Statens haverikommission
Swedish Accident Investigation Authority





Final report RL 2019:12e

Serious incident south of Norrköping/-Kungsängen Airport 17 October 2018 involving the aircraft G-RJXF an aero-plane of the model EMB-145EP, operated by BMI Regional and SE-VKA of the model Zephyr 2 000C, operated by a private individual.

File no. L-123/18

8 October 2019

SHK investigates accidents and incidents from a safety perspective. Its investigations are aimed at preventing a similar event from occurring in the future, or limiting the effects of such an event. The investigations do not deal with issues of guilt, blame or liability for damages.

The report is also available on SHK´s web site: www.havkom.se

ISSN 1400-5719

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

Postadress/Postal address	*Besöksadress/Visitors*	*Telefon/Phone*	*Fax/Facsimile*	*E-post/E-mail*	*Internet*
P.O. Box 6014 SE-102 31 Stockholm Sweden	Sveavägen 151 Stockholm	+46 8 508 862 00	+46 8 508 862 90	info@havkom.se	www.havkom.se

Statens haverikommission
Swedish Accident Investigation Authority

Content

General observations

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

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

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

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

Investigations of aviation incidents are governed mainly by Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and by the Accident Investigation Act (1990:712). The investigation is carried out in accordance with Annex 13 of the Chicago Convention.

The investigation

SHK was informed on 17 October 2018 that an a serious incident involving two aircrafts with the registration G-RJXF and SE-VKA had occurred south of Norrköping/Kungsängen Airport, in Östergötland county, the same day at 14:29 hrs.

The incident has been investigated by SHK represented by Mr Mikael Karanikas Chairperson, Mr Johan Nikolaou, Investigator in Charge, Mr Peter Swaffer, Operations Investigator and Mr Alexander Hurtig, Investigator Behavioural Science.

The investigation team of SHK was assisted by Mr Leif Hellgren as an expert specializing in air traffic control and Magnic AB as specialists in communication and radardata.

Mr Graeme Gow from the Air Accident Investigation Branch (AAIB) has participated as accredited representative on behalf of UK.

Mr Alvaro Neves has participated as advisor from European Aviation Safety Agency (EASA).

The investigation was followed by Mr Magnus Eneqvist of the Swedish Transport Agency.

The following organisations have been notified: International Civil Aviation Organisation (ICAO), EASA, EU-Commission, AAIB and Swedish Transport Agency (Transportstyrelsen).

Investigation material

- Interviews have been conducted with the pilots and the air traffic controller.
- Radar data has been obtained from LFV and from the Swedish Armed Forces.
- Communication between ATC and the aircraft has been compiled.
- Reference flights have been performed in the EMB-145 simulator and with a smaller aircraft in the area south of Norrköping/Kungsängen control zone.

A factual meeting with the interested parties was held on 13 March 2019. At the meeting, SHK presented the facts discovered during the investigation, available at the time.

Final report RL 2019:12e

Time of occurrence	17/10/2018, 14:29 hrs in daylight Note: All times are given in Swedish day-light saving time (UTC + 2 hours)
Place	South of Norrköping/Kungsängen Airport, Östergötland county, (position 58 30N 016 25E, 487 metres above mean sea level)
Weather	According to SMHI's analysis: wind south to southwest 5 knots, visability more than 10 kilometres, no cloud below 5 000 feet, temperature/dewpoint +19/+12 °C, QNH[1] 1017 hPa
Aircraft: A	
Registration, type	G-RJXF, EMB-145
Model	EMB-145EP
Class, Airworthiness	Normal, Certificate of Airworthiness and Valid Airworthiness Review Certificate (ARC)[2]
Operator	BMI Regional
Type of flight	Commercial
Persons on board:	21
crew members including cabin crew	3
passengers	18
Injuries to persons	None
Damage to aircraft	No damage
Other damage	None
Commander:	
Age, licence	42 years, ATPL[3]
Total flying hours	3 343 hours, of which 2 874 hours on type
Flying hours previous 90 days	146 hours, all on type
Number of landings previous 90 days	58
Co-pilot:	
Age, licence	32 years, CPL[4]
Total flying hours	3 443 hours, of which 742 hours on type
Flying hours previous 90 days	171 hours, all on type
Number of landings previous 90 days	56

[1] QNH (Barometric pressure at mean sea level).
[2] ARC (Airworthiness Review Certificate).
[3] ATPL (Airline Transport Pilot License).
[4] CPL (Commercial Pilot License).

Aircraft: B

Registration, type	SE-VKA, Zephyr 2 000C
Model	ATEC 122 Zephyr
Class, Airworthiness	UL, Valid Airworthiness
Owner	Norrköping Automobil & Aeroclub
Type of flight	Private
Persons on board:	1
crew members including cabin crew	1
passengers	0
Injuries to persons	None
Damage to aircraft	No damage
Other damage	None
Pilot in command:	
Age, licence	45 years, UL
Total flying hours	100 hours, all hours on type
Flying hours previous 90 days	2 hours
Number of landings previous 90 days	5

SUMMARY

The serious incident occurred during approach to Norrköping/Kungsängen Airport during a scheduled passenger flight from Munich. The aircraft, model EMB-145EP, had the call sign Midland 753G. During the approach, the weather conditions were good with a visibility of more than ten kilometres. The crew performed self-positioning for an ILS approach. At the time, there was an ultralight aircraft in uncontrolled airspace below Midland's cleared route.

During the self-positioning and about seven nautical miles south of the outer marker beacon "ON", Midland suddenly initiated a left turn towards the west outside the control zone and descended below controlled airspace, approaching the ultra-light aircraft. As Midland descended and approached the aircraft, a near collision incident occurred.

The approach aid ILS, which provides both horizontal and vertical guidance, gave command of the controls to the autopilot, which had been armed for approach. When Midland was outside the coverage area of the approach aid, the aircraft picked up a false signal, turned and descended.

The air traffic controller did not have time to correct Midland's incorrect navigation, as it was not quite clear how the approach should be performed. The initial turn was interpreted as Midland having visual contact with the airport and making a correction towards the airport. When Midland then continued the turn and descended, disturbances arose in the form of communication and surprise reactions, and this was probably the reason why a correction of the flight did not occur. According to the ATC provider’s operations manual, self-positioning for the ILS approach that Midland received should be terminated by radar vectors, which would have minimized the risk of picking up false lateral signals.

The incident was caused by the fact that planning and follow-up of the approach were not carried out in an appropriate manner.

A contributing factor has been lack of knowledge of false ILS signals.

Safety recommendations

EASA is recommended to:

- Ensure that clear requirements regarding the limitations of conventional navigation aids are included in the recurrent training. *(see chapter 2.2) (RL 2019:12 R1)*

The Swedish Transport Agency is recommended to:

- Evaluate and consider whether AOC holders have prescribed and appropriate procedures to monitor the crew members' knowledge of the limitations of conventional navigation aids. (see chapter 2.2) *(RL 2019:12 R2)*

- Inform air traffic control providers about the risks of issuing an approach clearance at an early a stage. (see chapter 2.1) *(RL 2019:12 R3)*

1. FACTUAL INFORMATION

1.1 Sequence of events

The serious incident occurred during approach to Norrköping/Kungsängen Airport during a scheduled passenger flight from Munich to Norrköping.

The aircraft, of the model EMB-145EP, had the call sign Midland 753G, ("Midland") and was under air traffic control by the air traffic controller at Östgöta control central (ÖKC). The crew consisted of two pilots and a cabin crew member.

During the approach, the weather conditions were good with a visibility of more than ten kilometres. Östgöta control suggested planning for visual approach, which the crew rejected and asked for a self-positioning for an ILS[5]. Self-positioning means that the crew uses their own navigation aids to position the aircraft for final approach. The reasons were that the crew deemed the visibility to be impaired due to mist, that the sun was dazzling in the approach direction and that the commander was not familiar with the airport.

ÖKC gave Midland the clearance to turn for final when ready. The crew navigated towards a point on the extended final which would lead them to the ILS for runway 27. The aircraft was first cleared to 3 500 feet and then to 2 100 feet. 2 100 feet is the lowest radar altitude in the area south of Norrköping/Kungsängen control zone that an air traffic controller can provide clearance for. The intention was for Midland to establish itself on the final.

About two and a half minutes later, the crew received *"cleared approach runway 27"* and the crew armed approach mode of the aircraft's ILS.

At the time, there was an ultralight aircraft (SE-VKA) at 1 400 feet in uncontrolled airspace below Midland's cleared route. The aircraft, flying under visual flight rules (VFR), was on its way to the VFR reporting point DOCKAN. DOCKAN is located five nautical miles south of Norrköping/Kungsängen Airport. The two aircraft were not on the same radio frequency.

Midland had TCAS[6] installed, while SE-VKA had an altitude-reporting transponder which enabled the TCAS to detect SE-VKA and give vertical commands to Midland.

During the self-positioning and about seven nautical miles south of the outer marker "ON", the ILS gave command of the controls to the autopilot. Midland initiated a left turn towards the west and descended. One of the pilots has stated that the system captured the glideslope and

[5] ILS (Instrument Landing System).
[6] TCAS (Traffic Collision Avoidance System).

followed it, while the other pilot stated that they were on final and above the glideslope. At this stage, they changed from the autopilot's automatic coupling for the glideslope to vertical speed mode "VS[7]", thereby increasing the descend rate to catch the glideslope indication.

The controller noted the left turn, but interpreted it as an adjustment of the flight path, which is not uncommon when aircrafts are given permission for self-positioning.

The Midland crew noted SE-VKA on their screens and asked the air traffic controller for the traffic. The controller, who now had some concerns about the turn and that the aircraft had begun to descend, stated that there was traffic below the TMA[8], at ten o'clock in relation to Midland and at an altitude of 1 400 feet in uncontrolled airspace below them. At the same time, the air traffic controller asked Midland what altitude they were on, whereby the crew stated that they could now see the other aircraft. SE-VKA was at this time in front of Midland at a distance of less than one NM[9] with an altitude difference of about 200 feet.

During the incident, the crew of Midland received a warning and a command from TCAS: *"monitor vertical speed".* They then cancelled the approach by carrying out a go around. Subsequently, the crew informed the air traffic controller that they were *"clear of traffic".* Midland then got radar vectors for a new approach. According to the pilots, only one RA[10] appeared that was not preceded by a TA[11].

The air traffic controller stated that he had been both surprised and concerned that Midland had acted on a TCAS RA and asked the crew about their altitude. The crew replied that they had not been below 2 000 feet and that they had visual contact with SE-VKA.

Midland then made a normal landing at Norrköping/Kungsängen Airport.

The incident occurred at position 58 30N 016 25E, 1 600 feet (487 metres) above sea level.

1.2 Injuries to persons

None.

[7] VS (Vertical Speed).
[8] TMA (Terminal Area).
[9] NM (Nautical mile).
[10] RA (Resolution Advisory).
[11] TA (Traffic Advisory).

1.3 Damage to aircraft

No damage.

1.4 Other damage

None.

1.5 Personnel information

1.5.1 Qualifications and duty time of the pilots

Airplane A
Commander

The commander, was 42 years old and had a valid ATPL license with flight operational and medical eligibility. At the time, the commander was PF[12].

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types	12	16	146	3343
Actual type	12	16	146	2874

Number of landings actual type previous 90 days: 58.
Type rating received in September 2010.
Latest PC[13] (proficiency check) conducted on 12 June 2018 on type.

The co-pilot

The co-pilot, was 32 years old and had a valid CPL license with flight operational and medical eligibility. At the time co-pilot was PM[14].

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types	6	22	17	3443
Actual type	6	22	17	742

Number of landings actual type previous 90 days: 56.
Type rating received on 2 February 2017.
Latest PC conducted on 15 July 2018 on type.

Airplane B
Pilot

The pilot in command, was 45 years old and had a valid UL license with flight operational and medical eligibility.

[12] PF (Pilot Flying).
[13] PC (Proficiency Check).
[14] PM (Pilot Monitoring).

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types	2	2	2	64
Actual type	2	2	2	64

Number of landings actual type previous 90 days: 4.
Class rating received on 6 March 2010.
Latest PC conducted on 15 May 2018 on type.

1.5.2 *Cabin crew*

The cabin crew in Aircraft A consisted of one person.

1.5.3 *Other personnel*

The air traffic controller in position TC was 31 years old at the time with a valid operational and medical authorization. He had worked at Östgöta control centre for 6 years.

1.5.4 *Duty schedule of the crew*

Commander

During the seven days preceding the event, the commander had been off duty for three days and worked the last four days before the event. The day of the event and the day before the commander hade started working at 04:00 hrs. The commander's duty schedule was within the permitted limits.

The commander has stated that he had slept well the night before the event. He had at least seven to eight hours of sleep each of the preceding nights.

Co-pilot

The co-pilot had been working for five of the last seven days before the event. He had an off-duty period of two days which ended three days before the event. The co-pilot's duty schedule the day of the event and the day before was the same as the schedule for the commander. The co-pilot's duty schedule was within the permitted limits.

The co-pilot has stated that he had at least seven hours of sleep each of the nights preceding the event.

1.5.5 *Duty schedule of the air traffic controller*

During the week preceding the event, the air traffic controller had worked four out of seven days. He had been off duty from 12 to 14 October.

During the last seven days, he had worked day and evening shifts. On the two days preceding the event, the shifts had ended at 23:55 and 19:30 respectively. On the day of the event, his shift started at 07:45. The air traffic controller's duty schedule was within the permitted limits.

The air traffic controller has stated that he felt as usual this day. He felt that he was alert and that there was nothing that affected him adversely.

1.6 Aircraft information

1.6.1 Airplane A

The model Embraer EMB-145 is a low wing, T-tail pressurized airplane, powered by two high by-pass ratio rear mounted turbofan engine.

The airplane is mainly made of aluminium alloys and has a pressurised fuselage. The airplane is almost 30 metres long and its wing span is just over 20 metres.

A glass cockpit panel has been developed with highly integrated onboard avionics, thus allowing pilots to better monitor airplane general operation.

The configuration of the actual airplane was two pilots and one observer seat in flight deck. The cabin configuration was for 49 passenger seats and two cabin crew seats.

To facilitate navigation and approach procedures, the aircraft EMB-145 is equipped with a ground collision warning system (EGPWS[15]), a traffic and collision warning system (TCAS) and a wind shear detection system. The aircraft is also equipped but FMS[16] as an aid for handling, among other things, navigation.

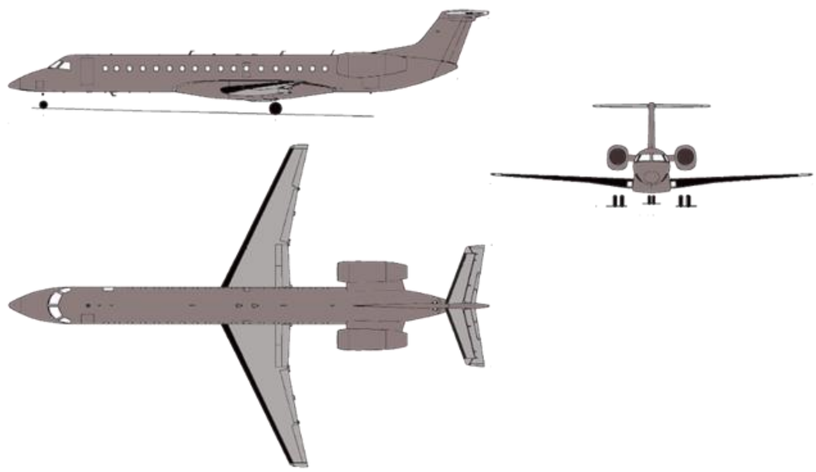

Figure 1. Three view drawing of the airplane model.

[15] EGPWS (Enhanced Ground Proximity Warning System).
[16] FMS (Flight Management System).

Airplane A

TC-holder	Embraer S.A
Model	EMB-145EP
Serial number	145280
Year of manufacture	2 000
Gross mass, kg	Max start/landing mass suspended load 20 990/18 700 current 15 900
Centre of gravity	Within limits
Total flying time, hours	32 369
Deferred remarks	QAR[17] was on HIL[18] according to MEL[19] The remark had no effect on the event.

The aircraft had a Certificate of Airworthiness and a valid ARC.

1.6.2 Airplane B

The model ATEC 122 Zephyr is a low wing ultralight airplane powered by an 80 hp piston engine.

The airplane is made of composites and wooden beams. It is about 5 metres long and has a wingspan of almost 10 metres.

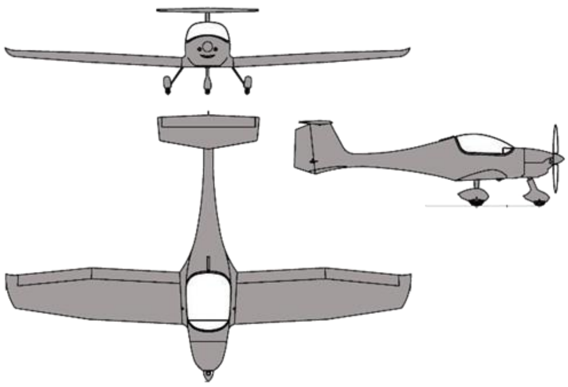

Figure 2. Three view drawing of the airplane model.

Airplane B

TC-holder	ATEC V.O.S
Model	ATEC 122 Zephyr
Serial number	Z1280106A
Year of manufacture	2005
Gross mass, kg	Max start/landing mass suspended load 450/450 current 400
Centre of gravity	Within limits
Deferred remarks	None relevant to the event.

The aircraft had a valid flight permit.

[17] QAR (Quick Access Recorder).
[18] HIL (Hold Item List).
[19] MEL (Minimum Equipment List).

1.6.3 TCAS

TCAS is a requirement for all civil aviation with aircraft equipped with turbines and jet engines with a maximum take-off mass exceeding 5 700 kg or a maximum approved cabin configuration of more than 19 seats.

EMB-145 is equipped with TCAS. The system is airborne and functions completely without ground stations.

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

The information received is then presented to the recipient on a display in the cockpit. The system also calculates how close a passage that will take place between the various aircraft and indicates with a Traffic Advisory (TA) which might become a threat. If a potential threat continues to approach according to certain specific criteria, TCAS issues a manoeuvre command, a Resolution Advisory (RA). These manoeuvre commands act vertically, that is, the pilot receives commands to manoeuvre vertically (See figure 3).

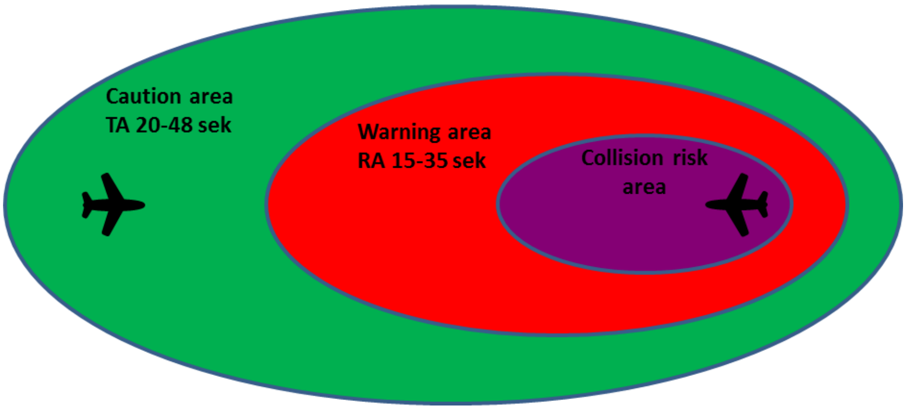

Figure 3. TCAS TA/RA areas.

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

Once an aircraft departs from its ATC clearance or instruction in compliance with an RA, or a pilot reports an RA, the controller ceases to be responsible for providing separation between that aircraft and any other aircraft affected as a direct consequence of the manoeuvre induced by the RA.

The correct terminology between aircraft and air traffic controllers to be followed at an RA is described below. (Reference ICAO Doc 4444 Phraseology Reference Guide)

Event:	Callouts to ATC:
If an RA is causing departure from the ATC clearance;	*(Callsign) TCAS RA (pronounced "TEE-CAS-AR-AY").*
When returning to assigned clearance:	*(Callsign) CLEAR OF CONFLICT, RETURNING TO (assigned clearance).*
When the assigned ATC clearance has been resumed:	*(Callsign) CLEAR OF CONFLICT (assigned clearance) RESUMED*
When an ATC clearance contradictory to the ACAS RA is received, the flight crew will follow the RA and inform ATC directly:	*(Callsign) UNABLE, TCAS RA.*

Chart 1. Terminology chart followed by a TCAS RA.

1.7 Meteorological information

According to SMHI's analysis: Wind south to southwest 5 knots, visibility more than 10 kilometres, no cloud below 5 000 feet, temperature/dewpoint +19/+12 °C, QNH 1017 hPa.

1.8 Aids to navigation

1.8.1 Instrument Landing System (ILS)

An instrument landing system (ILS) is a precision approach aid that allows pilots to descend safely in inclement weather.

An ILS localizer uses VHF (very high frequency) signals to provide accurate course information. This data is combined with UHF (ultra-high frequency) signals that provide glidepath information to the pilot. The signals are directional and can normally be received when the aircraft is within 10° to 35° of the on-course track.

The coverage and validity of ILS localizer signals are regularly confirmed by flight inspection within 35° to either side of the nominal approach path.

According to *ICAO Annex 10*, *3.1.3* Coverage, the localizer signal covers a sector out to 46.3 km (25 NM) ± 10 degrees from the front or back course and to 31.5 km (17 NM) ± 35 degrees (See figure 4). In this area, therefore, no false signals may occur.

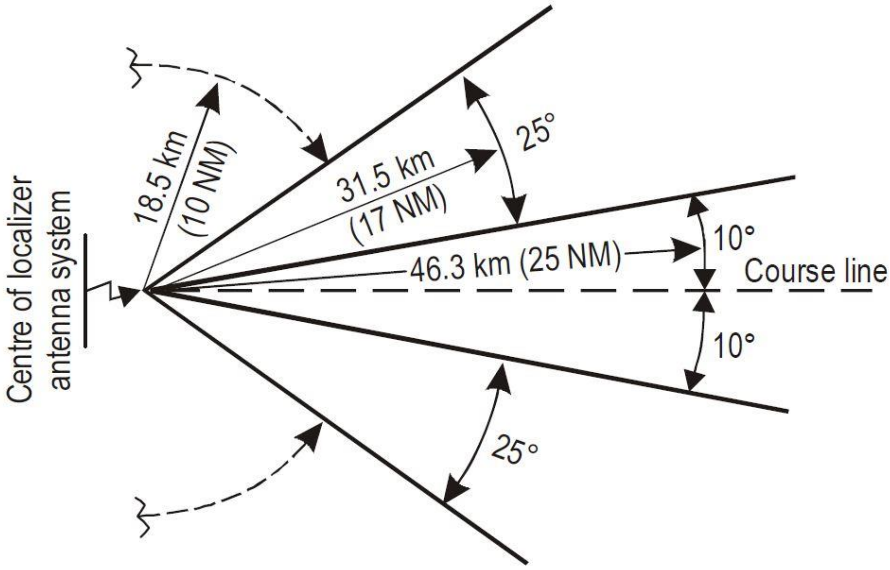

Figure 4. Localizer coverage area. Picture ICAO Annex 10.

According to LFV, there is a "false" localizer with a centre line indication 42 degrees from the inbound course to runway 27 at Norrköping/-Kungsängen Airport. This is common on certain types of localizers and does not violate the specification requirements (± 35°). However, an aircraft that is 42° from the localizer's centre line will get an instrument indication as if it was centred on the correct approach path. This is the reason why the ILS approach into Kungsängen/Norrköping must be verified with ADF and DME according to the approach chart for runway 27.

Some published approach charts have warnings regarding false localizers. As an example, AIP Sweden has a note on the STARs arriving from the south to Stockholm/Bromma runway 30 stating: *"Do not arm approach until OU QDM 002, due to risk for capture of incorrect localizer signal"*.

The airport's ILS was inspected and calibrated four months before the incident without remarks.

1.8.2 *Flight Management system (FMS)*

The FMZ 2000 Flight Management System (FMS) controls a complete range of navigation functions. Its primary purpose is to provide high accuracy in long range lateral and vertical navigation. The system on the actual aircraft had a single configuration installed.

The navigation functions calculate the aircraft's position and speed for all phases of the flight. The navigation priority modes, based on the sensor's accuracy, are as follows:

- GPS[20]
- DME/DME
- VOR[21]/DME
- IRS[22] (if installed)

The GPS has the most accurate sensor. When the GPS device is used, the other sensors are monitored for positional differences, but they do not contribute to the FMS position, unless the GPS signal becomes incorrect, inaccessible or manually cleared. In that case, the FMS automatically adjusts the DME/DME to provide position. If the DME/DME is unreliable, the VOR/DME is selected.

During the approach, the FMS was used to navigate towards the extended final until PF armed the localizer. During the entire event the correct final was still visually presented on the MFD.

1.9 Communications

The radio communication between Midland and the air traffic controller has been preserved and analysed. Only communication relevant to the event is included in the transcript below. *Communication within brackets translated from Swedish.*

Time	ATC/Aircraft	Communication
12.19.31	BMR753G	Östgöta control Midland 753G, descending flight level 100, direct ON, speed two-fifty knots
	TC	Midland 753G, Östgöta radar contact, the met report Kungsängen says wind calm, CAVOK, temperature 19, dew point 13, and the QNH 1017 so planning for a visual 27
12.19.53	BMR753G	Request self-position ILS runway 27 copied the QNH 1017 Midland 753G
12.19.59	TC	Then that´s the intention, you may turn for the final now if you wish
12.20.04	BMR753G	Set course for the final approach Midland 753G
12.20.20	BMR753G	And Midland 753G what´s the reason for the speed restriction?
12.20.27	TC	A helicopter during approach before you
	BMR753G	Roger
12.21.27	TC ringer T3	T3
	TC	*(Descend)* Midland
	T3	*(Descend Midland there, you are cleared below without contact)*
	TC	*(Below, thanks)*

[20] GPS (Global Positioning System).
[21] VOR (Very high frequency Omni-directional Range).
[22] IRS (Inertial Reference System).

12.21.34	TC	Midland 753G descend to altitude 3500 feet QNH 1017 transition level 60
12.21.42	BMR753G	Roger 3500 feet QNH 1017 Midland 753G
12.24.14	TC ringer Kungsängen AD	Kungsängen
	TC	TC *(here comes)* Midland 753G
	AD	*(Yes)*
	TC	*(With self positioning so to say, yes it will be some type of ILS variant for 27)*
	AD	*(some sort ILS 27 on Midland)*
	TC	*(Yes)*
12.24.55	TC	Midland 753G descend to 2100 feet
12.24.59	BMR753G	2100 feet Midland 753G
12.27.26	TC	Midland 753G you are cleared approach runway 27
12.27.29	BMR753G	Cleared approach 27 Midland 753G
12.28.53	BMR753G	753G we´ve got traffic 400 feet about 4 miles
12.28.59	TC	Yeah below TMA 500 feet below at your ten o´clock 1400 feet uncontrolled airspace
12.29.10	TC	Midland 753G what´s your altitude?
12.29.12	BMR753G	Okey we are visual with the traffic now Midland 753G
12.29.35	TC	*(TC Internal "Yes it was something with KA there")*
12.29.36	BMR753G	Midland 753G we are clear of the traffic now
12.29.43	TC	753G and I can vector in for a new ILS maintain 2100 feet left heading 090
12.29.51	BMR753G	Left heading 090 and maintain 2100 feet Midland 753G
23.30.00	TC	Yeah and left turn
12.30.08	TC	Are you in a right turn or left turn Midland?
12.30.10	BMR753G	Turning left turn Midland 753G heading 090
12.30.15	TC	Thank you Midland753G climb again 3500 feet
12.30.19	BMR753G	3500 feet climbing Midland 753G
12.31.13	TC	Midland 753G did you get the resolution alert TCAS or something
12.31.18	BMR753G	Affirm we did Midland753G
12.31.22	TC	Okay, from here I had yeah the limit for controlled airspace is 1600 feet and I had traffic below that indication 1400 feet, Did you get any other indication?
12.31.35	BMR753G	We got a TCAS?? about 400 feet below us on the turn inbound on the ILS BMR753G
12.31.43	TC	Yeah should be them, that point looked to be around 11 o´clock maybe 2 miles or something
12.31.49	BMR753G	Yeah that looks sounds about right Midland 753G
12.31.55	TC	But confirm you then initiated a descend after that
12.31.59	BMR753G	Negative, we levelled off at 2 or maintained 2100 feet Midland 753G
12.32.04	TC	Okay, you were never below that
12.32.05	BMR753G	Negative Midland 753G

12.32.10	BMR753G	We actually turned towards the south Midland 753G
12.32.14	TC	Yeah I got the turn but my system (were) indicating that you kept descending down to 1 point 6 and he was on 1 point 4
12.32.25	BMR753G	Negative Midland 753G
12.32.28	TC	Sounds good
12.31.31	TC	Midland 753G turn left heading 010
12.32.34	BMR753G	Left 010 Midland 753G
12.32.44	BMR753G	Midland 753G we caught the traffic when we´re intercepting on to the ILS, we actually did maintain 2100 feet. We made a turn to break off to the south. We were visual with the traffic but we did get a resolution advisory on it
12.32.57	TC	I understand, for some reason my system showed you still descending down to 1600 feet
12.33.02	BMR753G	Negative Midland 753G

1.10 Aerodrome information

Norrköping/Kungsängen Airport is a certified instrument airport according to AIP[23] Sweden. The airport has one asphalted runway with the dimensions 2205 x 45 metres and the runway designation 09 and 27.

The airport was equipped with an instrument landing system, ILS for runway 27 that was in use at the time of the incident.

The runway is equipped with low intensity approach and edge lights.

1.11 Flight recorders

Aeroplane A was equipped with DFDR[24], QAR and a CVR[25] and was not available or required for aeroplane B.

1.11.1 Flight Recorders (DFDR, QAR, GPS)

DFDR data were not available, as more than 25 hours had elapsed between the event and the time when SHK was notified.

BMI normally saved QAR data as they used Flight Data Monitoring, a system that is not a requirement for aircraft under 27 000 kg and operating for commercial air transport. However, the data was not saved as the current aircraft's QAR had failed the same day as the incident.

1.11.2 Cockpit Voice Recorder (CVR)

CVR data was not saved as too long time had elapsed between the event and the time when SHK was notified and the unit's storage space had been overwritten.

[23] AIP (Aeronautical Information Publication).
[24] DFDR (Digital Flight Data Recorder).
[25] CVR (Cockpit Voice Recorder).

1.12 Site of occurrence

The incident occurred over the south-eastern part of Söderköping and southeast of the VFR report point DOCKAN.

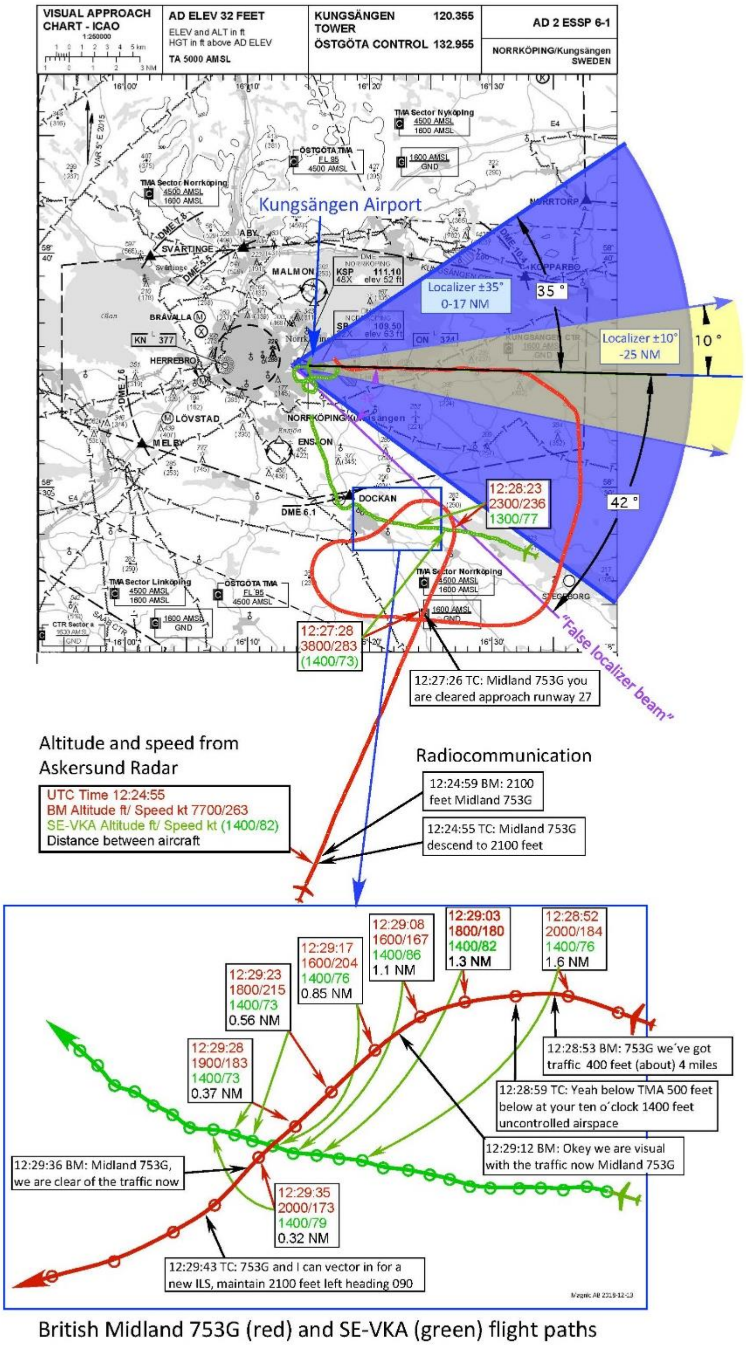

Figure 5. Map of the event. Midland in red and SE-VKA in green.

Figure 5 shows the position of the event and aircraft routes. The box below details how Midland (red line) gradually approaches SE-VKA (green line) in a descend, ending up 200 feet above it at a lateral distance of 0.85 NM. It is also from this time in the event that Midland's action to increase vertical speed has begun to take effect. During the seconds that follow, the sequence shows how Midland's altitude increases and that the two aircraft's routes no longer caused any direct collision risk.

1.12.1 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 the air traffic controller's 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 the layer between controlled and uncontrolled airspace. Swedish airspace is divided into airspace classes, (See figure 6). This incident took place in airspace class C and G.

In airspace class C, all aircraft must be separated from each other, whereas in class G, there is no separation. One aircraft was flying in accordance with IFR and the other in accordance with visual flight rules (VFR). The required separation in class C airspace is three nautical miles horizontally or 1 000 feet vertically.

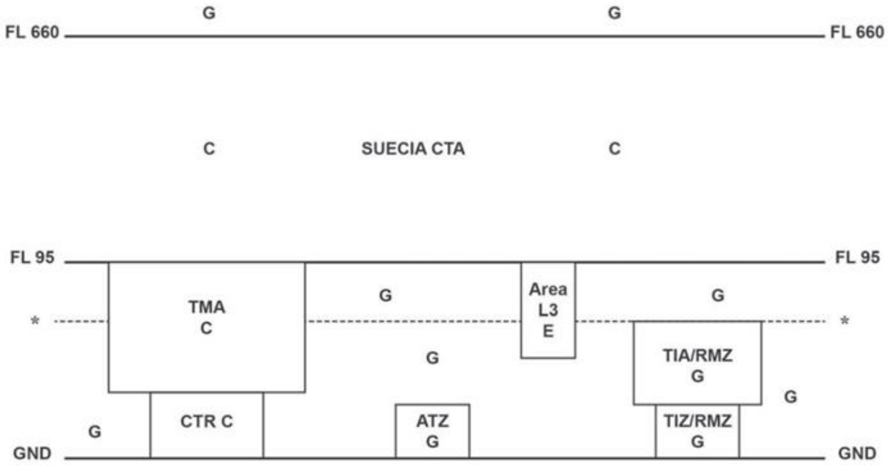

Figure 6. Airspace classification (AIP Sweden).

1.12.2 Responsibilities and regulations in the airspace in question

An air traffic controller's responsibility in airspace class C is to ensure that the specified separation minima in altitude and distance are complied with, to promote orderly air traffic and to provide advisory and information.

For airspace class C, all aircraft require clearance for all flights.

This incident occurred in daylight and the minimum separation in altitude in the TMA, which is airspace class C, is 1 000 feet between IFR/IFR and IFR/VFR. In the case of VFR in TMA, there is a separation in altitude by 1 000 feet towards IFR but only traffic information is provided along with flight advisory to other VFR upon request. Laterally, the minimum separation is three NM between IFR/IFR and IFR/VFR.

The lowest radar altitude is the altitude determined in the respective TMA with regard to obstacles, which is 500 feet above the bottom of the TMA, i.e. 2 100 feet in this case. The limit of 500 feet above the bottom of the TMA is due to the VFR being able to fly up to the lower limit of the TMA without radio contact and transponder as it is in class G airspace. In class G airspace, no separation occurs and no clearance is required.

When it comes to this incident, there was no requirement for the air traffic controller to provide information about the VFR traffic outside or below the TMA. Separation applies inside a TMA.

In the case of a TCAS RA, the controller should not intervene but allow the crew to sort out the “situation”.

1.13 Medical and pathological information

Nothing has emerged that suggests that the pilots' mental or physical condition has been impaired before or during the flight.

1.14 Fire

Not applicable.

1.15 Survival aspects

1.15.1 Rescue operation

Not applicable.

1.16 Tests and research

SHK has performed a reference flight in the area around position DOCKAN and found a false localizer signal where the event took place. In connection with this, a glide slope signal was also noted which was followed from 2 100 to 1 600 feet.

SHK has also performed a reference flight in an Embraer 145 simulator to document the presentation of the aircraft's TCAS system and the specific approach to Norrköping/Kungsängen Airport with the operator's Honeywell FMS database.

With an approach from the south towards the final, it was possible to choose IF[26] (SP09[27]) or IAF[28] (SP11), which represented an extension of the final of 9 and 11 nautical miles respectively according to AIP Sweden.

[26] IF (Intermediate Approach Fix).
[27] SP09 – SP corresponds to the identification code for LOC runway 27, 09 corresponds to distance 9 from SP DME.
[28] IAF (Initial Approach Fix).

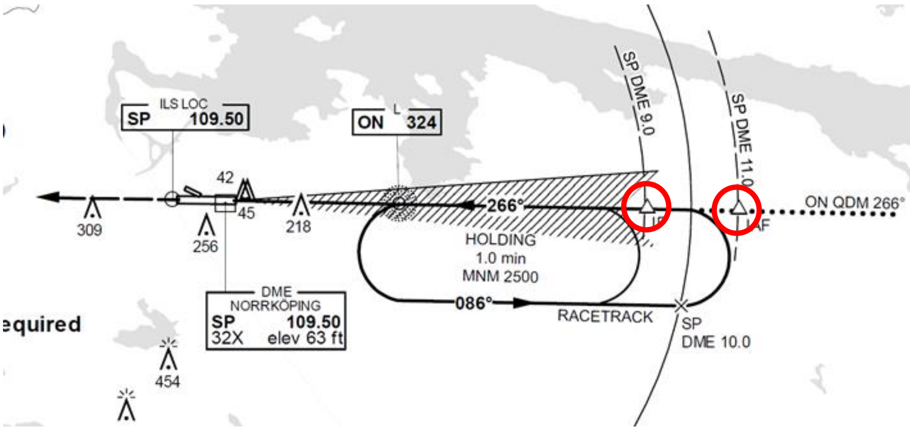

Figure 7. SP9 (IF) and SP11, Distance 9 respective 11 from DME SP. Picture: AIP Sweden.

Embraer 145 has five screens in a row, of which both pilots have a presentation of their screens (PFD[29]) and navigation display as for Embraer 145 is called multifunction display (MFD[30]). Between the two displays of the pilots, there is an EICAS[31] display, which, among other things, presents engine parameters, cautions and warnings (See figure 8).

Figure 8. The screens in flightdeck of the Embraer 145. Picture: Embraer operations manual.

There are several ways to present the approach on the screens.

According to information from the crew, they had the presentation at the final point SP09 (IF) during the approach, which then showed a white line towards their turning point.

The picture below, which was taken during the reference flight, shows an example of when the scale is set to 25 NM. The picture illustrates what the crew, according to their own statement, should have seen during the approach. However, they had chosen a larger scale of 12.5 NM, which gave an even clearer picture of the programmed route.

[29] PFD (Primary Flight Display).
[30] MFD (Multi Function Display).
[31] EICAS (Engine Indications and Crew Alerting System).

Figure 9. Picture taken from the simulator of left pilots PFD and MDF with a range of 25 NM.

1.17 Organisational and management information

1.17.1 BMI

British Midland Express (BMI) was a certified commercial air transport operator for passengers and cargo with an Air operator Certificate issued by the NAA UK.

The certificate's operations specifications included 18 airplanes of the actual type.

1.17.2 Luftfartsverket

LFV is a supplier of air traffic control services approved by the Swedish Transport Agency at Östgöta control centre. The staff is trained and certified according to the Swedish Transport Agency's regulations.

At Östgöta control center (ÖKC), which is located in Norrköping, integrated civil/military air traffic control service is exercised. There are six positions in the central office that serve the airports Linköping/Malmen, Linköping/Saab, Stockholm/Skavsta and Norrköping/Kungsängen. Four of the positions focus on military traffic and two on civilian traffic. The airspace operated by ÖKC has an elevation of 1 600 feet above ground and up to flight level 95 (9 500 feet).

1.17.3 Regulations

The Regulation (EU) 1178/2011 (Part-FCL) states that *“Applicants for an IR*[32] *shall have received a course of theoretical knowledge and flight instruction at an ATO*[33]”. In this training, the pilots should review the limitations of the localizer system in theory and be made aware of false localizer signals that can occur outside the coverage area.

[32] IR (Instrument Rating).
[33] ATO (Approved Training Organisation).

Regulation (EU) 965/2012 on air operations Annex III (ORO.MLR) states that *"the operator shall have a description of all navigation procedures, relevant to the type(s) and area(s) of operation"*. SHK has found that some operators have described the localizer system and its limitations in their operational manuals. However, there was no such information in the British Midland Express manual.

The chapter on autopilot limitations in the airplane operations manual states that:

"Approach mode selection during localizer capture is allowed only when airplane is inbound".

In the LFV's Operational Manual (ref. ATM (LOM) 4.20.8), the controller is expected to give the aircraft clearance towards a point on the approach line, monitor the flight and finally issue a turn instruction from which the aircraft can connect to a final approach. The purpose of this procedure is to reduce the risk of crews making incorrect position adjustments when there are no published approach procedures.

1.18 Additional information

1.18.1 Actions taken

The operator has after the incident implemented a NOTAC[34] for its pilots that describes the company approaches procedures into Norrköping/Kungsängen.

All instrument approaches into Norrkoping on either runway are to be conducted under radar vectoring by Air Traffic Control. If radar vectoring is not available, instrument approaches are to be flown procedurally in accordance with the published arrival and approach charts. Self-positioning to the final approach track for any approach into NRK is not to be conducted until further notice.

Visual approaches may be conducted in appropriate meteorological conditions.

After the incident, the Safety Department at LFV (the department responsible for rules and methods) sent out an operational information letter with a reminder of significant parts of the regulations in LFV LOM when requesting self-positioning for approach.

The operational manager of Östgöta control centre has reviewed the procedure for requests for self-navigation and methodology/actions at TCAS RA with the operational staff.

[34] NOTAC (Notifikation to Air Crew).

Recommendations have been issued in connection with LFV's report, focusing on the procedure for self-positioning towards points on the STAR/final and actions on conflict situations with and without elements of TCAS RA.

1.18.2 Similar events

EASA has, upon request, after searching the European database ECCAIRS found over 100 reported events from incidents involving false localizer and glideslope signals.

The Swedish Transport Agency has received a number of reports on aircraft that have captured and followed false signals by localizer and glideslopes.

Transport (TSB) Canada has in an investigation (A01P0129) of a similar incident from 2002, identified several incidents during the previous decade of aircrafts capturing and following false localizer signals.

1.19 Special methods of investigations

None.

2. ANALYSIS

2.1 Sequence of events

The crew requested and received clearance from the controller for self-positioning for an ILS approach to runway 27. However, the crew did not specify in their request which point on the final they intended to navigate towards. This meant that the controller was not sure how Midland intended to perform the navigation.

When the aircraft was 8–9 NM from the centre line of runway 27 Midland was cleared down to 2 100 feet and cleared for approach. In connection with the clearance, the pilots armed the approach mode when the track was more than 90 degrees from the approach direction, i.e. outbound.

The approach clearance probably contributed to the pilots arming the ILS system. In self-positioning to a point on the approach line, the air traffic controller is expected to monitor the flight and conclude it by issuing a turn instruction from which the aircraft can connect to a final approach and then receive the final approach clearance. An approach clearance issued at a later stage and within the coverage area of the localizer reduces the risk of the crew arming the ILS system to early and thus also the risk of the system catching false lateral signals.

When Midland was about 7 NM south of the final, the aircraft started a left turn due to a "false" localizer signal at +42° from the inbound course, which activated the ILS and gave command to the autopilot. The crew did not identify this, but instead believed that they were on the correct approach line, i.e. 7 NM further north than the aircraft's actual position.

During the approach, both pilots had the approach line presented on their navigation screens (MFDs), which enabled the pilots to notice that the aircraft began to swing at an early stage. This is also supported by the reference flight SHK carried out in the simulator (see section 1.16).

The fact that the pilots did not notice this is probably due to their attention being on the conflicting traffic displayed on the TCAS with subsequent visual scanning outside of the cockpit.

The distraction resulted in the crew's situational awareness of their correct position being reduced, as none of the pilots were paying attention to the upper part of the aircraft's MFD.

The crew was not aware of the risk that a false localizer signal could be captured by the aircraft's ILS. SHK returns to the question of training in section 2.2.

The controller initially believed that there was nothing abnormal about the turn, that it was only an adjustment of the course towards the approach point and that Midland was probably visual with the airport. Against that background, the controller did not see any reason to intervene.

When Midland passed 270 degrees during a left turn and descended below the lowest radar vectoring altitude, and simultaneously approached a conflict situation with SE-VKA, there were sufficient indications that something was not right and that an immediate intervention by the air traffic controller had been justified. At that stage, however, there was communication between the air traffic controller and Midland regarding the conflicting VFR traffic. The communication was certainly an interfering element, which contributed to the failure to make a correction.

According to the crew, the TCAS was activated while the aircraft turned and descended, resulting in the RA command *"MONITOR VERTICAL SPEED"* which means that the crew must follow a green area on the vertical speed indicator to avoid collision and at the same time make the call *"TCAS RA"* to the flight controller. No such call was made. In most cases, a TA occurs before an RA, but in this case, the RA was given immediately according to the crew. In connection with pilots being trained and tested in the simulator, a TA is given first, which makes the pilots monitor and prepare for a possible RA command. Since, according to the crew, there was no TA, which is thus reasonably expected by pilot, this may have been the reason why no call *(TCAS RA)* was made regarding the collision incident.

2.2 Requirements, procedures and training

The autopilot captured a false localizer and glideslope signal after the crew armed the approach mode to comply with the ILS. False localizers outside its coverage area are known and not an uncommon phenomenon. Knowledge of this should have been acquired in connection with theoretical training according to the requirements for training for instrument competence (IR) in PART-FCL.

The company has not described the risks of false localizer signals in its operation manuals. No recurrent training has been provided and thus the risks of possible consequences from false ILS signals have not been communicated by the company. Knowledge in this regard, which the crew is expected to have, instead comes from the basic training for instrument competence. The company took certain measures after the incident that solves the problem when approaching Norrkoping. However, this does not solve the problems that may arise at other airports around the world. The measures show that there was no knowledge within the company of the basic problem of false localizer signals and its occurrence.

As mentioned, there are no other requirements, as far as SHK is aware, for training regarding these risks other than the requirements of PART-FCL in connection with the basic training for instrument competence. In many cases, it can thus be several years or even decades since a pilot was given this specific information. Since there are also no requirements in the current regulations on recurrent training that deal with these issues, the likelihood that the knowledge about false localizer signals is forgotten increases. The review of similar events carried out by SHK (see section 1.8.3) shows that the phenomenon is not unusual and that the pilots did not always understand why the aircraft behaved as it did, but that it was instead perceived as a technical fault.

This type of risk, like all possible risks, must be captured in the operator's safety management system. However, as can be seen, this is not always the case. In SHK's opinion, EASA should ensure that there are clear requirements regarding the limitations of conventional navigation aids included in the recurrent training.

3. CONCLUSIONS

3.1 Findings

a) The pilot was qualified to perform the flight.
b) The aircraft had a Certificate of Airworthiness and valid ARC.
c) The air traffic controller was authorized to perform flight control service at position TC at Östgöta control center.
d) The event occurred under visual weather conditions.
e) The criteria for activating approach mode were not met.
f) When the crew armed the approach mode, the aircraft was within the recommended distance from the airfield but outside the limits of the ILS lateral distance to the center line.
g) A false localizer was captured and followed outside the ILS coverage area.
h) A false glide slope signal was probably also followed.
i) Similar events involving aircrafts capturing and following false localizer signals have occurred and been reported.
j) A collision incident occurred when Midland descended towards SE-VKA, which was in uncontrolled airspace.
k) During the closure, an RA was given in the form of *"monitor vertical speed"*.
l) LFV has issued recommendations focusing on the procedure for self-positioning towards point on the approach line and acting on urgency from acute conflict situations with and without elements of TCAS RA.

3.2 Causes/Contributing Factors

The serious incident was caused by the fact that planning and follow-up of the approach were not carried out in an appropriate manner.

A contributing factor has been lack of knowledge of false ILS signals.

4. SAFETY RECOMMENDATIONS

EASA is recommended to:

- Ensure that clear requirements regarding the limitations of conventional navigation aids are included in the recurrent training. (see chapter 2.2) *(RL 2019:12 R1)*

The Swedish Transport Agency is recommended to:

- Evaluate and consider whether AOC holders have prescribed and appropriate procedures to monitor crew member knowledge of the limitations of conventional navigation aids. (see chapter 2.2), *(RL 2019:12 R2)*

- Inform air traffic control providers about the risks of issuing an approach clearance at an early stage. (see chapter 2.2), *(RL 2019:12 R3)*

The Swedish Accident Investigation Authority respectfully requests to receive, **by 8 January 2020** at the latest, information regarding measures taken in response to the safety recommendations included in this report.

On behalf of the Swedish Accident Investigation Authority,

Mikael Karanikas Johan Nikolaou