft

No damage.

1.4 Other damage

No damage.

1.5 Crews and air traffic control personnel

1.5.1 Commander SAS 4083

The commander was 45 at the time and had a valid ATPL.

Flying time (hours)				
Previous	24 hours	7 days	90 days	Total
All types	–	–	–	14 560
Current type	6	21	197	4 460

Number of landings, current type, previous 90 days: 65.
Type rating was completed on 18 January 2006.
Latest PC (proficiency check) took place on 20 July 2010 on the current type.

1.5.2 Co-pilot SAS 4083

The co-pilot was 45 at the time and held a valid ATPL.

Flying time (hours)				
Previous	24 hours	7 days	90 days	Total
All types	–	–	–	11 000
Current type	5	11	160	2 100

Number of landings, current type, previous 90 days: 90.
Type rating was completed in 2002.
Latest PC took place in January 2010 on current type.

1.5.3 Commander FIN 2414

The commander was 43 at the time and held a valid ATPL.

Flying time (hours)				
Previous	24 hours	7 days	90 days	Total
All types	–	–	–	12 642
Current type	8	25	121	2 692

Number of landings,current type, previous 90 days: 11.
Type rating was completed on 16 December 2005.
Latest PC took place on 11 May 2010 on current type.

1.5.4 Co-pilot FIN 2414

The co-pilot was 44 at the time and held a valid ATPL.

Flying time (hours)				
Previous	24 hours	7 days	90 days	Total
All types	-	–	–	5 428
Current type	8	29	101	1 884

Number of landings, current type, previous 90 days: 11.
Type rating was completed on 21 March 2007.
Latest PC took place on 28 January 2010 on current type.

1.5.5 Pilots’ duty schedules

The pilots’ duty schedules and rest times were within the prescribed limits.

1.5.6 Air traffic controller’s schedule

The air traffic controller had long experience and full authorization in Group Z, comprising sectors 4, F, K, and N.

The air traffic controller began his morning shift at 07:00 to work until 15:00. The shift was preceded by three evening shifts between 14:30 and 22:30 and before that one day shift. During the evening shifts and the morning shift the air traffic controller worked in operations. The air traffic controller was off work for three days before the working week in question.

Since the end of 2009 the air traffic controller had worked half the time with operations and half the time with administration in the support group. During the break that preceded the position handover, he participated in an informal meeting on issues that had arisen within his administrative area of duties.

During a period prior to the incident unexpected events had occurred within the area that the controller was responsible for in his administrative capacity, a fact which emerged in the LFV investigation of the incident. Operational shifts had been replaced by administrative shifts and according to the air traffic controller there was a lot of administrative work during operational working days too. The air traffic controller stated that he had previously been stricter in separating the two tasks, but that information was increasingly coming in that he felt forced to deal with during breaks, despite his intentions to use breaks for rest.

According to the group manager, the air traffic controller had worked 54 hours of overtime during the year up to the incident. However, this overtime work was not in connection with the shift or the working week in question.

Single manning in the position

Sectors K and N (see also section 1.12.3) were combined and manned by one air traffic controller working alone, responsible for the duties of an air traffic controller in E position (EC) and an air traffic controller in P position (PC). The PC position is opened at a specified level of traffic or according to the assessment of the tactical supervisor for the area control service (TS-A) or EC, in accordance with the air traffic service operations manual for the Stockholm air traffic control centre (see 1.17.2).

At the time when the air traffic controller was on duty the assessment was made that the traffic situation was not such that the PC position needed to be opened. The air traffic controller has stated that it would have made things easier for him if the PC position had been opened, since he then would have been able to see the entire sector and what was on its way into the sector.

1.6 Aircraft information

1.6.1 Airworthiness and maintenance

SAS 4083	
TC holder	The Boeing Company
Type	Boeing 737-700
Serial number	30191
Year of manufacture	1999
Gross mass	Maximum authorized take-off/landing mass 61,688 kg/58,059kg, actual 57,504 kg
Total flying time	22,274 hours
Number of cycles	25 248
FIN 2014	
TC holder	The Boeing Company
Type	Boeing 757-200
Serial number	28170
Year of manufacture	1998
Gross mass	Maximum authorized take-off/landing mass 115,666 kg/95,245 kg, actual 87,000 kg

Total flying time	51,260 hours
Number of cycles	12 220

The aircraft had Certificates of Airworthiness and valid Airworthiness Review Certificates (ARC[1]).

1.6.2 *Accessibility and utility of TCAS*

Both aircraft were equipped with a collision warning system called TCAS. The system is airborne and works entirely without ground based stations. TCAS works by a transponder in the aircraft sending an interrogation signal to all aircraft in the vicinity. Aircraft that have a transponder receive the interrogation and respond with a message that is received by the direction-sensitive antennae of the interrogator. With the aid of this signal, the system then calculates the distance and relative bearing to the respondent aircraft and, if altitude information is received, their relative altitudes. The information received is then presented to the receiver on a display in the cockpit. The system also calculates how close the passage between the different aircraft will be and indicates with a Traffic Advisory (TA) which aircraft may constitute a threat. If a potential threat continues to approach according to certain criteria, the TCAS issues a control command, a Resolution Advisory (RA). These control commands operate in the vertical direction, i.e. the pilot receives a command to change altitude.

1.7 Meteorological information

Weather according to the analysis provided by the Swedish Meteorological and Hydrological Institute (SMHI):

Wind at flight level 360 west to northwest 50 knots, visibility >10 km, no clouds at flight level 360 but 1-2/8 cirrus at slightly lower levels.

1.8 Aids to navigation

Usual navigation methods were used and operated as intended.

1.9 Radio communications

Audio transcript ESOS ATCC, sector N/K, 02/07/2010

Time	From	
12:11:43	**FIN**	Radar good afternoon, Finnair 2414 flight level 360
	Air traffic controller (ATC)	Finnair 2414, Sweden, radar contact
12:15:21	**ATC**	Finnair 2414 descend now to flight level 250
12:15:29	**ATC**	Scandinavian 4083 climb to flight level 370
	SAS	Climbing to flight level 370 Scandinavian 4083
12:15:38	**ATC**	Finnair 2414 descend now to flight level 350, traffic above
12:15:45	**ATC**	FIN2414 descend now to FL 350, traffic to your left
	FIN	OK now to 350, Finnair uhh
	TCAS	Descend
12:16:05	**ATC**	SAS4083 traffic to your right
		SAS4083 traffic to your right, uhh, distance two
	SAS	Yeah, we did get a resolution advisory on TCAS

[1] ARC - Airworthiness Review Certificate

	ATC	Thank you
12:16:20	**FIN**	FIN2414, we have TCAS RA
	ATC	2414, thank you
	?	A bit too close with
12:17:00	**ATC**	Can I have relief here, I just had a loss of separation OK
12:17:12	**FIN**	FIN2414, do you want us to resume FL360?
	ATC	2414, yeah you can resume, clear of traffic
	FIN	OK, leave 350 climbing 360 now, Finnair 2414
12:17:45	**ATC**	SAS4083, descend now to FL360, clear of traffic
	SAS	Descending now to FL360, clear of traffic...

1.10 Aerodrome data

Not relevant.

1.11 Flight recorders

Not relevant.

1.12 Location of incident/Airspace

1.12.1 Location of the incident

The loss of separation occurred in controlled airspace 60 nautical miles southwest of Östersund.

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 air traffic 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 upper control area SUECIA UTA. Swedish airspace is also divided into airspace classes. 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 1,000 feet vertically.

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. Airspace in Sweden's FIR is divided into areas of responsibility, AOR, as regards air traffic control services. The area of the incident was part of two combined sectors N/K, which were included in AOR OS01 and which were monitored by the part of ATCC Stockholm called ACC (see figs. 1 and 2 below).

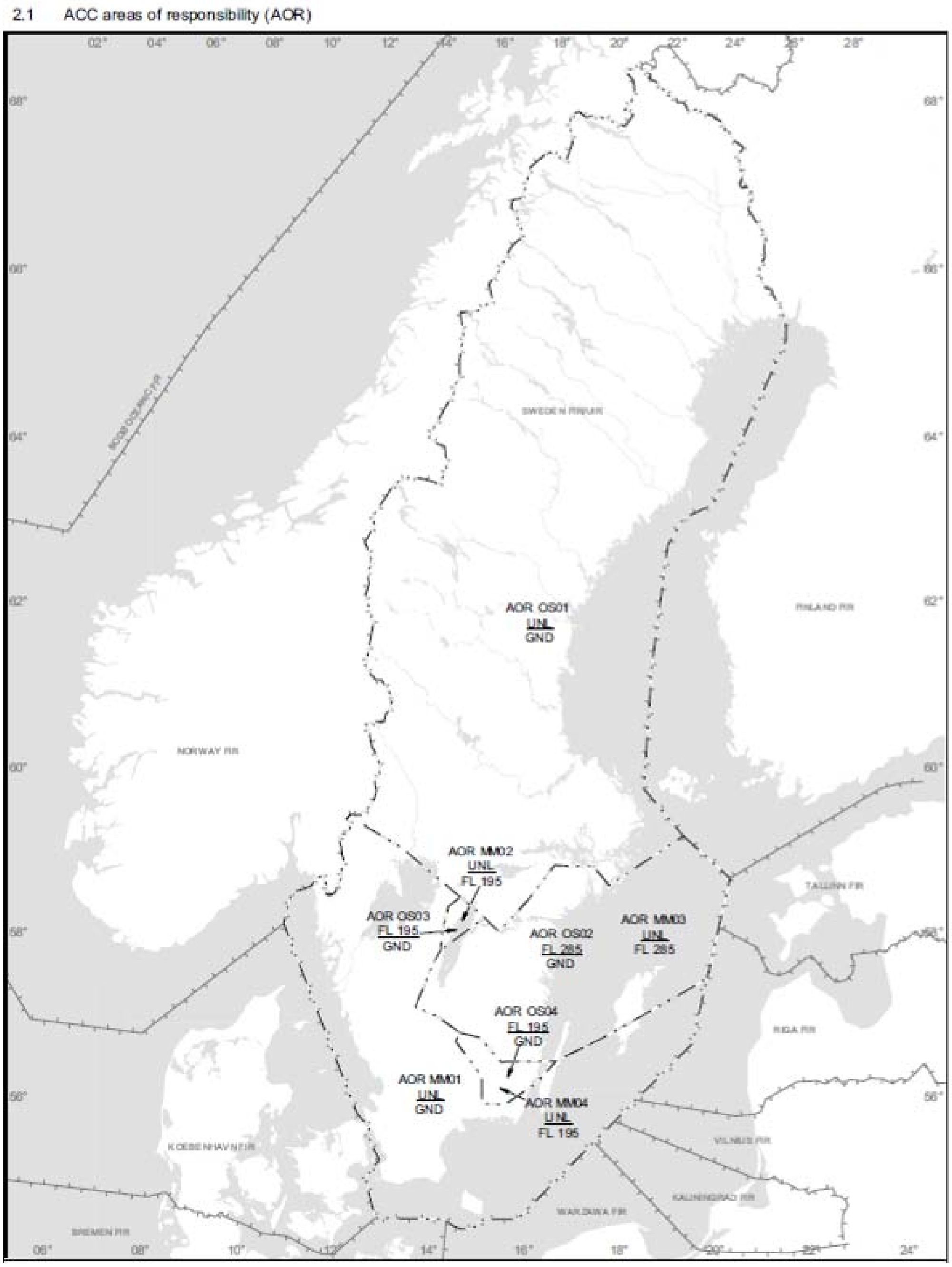

Figure 1. Areas of Responsibility in Swedish airspace.

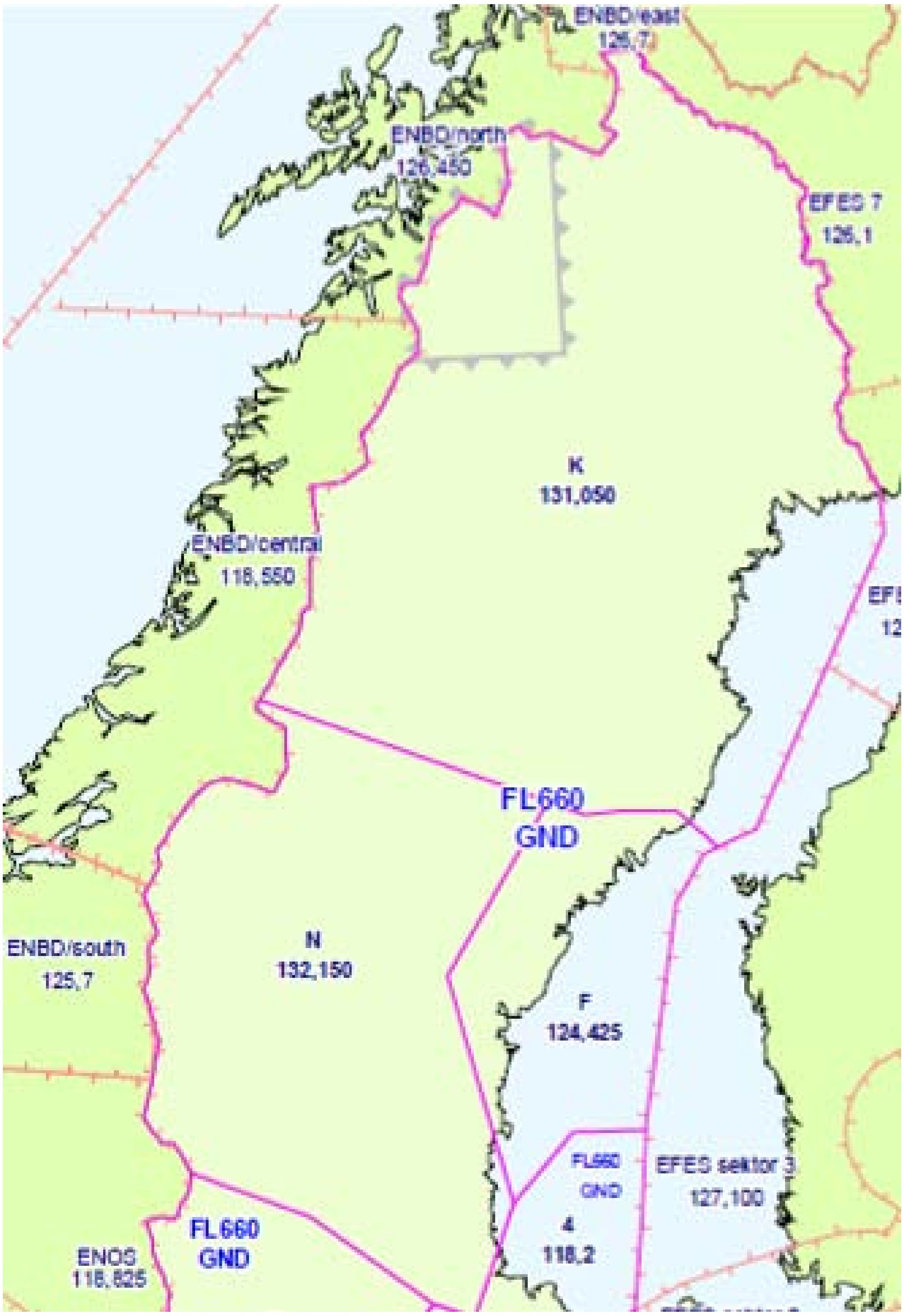

Figure 2. Sectors N and K in AOR OS.

According to the aviation information publication AIP ENR 1.3, the following applies to IFR flight in SUECIA UTA: "To facilitate air traffic control services, flights in SUECIA CTA/UTA shall be planned along published ATS flight paths whenever reasonable. When the traffic situation permits, ATC may issue clearance for a shorter route than the flight planned and/or assigned to the aircraft in the previously issued clearance."

In Ch. 4 Section 6 of the Swedish Transport Agency regulations on traffic rules for aircraft (TSFS 2010:145) the following is prescribed: "For IFR flights in controlled airspace, cruising levels must be selected in accordance with the tables in Annex 6. This also applies to levels selected for the application of cruise climb technique. The conformity between the flight level and the magnetic track as described in the table shall not be observed if otherwise specified in the clearance or in the national AIP. "

AIP ENR 1.7-2 states that the flight at cruise levels shall be in accordance with the table for semicircular flight levels (see figure 3 below).

ANS operations manual part 3, section 2, ch. 2 states that: "flight levels to be assigned to controlled flights over transition altitude shall (with the following exceptions) be selected from those applicable in accordance with BCL-T Annex C (see table below). Exception 1: this conformity between altitudes and magnetic track may be disregarded if others are appropriate or necessary for traffic management reasons, or if others are published in the AIP or AIP-SUP."

ENR 1.7-2 07 JUN 2007 AIP SWEDEN/SVERIGE

3 Marschhöjder

Om inte annat angivits skall flygning på marschhöjd ske i enlighet med denna tabell.

3 Cruising levels

Unless otherwise instructed cruising level shall be selected in accordance with this table.

	Magnetisk färdvinkel/Magnetic track			
	000°– 179°		180°– 359°	
	IFR-flygning /IFR flight	VFR-flygning /VFR flight	IFR-flygning /IFR flight	VFR-flygning /VFR flight
	.90	---	0	---
	10	---	20	25
	30	35	40	45
	50	55	60	65
	70	75	80	85
	90	95	100	105
Flygnivåer (FL)	110	115	120	125
	130	135	140	145
Flight levels (FL)	150	155	160	165
	170	175	180	185
	190	195	200	
	210		220	
	230		240	
	250		260	
	270		280	
	290		300	
	310		320	
	330		340	
	350		360	
	370		380	
	390		400	
	410		430	
	450		470	
	490		510	
	etc		etc	

Figure 3. Flight levels as in the semicircular rule.

1.13 Medical information

Nothing has emerged to suggest that the pilots' or the air traffic controller's mental or physical condition was impaired before or during the incident.

1.14 Fire

Not relevant.

1.15 Survival aspects

Not relevant.

1.16 Tests and research

1.16.1 Interviews with crewmembers

According to the crew of SAS 4083, a slow climb was started using the autopilot after clearance had been obtained. When the TCAS warned with a TA, climb rate was increased to around 1,500 feet per minute. At about the same time the commander noticed the oncoming aircraft. When the TCAS then warned with an RA and the message "climb, climb", the aircraft's nose position was already above the red area in the instrument presentation, and for this reason the autopilot was not disconnected.

The crew of FIN 2014 stated that they were flying at flight level 360 for about two hours before the incident. Descent to flight level 350 began approximately 30 seconds before the RA warning "descend". The oncoming aircraft was successively observed on the flight instruments as white (proximate traffic), orange (TA) and red (RA) symbols. When the RA came through, the autopilot was disconnected and the aircraft was flown manually to flight level 350.

1.16.2 Interview with the air traffic controller

In the interview with the air traffic controller, the following emerged:

The transferring air traffic controller handed over the traffic situation about ten minutes before the incident in the combined sector N/K with the information that FIN 2414 was cleared at the wrong semicircular flight level directly towards the point of TOGMI at the request of Bodö ATCC. The air traffic controller accepted the request, since the assessment was made that there would be no conflict between FIN 2414 and SAS 4083. The relieving air traffic controller made the same assessment. As the radar echo of FIN 2414 did not correspond to the label, the air traffic controllers made a manual correlation and corrected the track during handover. The relieving air traffic controller accepted and took over the position.

Shortly after the controller had taken up his position, FIN 2414 called up control. The air traffic controller looked down at the screen, confirmed and made an "assume" on the flight. The air traffic controller's focus was on the northern part of his work area where traffic included coordinations, VFR flights, transfers to the tower, calls and so on.

During a routine scanning of the radar screen the air traffic controller noticed that SAS 4083 and FIN 2414 were at the same flight level. He had no recollection of an STCA warning. The air traffic controller's first reaction was to separate the aircraft. He requested FIN 2414 to descend and when a response from FIN was not obtained he called SAS 4083 and requested them to climb. He saw that SAS 4083 began to climb and then called FIN 2414 who replied that they had started descent.

1.16.3 Description of the air traffic control system

Eurocat 2000E (E2kE) is an air traffic control system used in Swedish airspace. The system includes monitoring aids, tools, safety nets and other functions. The following is a description of the parts of the system that are directly related to the incident and that were used and presented in the air traffic controller's working position.

The tools Medium Term Conflict Detection (MTCD) and Flight Leg (FLEG) help the controller to see a flight's profile in advance and relative to other flights. The air traffic controller can use this information to make decisions about ensuing clearances. Conflict Alert and Risk Display (CARD) is an information function on the radar screen that shows MTCD conflicts and risks, depending on what is selected. MTCD, FLEG and CARD are based on flight plan data.

Safety nets are based on data from monitoring equipment and alert when certain values are too low. One of the safety nets is called Short Term Conflict Alert (STCA), which is based on radar data. STCA is a warning to the air traffic controller of loss of separation. The conflict is detected between two radar tracks, provided that at least one of the tracks has positive correlation. The STCA function looks forward and warns 90 seconds ahead of a possible conflict. This warning appears as a red frame around the radar labels on the flights concerned as well as a red background behind call signals in all lists where the flights are represented.

E2kE also contains a function that allows an air traffic controller to selectively mark radar labels. With the aid of the function "irregular", a label is marked with a yellow A (Alert) to remind the air traffic controller that an aircraft is at a flight level that deviates from the semicircular principle. The function "highlight" means that the radar label is marked in its own position with a yellow colour. A function called SEP tool can be used to display the minimum separation between two flight paths with respect to the position, bearing and speed. The Prediction Line (PRL) is another function that can be used to display the aircraft's future flight path (see figure 4 below).

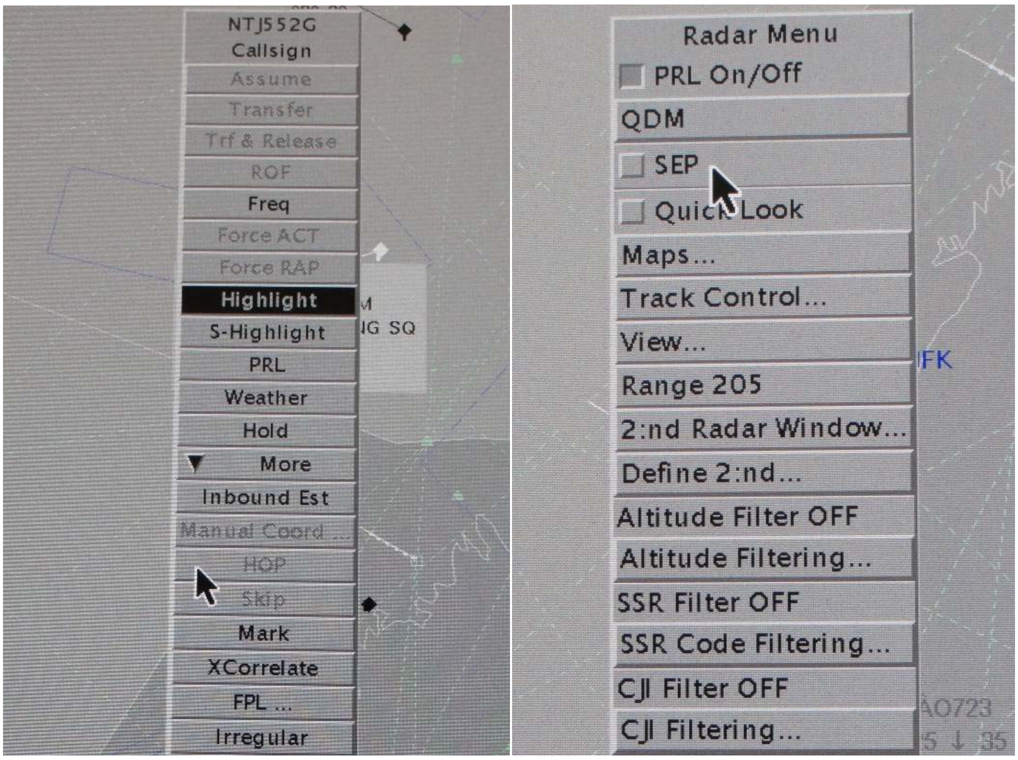

Figure 4. The functions Highlight, PRL, Irregular and SEP tool in the Callsign and Radar menu.

1.16.4 Warning levels and variables in the safety net

According to information from LFV, the system has been evaluated regarding the various colour intensities and thickness of the red STCA frame around the radar labels and behind Callsign. It was found that the current colour coding and frame thickness are the most suitable with the present system. Flashing STCA was used in previous systems with monochrome presentation, but this is not used in the E2kE where colours have been chosen instead. It has not been possible to complement the visual warning with a sound signal.

1.17 LFV organization and management

1.17.1 LFV

LFV is a state owned enterprise that operates air navigation services for civil and military clients in Sweden. Operations are organized into business areas. Production En Route operates mainly at the two control centres ATCC (Air Traffic Control Centre) Malmö and ATCC Stockholm. Production Terminal manages local air traffic control at locations around the country.

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). For controlled flights at cruising altitude, area control services are provided by ACC and TMC.

Operations manual

The local operations manual for ATCC Stockholm contains local supplements or deviations from LFV's central directives.

Manning of positions

The EC position is opened first in the sector and the PC position is opened at a specified traffic intensity level or in accordance with TS-A, or by EC's assessment. TS-A produces data on traffic intensity. The recommended level for opening an air traffic controller position is marked with red in a bar chart. The traffic bars present the number of movements for continuous hours at 20 minute intervals. At traffic intensity level 18 for the merged N/K sector, it is recommended that the PC position or another EC position be opened.[2]

On the morning of 2 July 2010 the traffic intensity level in sector N/K was just above the red marked level 18 between 09:20 and 10:00 hrs and was then below the level. Between 11:40 and 12:20 the level was between 14 and 15.

According to the group manager and air traffic controllers, the traffic intensity level is defined by flight planned traffic volume but not VFR flights, military traffic or other co-ordinations.

Working instructions

The operations manual contains comprehensive working instructions for the EC and PC positions and specifies the following:

"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 ACC sectors. In the case of single manning, P's duties and responsibilities are transferred to E."

EC is responsible for the exercise of air traffic control service within his own sector as well as other sectors assigned to the position. EC is responsible for flights and updating of E2kE flight plans for traffic taken over (Sector state Assume) and a number of additional tasks. For traffic at en route altitude which is not accepted or at the wrong semicircular level, EC must add an A (Alert) to the label via the Callsign menu in E2kE.

PC is responsible for flights and updating E2kE flight plans for traffic that has been coordinated (Sector state Coordinated) and that is in the process of ongoing coordination (On-going coordination). In addition, PC must search for

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[2] ATS Operations handbook, part 3 section 1 chapter 3 items 1 and 3.2, 22/10/2009.

conflicts using MTCD and make EC aware of any conflicts that require action and respond to and rectify system co-ordinations in Sector state Coordinated and On-going coordination.[3]

1.17.3 An 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.

The radar screen for authorization group Z (Norrland) is about 40 cm wide and 64 cm high. It is higher than other screens in the control centre. It is on a stand that can be adjusted in height. The work desk also has an adjustable height. This higher screen was introduced in 2009 to improve air traffic controllers' forward planning and the ability to see the entire area of responsibility, when all sectors in Z are merged. With the radar screen that was used for other authorization areas, the whole map image would not fit in with an acceptable scale. When a safety assessment of the change was made, no negative safety effects were judged to exist.[4]

1.17.4 Interviews with other air traffic controllers

Interviews were conducted in April 2011 with seven air traffic controllers who worked with Norrland air space to gain an impression of their opinions, particularly on the issues of single manning and the use of PC, radar screens and tools for pointing out irregularities and detecting conflicts. The results are summarized below.

Viewpoints on manning and the use of the PC position

The bar diagrams for flight planned traffic were able to provide some guidance for the assessment of the need to open the PC position. But it was mentioned that three flights, e.g. VFR flights, can generate as much work as fifteen other flights. It was also said that, since radar coverage in the north is poor, an air traffic controller may need to work with a manual procedure using labels, known as strips, as well as using E2kE and communicating with pilots. Several said that once a situation had arisen it was already too late to gather traffic information and transfer it to a PC.

Several different examples were given of situations where the PC position was considered to be good:

- during military flights in the area,
- when focusing on data in parts of the sector with poor radar coverage,
- when working with many interfaces, tower and sectors
- for avoiding too frequent transfers,
- for obtaining help and someone to consult with,
- for providing better forward planning,
- for managing variations in daily performance and sudden nausea,
- for learning from each other and for increasing the capacity of the sector, and
- for maintaining high flying safety, quality and levels of service.

Some wanted PC during the daytime, but were aware that this was not supported by all air traffic controllers. Some felt that at times there could be too little to do and it could feel tedious. There would then be a risk of reduced at-

[3] ATS Operations handbook, part 3 section 2 chapter 1 items 2, 3 and 4, 22/10/2009.
[4] Flight safety assessment, release 21.3 for Eurocat 2000E, LFV Report D-LFV 2009–0451118.

tention and more non-work related conversations with colleagues. One proposal was to introduce a trial period during which both EC and PC positions would be manned during the day.

There were some air traffic controllers who felt that the responsibility was heavy on the individual controller in a conflict situation when the controller did not request a PC. The responsibility for requesting PC was perceived by many to be almost entirely on the individual controller.

One mentioned that in the end it must be a management issue what quality and level of service you want to set and at what cost as manning levels might be affected.

Most of the air traffic controllers interviewed wanted a better dialogue with managers and more responsibility on the part of the management, as well as clearer rules and procedures.

Viewpoints on the radar screen

The radar screen was judged to be very good, especially when working on the entire Norrland sector on weekends and nights. Problems mentioned were difficulties maintaining an overview of the entire region when focusing on one area and the difficulty of assessing distances visually. Uncomfortable working posture was also mentioned, when the neck is bent backwards. Several said they had problems or knew colleagues who had problems with their necks.

Despite these inconveniences, the larger screen was thought to be better than the previous screen.

Comments on some tools

Several air traffic controllers felt that CARD is not very helpful, but that it still works "reasonably" in Group Z for flights at height and during low traffic intensity. They mentioned that in some situations there could be many red boxes in CARD without any conflicts being present. The information in CARD is not ignored, said one, but it does not add anything and you rely more on your experience. It is possible, said a few, that you become inured when CARD warns too many times without any conflicts arising. The tool is not fully used for this reason, according to some of those interviewed.

Several of the air traffic controllers interviewed usually moved CARD to the bottom right corner of the screen. If an air traffic controller is focusing on something in the upper part of the screen, that may contribute to what is happening in CARD being easily overlooked. At the same time, some air traffic controllers thought that there are many aspects of CARD that are unimportant.

Most felt that the red frame around the label during an STCA alarm was sufficiently clear. At the same time, it was stated that on some occasions air traffic controllers had not noticed the alarm.

A tool described in very positive terms was the SEP separation tool. It was thought to work best for flights at high altitude at a steady speed.

Air traffic controllers used Prediction Line (PRL) not only to see where the selected aircraft would be in the near future, but also to remind themselves of any irregularities.

Highlight was also used to note that there was something special about a flight. As regards the use of irregular (A), someone thought that an A is not always self-evident, as in this case when an aircraft flying at the wrong semicircular flight level crosses one of the parallel southbound and northbound routes.

Viewpoints on accepting incorrect semicircular flight levels
Some of those interviewed mentioned air traffic controllers' attitudes towards requests from aircraft to fly at the "wrong" semicircular flight level. There were views that only in exceptional cases such as severe turbulence, icing, and emergencies should the semicircular flight level principle be waived, since it is an accepted system for building in safety and reducing the risk of conflicts. It should also be written that only in emergencies may the principle be waived, said one. But there were also views that the appropriateness of accepting requests depends on the traffic flow within a sector. In such a large sector as Norrland, the occasional aircraft flying at an incorrect semicircular flight level for reasons other than emergencies could be accepted, as long as no immediate conflict is seen, since there is a desire to be service-minded and help shorten the route, etc.

1.18 Additional information

1.18.1 Equality issues

Not relevant.

1.18.2 Supervision

In May 2011 the Swedish Transport Agency requested a statement from LFV on the question of measures taken as a result of incidents on several occasions in the last year in which air traffic controllers for various reasons had not immediately noticed the visual STCA alarm on the radar screen. Previous investigations had also taken up the issue of the STCA alarm signal strength, unwanted alarms and the risk of inurement.[5]

In the Transport Agency's letter to LFV it is stated that they believe LFV has a detailed and ambitious safety management system, including procedures for handling deviations and investigations. As regards incident reports and investigations and the problems with STCA, however, the Swedish Transport Agency considers that some relevant and risk-reducing measures have not been taken.

In an interview in August 2011 with ANS inspectors at the Swedish Transport Agency, it was mentioned that during an audit of LFV the Agency had found shortcomings in systems and traceability in respect of how proposed measures from investigations into reported incidents were dealt with. The Swedish Transport Agency has urged LFV to rectify this situation. During the interview it was said that there was a growing understanding for the Swedish Transport Agency's views on the matter.

1.18.3 Analysis of previous incidents at control centres

An analysis of 36 incidents at ATCC Malmö and ATCC Stockholm from 1996 to 1998 from an HTO (humans-technology-organization) perspective has been carried out by Weikert and Johansson[6]. Handover was one of five contributing factors, while the others were lack of concentration, lack of training, method-

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[5] Request for report on measures taken as a result of unnoticed STCA alarms. Letter from Swedish Transport Agency to LFV, 20/05/2011.
[6] Weikert C. & Johansson C.R. Analyzing incident reports for factors contributing to air traffic control related incidents. Proceedings of the Human Factors and Ergonomic Society 43rd Annual Meeting, 1999. See also Mooij M., Dekker S. & Weikert C. The Future of Air Traffic Control in Sweden. Report of a pilot study. Vinnova Report VR 2001:15.

ology and phraseology. An analysis of background factors showed that most incidents occur at low to average traffic density. A majority of these occurred in area control rather than in tower or terminal control. A large proportion seemed to take place during the morning shift, which was assumed to be due to a fairly high initial workload which then decreases. Coming down from a higher to a lower workload can lead to concentration problems. The desire to be service-minded towards pilots was also a potential risk factor. Air traffic controllers are sometimes influenced by the desire to accept pilots' requests to use a more direct flight route and to change flight levels, even if this is not necessary because of the traffic situation.

1.18.4 Study of single manning and handover

In response to the accidents in Linate and Überlingen, Eurocontrol developed a strategic plan which included a study to investigate a number of questions on manning.[7] The purpose of this study was to inform, to explain and to define good practice. Below is a brief summary of the parts that are relevant to this inquiry: single manning and handover.

The study looked into two types of single manning for a certain time during a 24-hour period. The report did not advocate single manning, but had the sole purpose of summarizing risks and preventive measures. One recommendation was to make a detailed risk assessment before any decisions to introduce single manning and in the department's "safety case" to draw up plans for dealing with unforeseen events.

The risks stemming from single manning of an air traffic controller position were discussed, including workloads when multitasking, distractions, not detecting threats and recognizing errors and decreased transfer of knowledge within the team. Among the situations deemed to involve increased risks were normal conditions in combination with high workloads, and all situations with low workloads.

The risks related to position handovers, as mentioned, include incorrect assumptions or expectations being transferred and procedures or checklists not being followed. Several examples of measures to decrease these risks were discussed.

1.18.5 Risk assessment of single manning

The following information has been submitted by the Swedish Transport Agency.

In the documentation of the former Aviation Inspectorate's access control of System 2000 there were OF documents (Operating Conditions) in which it was specified that controllers could work alone or two together (OF 00019). OF 00032 states that single manning should only take place with "significantly low-intensity traffic". The methods used were safety analyses. Access control went on for several years and ended with the Aviation Inspectorate's operating approval in March 2005.

1.18.6 Research into 24-hour resting periods and safety

The significance of 24-hour resting periods for health and safety is one of the issues related to working hours dealt with in the report, "Arbetstider, hälsa och säkerhet – en uppdatering av aktuell forskning" (Working hours, health and

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[7] Study report on selected safety issues for staffing ATC operations, Eurocontrol DAP/SSH-2006/140,15.12.2006.

safety – an update of current research), by Göran Kecklund et al.[8] The following is a summary of the part of the report that deals with 24-hour resting periods.

Short resting time (less than 11 hours) between shifts, sometimes called "quick changes", is used to compress working hours into fewer days. This means generally that an evening shift is followed by a morning shift. The system is popular because employees have more consecutive days off. The result is considerably shortened periods of sleep, resulting in fatigue, and possibly also in an increased risk of accidents. A number of studies indicate that the minimum length of periods of sleep required for unaffected functioning levels is around seven hours and that the effects of shorter sleeping periods accumulate over several days. The effects on wakefulness and functioning capacity accelerate with each hour's decrease in sleep.

The authors' conclusion from the review of research is that seven to eight hours of sleep is the minimum required for recovery, health and safety. Since it takes time to travel between work and the place of rest (usually at home), as does eating and hygiene, 11 hours of rest between work shifts is probably a minimum. This assumes that priority is not given to one's social life. Eight hours is unacceptable if a lack of sleep is to be avoided. In special cases, when rest is taken in immediate proximity to the workplace and without any social or other obligations (such as when staying overnight in an unfamiliar location), 10 hours can possibly be accepted. Systematic studies on 24-hour resting periods in real work situations are generally lacking, however.

1.18.7 *False alarms*

According to human factors literature[9], operators do not react optimally to real alarms in environments with a large number of false alarms. The result is that they may lose confidence in the system and become insensitive to real alarms. Under such conditions the risk increases that operators ignore these alarms because they are accustomed to treating them as false alarms.

1.18.8 *Measures taken*

LVF will adjust the opening hours for positions in Group Z within ATCC Stockholm. Sector K will be manned with a PC during weekdays when there is military activity.

1.18.9 *Future changes in the air traffic control system*

LFV will deploy a new air traffic control system, Eurocat/COOPANS, in early 2012. The new system includes completely new software and hardware and the presentation of STCA has been changed. In addition to a red frame around the radar labels, the following have been added:

- radar position symbol (RPS) in red,
- vector line for one minute in red,
- the line between the RPS and the label will be red,
- historical plots are in red,
- STCA warning window in red in the flight traffic lists, and
- a sound warning.

[8] Kecklund G., Ingre M. & Åkerstedt T. Arbetstider, hälsa och säkerhet – en uppdatering av aktuell forskning (Working hours, health and safety – an update of current research). Stress research reports no. 322, Stockholm 2010.

[9] Allendoerfer K. et al. Human factors analysis of safety alerts in air traffic control, FAA. Atlantic City 2007.

1.19 Special or effective investigation methods

1.19.1 Visualization of air traffic in three dimensions.

The ATV3D[10] project is a joint study between Eurocontrol[11] and Division C research at Linköping University. The goal of the study is to develop experimental software to visualize air traffic information in real time, real or simulated, and to carry out experiments to assess the potential value of three-dimensional presentations for air traffic controllers.

SHK has chosen to illustrate the event with the help of ATV3D because the method enables a precise synchronization and a clear visualization of the incident.

A CD with this visualization is attached with this report as Appendix 1.

2 ANALYSIS

The event has been analyzed from an HOF perspective (Human and Organizational Factors interactions). The purpose of the analysis was to identify the conditions that affected the occurrence of various sub-events and the technical, administrative and human barriers which were built into the system but which failed. These conditions are discussed below.

2.1 Irregular cruising level

The changed flight path is deemed to have only involved a marginal change. However, the modified cruising level, an incorrect semicircular flight level, did involve a risk. It would seem that the risk of conflict was considered as potential and small, but SHK has not been able to determine on what basis that assessment was made.

In interviews with air traffic controllers in the authorization group in question, it has emerged that clearances for incorrect semicircular flight levels are given for individual flights in the combined sector if there is no immediate risk.

When the request for an amended cruising level was granted, a latent risk – a "trap" – was introduced in the system. As previously mentioned, the analysis of past events has shown that such requests are sometimes complied with even when an amended cruising level is not motivated by the current traffic situation. The desire to be helpful and comply with such requests constitutes a potential risk factor.

In interviews with air traffic controllers it has been stated that for flight safety reasons the principle of semicircular flight levels should be upheld and only in very exceptional cases should changes that are contrary to this principle be accepted. This suggestion should be taken very seriously.

2.2 Divided attention

The fact that the air traffic controller had had to deal with issues related to his administrative responsibilities may unconsciously have made demands on and limited his attention. The information about the aircraft arriving at the same altitude, and that there could be a potential conflict was not processed by his working memory and was forgotten. The unconscious preoccupation with his

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[10] ATV3D – Air Traffic Visualization Three Dimensional

[11] Eurocontrol – European organization that controls airspace over parts of Europe.

administrative responsibilities may also have influenced the air traffic controller's attention in the continued course of events.

The knowledge of air traffic controllers is sought after also in areas other than the purely operational. This is the case not least for the continuing development of the air traffic control system. Work in these different areas is demanding, but requirements are different from one to the other. The consequences of a moment's distraction may be extensive in operational work, while for administrative tasks they are less dramatic and there are more opportunities to deal with them in time. Although controllers are fully aware of the importance of focusing solely on their operational responsibilities, when they go into the control centre and take up their positions, it can be difficult to consciously check and control the brain's continued processing of other matters.

How operational work and other duties are best structured is ultimately a managerial issue, in which the above mentioned aspects need to be taken into account. In this context the question also needs to be raised of the appropriateness of air traffic controllers combining operational and administrative duties while working alone in a position. This matter is dealt with in more detail below.

Information in the northernmost parts of the sector was also drawing the controller's attention from the southern parts of the sector, where the conflict occurred. His concentration on these tasks may have contributed to the red marker in FLEG not being noticed and examined more closely. It may also have contributed to the red marking in CARD not being noticed.

The fact that the combined sector N/K is presented as a long image on the high screen, with a large distance between the northernmost parts and the south, is a factor which may further interfere with the ability to detect deviations in the southern parts of the sector when the focus is on the northernmost parts. It may be added that CARD had been placed at the bottom right hand corner of the screen, as is common among air traffic controllers.

Concentration may also have been reduced, as a consequence of the workload decreasing after a higher workload during early morning shifts. This is a phenomenon which has been observed and identified as a contributing factor in the analysis of past events.

2.3 Fatigue

It is known that fatigue reduces people's working memory and attention span. It cannot be entirely ruled out that the resting period between evening and morning shifts had not provided sufficient recovery. The length of the rest in this case amounted to 8 hours and 30 minutes, but in addition to sleep it included commuting between work and home, eating and hygiene activities.

2.4 *Forgetfulness*

When the controller handing over the position accepted the changed altitude, this was not marked or noted. When the handover was made, only oral information on the conflict was given. After the flight was correlated no "highlight" was made. At this time, the flight had not yet been taken over through "assume" and irregular (A) could not be entered in E2kE.

Conditions that contributed to neither highlight nor a yellow (A) being used to draw attention to the fact that the FIN 2014 was flying at an incorrect semicircular flight level are deemed to be:

- The task of highlighting ended up being lost in between the two air traffic controllers when they together made a manual correlation of the label.
- The controller taking over had forgotten and did not notice the flight level when he confirmed the label. His concentration was on data in the north of the sector.

2.5 Design of CARD

Another reason for the conflict point not being noticed in CARD may be that CARD is felt to show so much irrelevant information that less attention is paid to the CARD window. As mentioned in section 1.18.7, it is well known that the experience of false alarms can increase the risk of air traffic controllers ignoring real alarms. The fact that conflict points in CARD have not been noticed has been mentioned previously.

2.6 Design of STCA

One reason why STCA did not immediately capture the attention of the controller is deemed to be that the alarm could only be detected visually, which is the most widely used sense in radar monitoring. The ability to detect movements, such as “flashing”, through peripheral vision, is not used to draw attention.

The results of interviews with air traffic controllers and inspectors at the Swedish Transport Agency, as well as the outcome of LFV investigations, have shown that it has happened before that STCA alarms have not been noticed..

2.7 Single manning of sector N/K – insufficient management

The PC position at the workplace was not manned by an air traffic controller to carry out specific PC duties, despite the fact that traffic intensity could not be considered as significantly low. The air traffic controller performed EC and PC tasks alone. As a consequence, the safety net that another air traffic controller provides to search for conflicts and notify the EC person responsible for the sector of conflicts that require action, was lacking.

A contributing factor to the PC position not being manned was that the traffic intensity was not judged to require this. The air traffic controller himself did not think that he would be distracted by his administrative responsibilities during his shift.

Also, allegedly in Stockholm ATCC there has been a longstanding culture of PC positions not necessarily being open in the daytime, as indeed they are in Malmö ATCC, except in certain sectors. The responsibility for assessing the need for a PC is largely placed on the individual controller. This may mean that a controller in some cases, either consciously or unconsciously, is reluctant to request a PC, such as when more than one sector position is open and the number of available controllers is limited. In the present case, however, it has not been shown that the controller was consciously reluctant to call in a PC for these reasons.

LFV has brought up the question of manning and decided to adjust the opening hours for the actual PC position.

Due to the measures taken about manning and since the issue has thus already been addressed by LFV, SHK will not give any recommendations on this subject.

2.8 Weaknesses in the application of the safety management system

As is clear from the LFV investigation, earlier analyses of reported events and interviews with air traffic controllers and inspectors at the Swedish Transport Agency, several of the causal factors identified in this investigation have been identified already before. This suggests that measures have either not yet been taken, or have not been effective. This shows that a fundamental cause of the incident were flaws in the application of the safety management system procedures regarding measures to be taken and the follow-up of the effects of such measures.

2.9 Pilots' responses to the TCAS warnings

The pilots of SAS 4083 and Finnair 2414 responded to the TCAS warnings in an appropriate manner. The fact that the autopilot was never disconnected from the SAS flight can be explained by the fact that the airplane nose was already out of the Red RA area when RA was enabled.

3 STATEMENT

3.1 Findings

a) The pilots had the qualifications to perform the flights.
b) The aircraft had certificates of airworthiness and valid ARC's.
c) The air traffic controller had full authorization for the sector concerned.
d) The air traffic controller was performing EC and PC tasks alone in the merged sector.
e) Two sectors were shown simultaneously on a large screen.
f) The air traffic controller came directly from a break during which he had carried out administrative work.
g) FIN 2414 was cleared at an incorrect semicircular flight level.
h) A potential conflict was handed over.
i) The potential conflict was forgotten.
j) MTCD and STCA were not noticed by the air traffic controller in position.
k) The air traffic controller did not manage to separate the aircraft prior to the TCAS warnings.

3.2 Causes of the incident

3.2.1 Findings as to cause and contributing factors

- Irregular cruising level.
- Divided attention and focus on information in the northern sector.
- Single manning and the culture around single manning.
- Fatigue.
- Forgetfulness.
- The design and placement of CARD.
- Weaknesses in the application of the safety management system

3.2.2 Finding as to risk

- Design of the STCA alarm.

4. RECOMMENDATIONS

None.

APPENDIX

1. ATV3D visualization.