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Swiss Transportation Safety Investigation Board STSB

Final Report No. 2342 by the Swiss Transportation Safety Investigation Board STSB

Concerning the serious incident involving the SAAB 2000 aircraft, HB-IZW, operated by Etihad Regional/Darwin Airline under flight number AB 8054,

on 10 December 2015

4.5 NM east of Billund Airport (EKBI), Denmark

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General information on this report

This report contains the Swiss Transportation Safety Investigation Board's (STSB) conclusions on the circumstances around and causes of the serious incident under investigation.

In accordance with Article 3.1 of the 10th Edition of Annex 13, effective from 18 November 2010, to the Convention on International Civil Aviation of 7 December 1944 and Article 24 of the Federal Aviation Act, the sole purpose of an investigation into an aircraft accident or serious incident is to prevent further accidents or serious incidents from occurring. Legal assessment of the circumstances and causes of aircraft accidents and serious incidents is expressly excluded from the safety investigation. It is therefore not the purpose of this report to establish blame or to determine liability.

Should this report be used for purposes other than those of accident prevention, this statement should be given due consideration.

The German version of this report constitutes the original and is therefore definitive.

Unless otherwise indicated, all information relates to the time of the serious incident.

All of the times mentioned in this report, unless otherwise indicated, are given in coordinated universal time (UTC). For the regions of Denmark and Germany, Central European Time (CET) was the local time (LT) at the time of the serious incident. The relationship between LT, CET and UTC is:
LT = CET = UTC + 1 h

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Summary

Overview

Owner	Nordic Aviation Capital A/S, Stratusvej 12, 7190 Billund, Denmark
Operator	Darwin Airline SA, via alla Campagna 2A, 6900 Lugano, Switzerland
Manufacturer	Saab Aircraft AB, Stockholm, Sweden
Aircraft type	SAAB 2000
Country of registration	Switzerland
Registration	HB-IZW
Location	4.5 NM east of Billund Airport, Denmark
Date and time	10 December 2015, 13:21 UTC

Investigation

The serious incident took place on 10 December 2015 at 13:21 UTC. The Swiss Transportation Safety Investigation Board (STSB) received notification of the incident on 11 December 2015 at 14:00 UTC. The Danish investigation board then delegated the investigation to Switzerland. Subsequently, the investigation board appointed an authorised representative who took part in the investigation. The STSB opened the investigation on 21 December 2015.

Essentially, the following were available for the investigation:

- Recordings of the radio communication, the radar and QAR[1] data
- Statements made by crew members

This final report is published by the STSB.

Synopsis

On 10 December 2015 at 12:14 UTC, the SAAB 2000 aircraft registered as HB-IZW took off from Berlin Tegel Airport (EDDT) for a scheduled flight to Billund Airport (EKBI) under flight number AB 8054. On this flight, the commander was the pilot flying.

After an uneventful cruise flight, the pilots noticed problems with the glideslope indication during the approach to Billund Airport. At an altitude of 800 ft above ground and 250 ft below the minimum altitude stipulated for this position, the pilot flying initiated a go-around.

Because of the problems with the glideslope indication, the pilots decided to perform a non-precision approach using the localiser for the second approach. During this approach, the aircraft descended too steeply and continued to descend below the stipulated minimum altitudes. The excessive descent then triggered the ground proximity warning system to which the pilots reacted with another go-around. After they had completed an analysis of the problem, the crew decided to return to Berlin. The remainder of the flight was uneventful.

[1] QAR: Quick access recorder – a device that, similar to a flight data recorder, records important parameters which the airline uses to supervise flight operations and for maintenance purposes.

Causes

The serious incident emerged from the aircraft’s descent below the stipulated minimum altitude for a non-precision approach. Therefore, a safe altitude above the obstacles was no longer guaranteed.

The crew’s poor monitoring of the vertical flight path has been identified as the direct cause of the incident.

The following factors have been identified as directly contributing to the serious incident:

- Deficient approach planning with regards to the vertical flight path.
- Reduced performance of the pilot flying, probably due to tiredness.

The approach chart, which had no distance/altitude table and thereby impeded the monitoring of the approach, systematically contributed to the serious incident.

Although it did not influence the development and course of the serious incident, the following risk factor was identified during the investigation:

- The procedure following a warning from the enhanced ground proximity warning system (EGPWS) was not consistently applied.

Safety recommendations

No safety recommendations nor pieces of safety advice are issued with this final report.

1 Factual information

1.1 Background and history of the flight

1.1.1 General

The commander was the pilot flying (PF) and the first officer was the pilot monitoring (PM) throughout the entire flight during which the serious incident took place.

The flight was conducted under instrument flight rules (IFR) and was a scheduled flight from Berlin Tegel Airport (EDDT) to Billund Airport (EKBI).

1.1.2 Background

According to the pilot's original roster, he was scheduled to have a day off in Prague on 8 December. For 9 December, three flights were scheduled with his shift ending at 11:10 UTC and being followed by an overnight stay in Berlin. For 10 December, his shift was planned to begin at 11:05 UTC and to consist of five flights. However, Operational Planning changed the shift plan. The pilot was instead rostered for five flights on 8 December and his shift ended at 21:51 UTC. His day off was now planned for 9 December in Prague. On this day, he went to a private appointment which, because of the original roster, he had arranged to take place in Berlin. He flew on Air Berlin AB 8243 from Prague to Berlin. The flight's departure time was 09:39 UTC and the arrival time was 10:28 UTC. For the return flight in the evening, he took flight AB 8240 which left Berlin Tegel at 20:36 UTC and landed in Prague at 21:32 UTC.

On 10 December, the day of the serious incident, the pilot was picked up from the hotel at 04:20 UTC so he could begin his shift at 04:35 UTC at Prague Airport. The pilot had 6 hours and 48 minutes between the arrival of his flight in Prague on 9 December 2015 and the hotel pick-up time for the flight on 10 December. This period of time also includes the hotel transfer, check-in and the time between getting up and being picked up from the hotel. The subsequent three flights followed: AB 8241 from Prague to Berlin Tegel, AB 8242 from Berlin Tegel to Prague and AB 8243 from Prague to Berlin Tegel – he conducted these three flights with a different first officer. At 11:05 UTC he met the first officer involved in the serious incident to plan the flights to Billund and back to Berlin Tegel.

There had not been any roster change for the first officer. He was scheduled to have a day off on 8 December in Prague. On the morning of 9 December 2015, he completed three flights; his shift ended at 10:59 UTC with a subsequent overnight stay in Berlin.

The first officer began his flight duty at 11:05 UTC on 10 December 2015, the day of the serious incident, in Berlin by planning the flights from Berlin Tegel to Billund and back. He held the rank of a captain at Etihad Regional, but he fulfilled the role of a first officer.

The two pilots already knew each other and, according to their statements, the working atmosphere was good. Once they had completed the planning, the crew prepared the aircraft for the upcoming flight together. Everything went according to plan and the aircraft was ready to fly without any restrictions.

1.1.3 History of the flight

On 10 December 2015 at 12:14 UTC, the SAAB 2000 aircraft registered as HB-IZW took off from Berlin Tegel Airport (EDDT) for a scheduled flight to Billund Airport (EKBI) under flight number AB 8054. On board were two pilots, one cabin crew member and 26 passengers.

The climb and cruise flight were uneventful. The crew obtained information from the Automatic Terminal Information Service (ATIS) with the identification code UNIFORM in good time and conducted the approach briefing. An instrument landing system (ILS) approach to runway 27 was discussed, which begins at 2,000 ft AMSL[2] as standard.

In good time, air traffic control granted clearance to fly directly to waypoint LOKSA, which is located on the long final approach to runway 27 at a distance of 11 NM. At 13:01 UTC, the aircraft was descending 16 NM east-south-east of Billund Airport and was just passing flight level (FL) 45 when the crew was instructed to turn 10 degrees to the left and to descend to 3000 ft AMSL, which shortened the flight path slightly. At 13:02 UTC, another shortcut was issued by instructing the crew to turn left to a heading of 290 degrees and to descend to 2,000 ft AMSL. At the same time, the crew received clearance for the instrument approach to runway 27.

The approach to the level of the localiser could be seen on the first officer's displays much sooner than on the commander's displays. Shortly before the aircraft was aligned to the localiser, the first officer also noticed that the glideslope indicator was briefly displayed and was followed shortly afterwards by a glideslope flag on the primary flight display (PFD), which disappeared immediately.

At 13:03:45 UTC, at 9.4 NM and an altitude of 2,000 ft AMSL, the aircraft was aligned to the localiser and was being configured for the approach.

At a distance of 8.7 NM to the runway threshold, the glideslope indicator showed a quick approach to the glideslope, which caused the autopilot to switch to capture mode[3]. During this phase, the pilot noticed the quick approach to the glideslope and that the indicator was fluctuating. A couple of days earlier, he had observed fluctuations on the glideslope indicator when approaching the glideslope of runway 27's ILS at Billund Airport from an altitude of 3000 ft in a different SAAB 2000. In that instance, the autopilot had led the aircraft onto the glideslope without any problems. Thus, he observed the fluctuations again on this occasion and allowed the autopilot to steer the aircraft onto the glideslope. The fluctuations were bigger this time and did not stabilise as quickly as they had done the last time.

After the autopilot had switched to capture mode, the glideslope indicator moved upwards to 'fly up' and the autopilot followed the indicator (see illustration 3). At 8.5 NM the glideslope indicator was centred, however, subsequently it fluctuated between 'full fly up'[4] and the centred display. This caused the aircraft to climb.

At 13:04:18 UTC, another commercial aircraft under flight number KLM 34K was cleared for take-off by the Billund Tower air traffic controller (ATC). At this time, AB 8054 was at 8.2 NM climbing at a vertical speed of 1900 ft/min. at 2,200 ft AMSL and the glideslope indicator showed 'full fly up'. The pilot switched off the autopilot and controlled the aircraft manually. At 8.1 NM and an altitude of 2,300 ft AMSL the glideslope indicator moved without fluctuations towards the centred position and remained stable at a slight deviation. At 13:04:50 UTC, at 7.6 NM, the fluctuations restarted and by this time the aircraft had reached 2,600 ft AMSL and was beginning to descend again. At this point, the commander switched on the autopilot and switched it off again at 7.3 NM. Between 7.3 NM and 5.5 NM the

[2] AMSL: Above mean sea level

[3] Capture mode: Operating mode of the autopilot where it captures the localiser signal or the glideslope signal and aligns the aircraft to these signals to follow them subsequently.

[4] On the glideslope display there are deviation scales above and below the centre line, each has two dots, which indicate the position of the aircraft in relation to the nominal glideslope. One dot is equivalent to an angular degree of 0.5. 'Full fly up' is displayed when the glideslope indicator is at the upper stop which means the aircraft is more than 1° below the nominal glideslope.

deviations from the localiser were less than 0.5 dots and the glideslope deviation was less than one dot with the glideslope indicator still fluctuating.

At 13:05:15 UTC, the aircraft was at a distance of approximately 6.7 NM and the crew notified the ATC of the problems with the ILS display. The ATC asked if they wanted to abort the approach to which the crew responded in the negative. They stated that they wanted to continue flying up to the outer marker. Subsequently, the ATC granted the aircraft clearance for landing.

According to the pilot's statement, the wind speed was approximately 50 kt. According to the recordings, the head wind component during the approach fluctuated between 20 kt and 44 kt. The indicated airspeed (IAS) fluctuated between 141 kt and 154 kt. The ground speed (GS) fluctuated between 103 kt and 120 kt.

At 5.5 NM and an altitude of 1750 ft AMSL, the larger fluctuations on the glideslope indicator returned, fluctuating between 'full fly down' and one dot 'fly up'.

At 13:05:59 UTC, KLM 34K was climbing at an altitude of 1,600 ft AMSL approximately above the end of runway 27.

At 13:06:13 UTC, the ATC told the crew of AB 8054 that the ILS was functioning properly as far as he could tell. AB 8054 replied, "*But, uh, it's going off and on, the localizer, we continue with the localizer, glideslope out, for the time*," whereupon the ATC advised the crew of a cloud base at 600 ft AGL[5], turned the approach lighting to maximum brightness and once again granted the crew clearance to land. The decision altitude for a localiser approach to runway 27 was 306 ft above the altitude of the runway threshold.

When the distance measuring equipment (DME) – which enables a continuous display of the distance to the landing threshold – showed a distance of 4.5 NM, AB 8054 was at an altitude of 1250 ft AMSL which is equivalent to approximately 1000 ft AAL[6]. The glideslope indicator was still fluctuating between 2 dots 'fly up' and 1 dot 'fly down'.

At 13:06:33 UTC, the digital flight data recorder (DFDR) data showed a message for 4 seconds, which pointed to a discrepancy between the two systems (see section 1.6.2.2).

Approximately 5 seconds later, at an altitude of 1050 ft AMSL (which is equivalent to approximately 800 ft AAL), when the DME showed 3.9 NM and two dots 'fly up' were displayed, the commander initiated a go-around.

At 13:07:04 UTC, the crew reported that they were executing a go-around and would be climbing to 2000 ft in a straight line. During this go-around, the crew briefly climbed to 2600 ft AMSL and subsequently descended back to 2000 ft. The initially angle nose-up attitude (ANU) of 2.5° was maintained for about 8 seconds, the ANU was then increased to 7.5°. During this phase the speed of the aircraft rapidly increased, and the V_{LO}[7] and V_{FE}[8] were exceeded by 5 kt and 4 kt respectively.

After another check of the ILS, the ATC confirmed once more that the ILS was functioning properly and that the fault was more likely to be in the aircraft's equipment. He asked the crew if they wanted to make another attempt, whereupon the crew replied that the aircraft systems might have a fault and that they therefore

[5] AGL: Above ground level

[6] AAL: Above aerodrome level

[7] V_{LO}: Limiting speed when retracting or lowering the landing gear

[8] V_{FE}: Limiting speed for extended landing flaps

wanted to conduct a non-precision approach using the localiser: *"Yes, but we had a full deflection just at the intercept, about 8 miles out, and then it was going on off on off all the approach until the outer marker and then we decided to make a go-around. So, in this case I think, maybe our equipment has a problem, we will make a localizer glideslope out approach, fully established stabilized, expect a ground speed of about 140 knots."*

Subsequently, the crew was advised to switch to the Billund approach frequency on which they requested radar vectoring to 3000 ft AMSL in order to pick up the localiser 13 NM before the landing threshold. After a short analysis of the situation, the crew decided on a localiser approach. A short approach briefing was conducted during which the PM added that, in accordance with the table on the approach chart, an average rate of descent of 750 ft/min. was to be expected for a ground speed of 140 kt (see section 1.8.2).

The crew received radar vectoring as requested. During the new approach, the aircraft was already aligned to the localiser 13 NM before the landing threshold. At 10 NM, the aircraft was configured for the approach. The crew decided to initiate the descent 1 NM before the point of descent. At 9.4 NM, the vertical speed mode was selected, and the descent initiated at a rate of 800 ft/min. At this time, the commander noticed that there was no recommended altitude descent table on the approach chart for the final descent, just two altitudes to be observed due to obstacles: the minimum altitude above the outer marker and the approach minimum. Thereupon he asked the first officer to keep an eye on the vertical profile and concentrated on monitoring the autopilot. According to the crew, the weather was challenging due to the low clouds and the turbulent wind.

During the descent, the PM tried to calculate the reference altitude for the correct glide path for a specified distance. He was not able to calculate this because he wanted to use the DME distance but could not find any DME information on the approach chart. He did not communicate that he was unable to come to a result and hence was not monitoring the vertical flight profile. The PF assumed that the PM was monitoring the vertical profile and was therefore not doing it himself. The display of the ILS glideslope was still fluctuating; the localiser indicator was stable. From 6 NM until they performed the go-around, the glideslope indicator mainly showed 'full fly up', but it was still fluctuating. However, the crew consciously ignored this as the indicator was considered to be faulty and they had decided to fly a non-precision approach.

When the aircraft was at a DME distance of 5.5 NM and an altitude of 1240 ft AMSL, the auto-callout 'one thousand' sounded, meaning that the aircraft was 1000 ft above ground. According to their statements, the crew noticed at this time that something was not right, but they did not realise what was wrong. 19 seconds later, the enhanced ground proximity warning system (EGPWS) sounded for one second with a glideslope warning. According to their statements, the crew was convinced that something was wrong when the auto-callout 'five hundred' sounded another 12 seconds later. 7 seconds later, at an altitude of 757 ft AMSL or 404 ft AGL, the PF decided to initiate a go-around. At approximately the same time, the EGPWS 'terrain ahead, pull up' warning sounded.

The PF flew the normal go-around procedure and, one second after the EGPWS warning, the go-around mode was active. The lowest altitude during the go-around was 700 ft AMSL or 346 ft AGL.

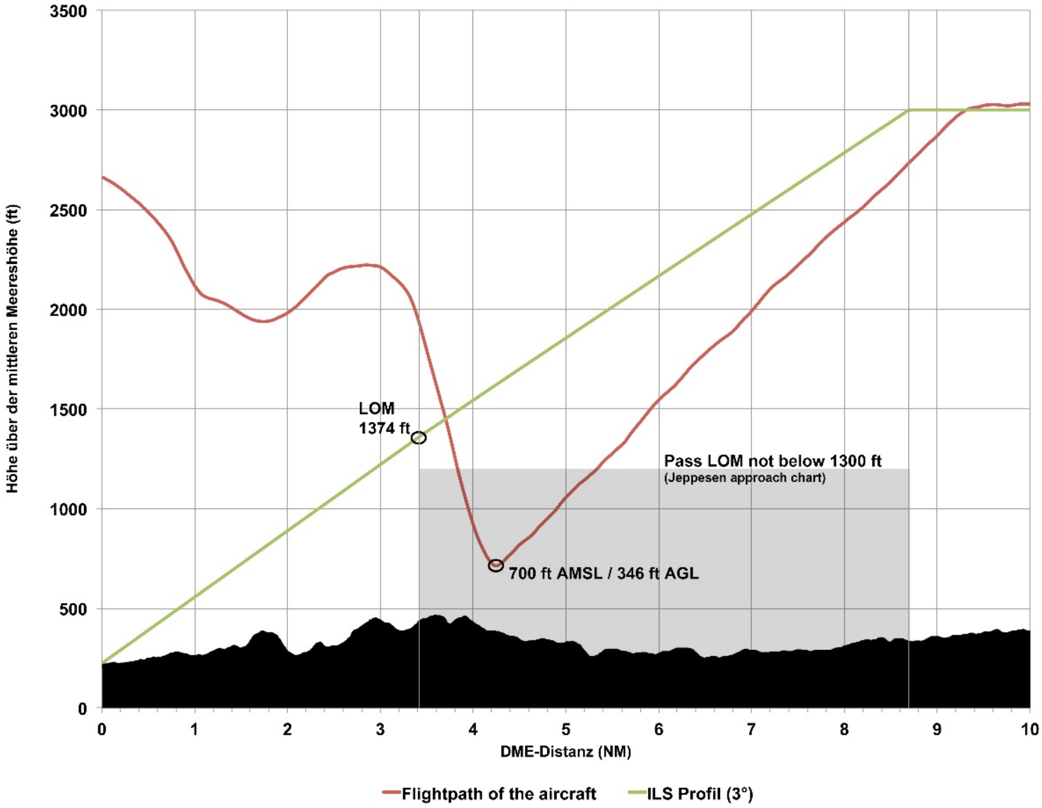


Illustration 1: The vertical profile of the localiser approach according to the DFDR data (red line) compared to a continuous descent final approach[9] (green line). The grey area shows the lower approach limit, which an aircraft must not fly below until reaching the outer marker (LOM).

The average vertical approach speed was 771 ft/min. The indicated airspeed (IAS) was approximately 140 kt. The average ground speed was 103 kt. This resulted in an average vertical flight angle of -4.2 degrees.

After the go-around, the crew requested a climb above the clouds to have time to come to a decision. After assessing the problem, the weather, the remaining fuel and the operational conditions, the crew decided to fly back to Berlin Tegel as the weather in Berlin allowed for a visual approach. The flight to Berlin Tegel and the approach were uneventful. There were also no inaccurate indications during the ILS approach to Berlin Tegel Airport.

1.1.4 Location and time of the serious incident

Location	4.5 NM east of Billund Airport (EKBI)
Date and time	10 December 2015, 13:21 UTC
Light conditions	Daytime
Altitude	700 ft AMSL

[9] Continuous descent final approach (CDFA): Non-precision approach procedure with a continuous descent to the decision altitude.

1.2 Injuries to persons

1.2.1 Injured persons

Injuries	Crew	Passengers	Total no. of occupants	Third parties
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	0	0
None	3	26	29	n/a
Total	3	26	29	0

1.3 Damage to aircraft

The aircraft was not damaged.

1.4 Third-party damage

There was no third-party damage.

1.5 Information on people concerned

1.5.1 Flight crew

1.5.1.1 Commander

Person	Italian citizen, born 1971	
Licence	EASA (European Aviation Safety Agency) airline transport pilot licence aeroplane (ATPL (A)), issued by the Federal Office of Civil Aviation (FOCA)	
Flying experience	Total	8022 h
	On the incident type	170 h
	During the last 90 days	97 h
	Of which on the incident type	97 h

All of the available information indicates that the commander reported for duty healthy. There are indications that fatigue may have been a factor at the time of the serious incident (see section 2.2.2).

Whilst working with Etihad Regional / Darwin Airline, the commander had the following additional functions: Theoretical Knowledge Instructor, ATR Chief Fleet, Training Captain, SAAB Chief Fleet.

1.5.1.2 First Officer

Person	Austrian citizen, born 1964	
Licence	EASA ATPL (A), issued FOCA	
Flying experience	Total	12 100 h
	On the incident type	1180 h
	During the last 90 days	72 h
	Of which on the incident type	72 h

All of the available information indicates that the first officer reported for duty well-rested and healthy. There is no indication that fatigue was a factor at the time of the serious incident.

Since 2010, the first officer, who was then employed as a captain, had a history of shortcomings in the areas of systematics, communication and compliance with standard operating procedures (SOP). The training department tried to correct these shortcomings through discussions and additional training. After a line check in 2013, it was decided to roster him again as a first officer. Since then he has held the rank of a captain but has been flying as a first officer.

Whilst working at Etihad Regional / Darwin Airline, the first officer had the following additional functions: Deputy Post Holder Flight Operations, Post Holder Flight Operations, Flight Ops Engineering.

1.6 Information on the aircraft

1.6.1 General information

Registration	HB-IZW
Aircraft type	SAAB 2000
Characteristics	Twin-engined, regional, jet-prop aircraft designed as a self-supporting, low-wing monoplane in an all-metal construction with retractable landing gear in a nose-wheel configuration
Manufacturer	Saab Aircraft AB, Stockholm, Sweden
Owner	Nordic Aviation Capital A/S, Stratusvej 12, 7190 Billund, Denmark
Operator	Darwin Airline SA, via alla Campagna 2A, 6900 Lugano, Switzerland
Mass and centre of gravity	The operational flight plan and the calculation of mass and centre of gravity were no longer available. According to the flight data monitoring (FDM) it is very likely that both mass and centre of gravity were within the permissible limits of the aircraft flight manual (AFM).

1.6.2 Selected aircraft systems and equipment

1.6.2.1 Ground proximity warning system

The aircraft involved in the serious incident was equipped with an enhanced ground proximity warning system (EGPWS). This system continuously compares the intended flight path (both the horizontal and the vertical aircraft position) with a safe flying altitude (terrain clearance floor - TCF), which depends on the distance to the runway. This TCF relates to obstacle data that are stored in the system's database. The warning envelope can be imagined as a funnel with the runway at its centre (see illustration 2). If an aircraft flies below this altitude, the system generates the acoustic notification 'too low terrain' and, in addition, the 'TERRAIN/BELOW G/S' indicators flash on the glare shield, i.e. directly in the pilots' field of view.

During the second approach to Billund Airport, the EGPWS warning 'too low terrain' was generated approximately 5 NM before the runway threshold. At this distance, the safe flying altitude was 400 ft AGL. The pilots can have the obstacles shown on their navigation displays (ND). Here, the obstacles are displayed in various gradings from red to yellow to green depending on the flying altitude. At a flying altitude of 400 ft AGL, the NDs show the obstacles as green dots with a density of 50%.

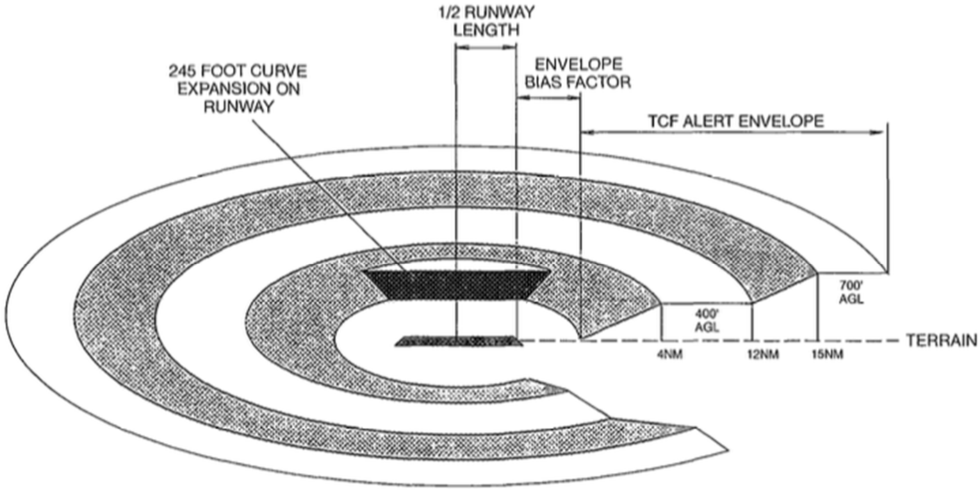


Illustration 2: Warning envelope with the runway at its centre

1.6.2.2 Electronic flight instrument system (EFIS)

The EFIS receives data from various systems and converts these into appropriate symbols and text for the primary flight display (PFD) and the ND. The information fed into the EFIS includes position data, speed data, radio altitude data, localiser data, glideslope data and navigation data (see illustration 3).

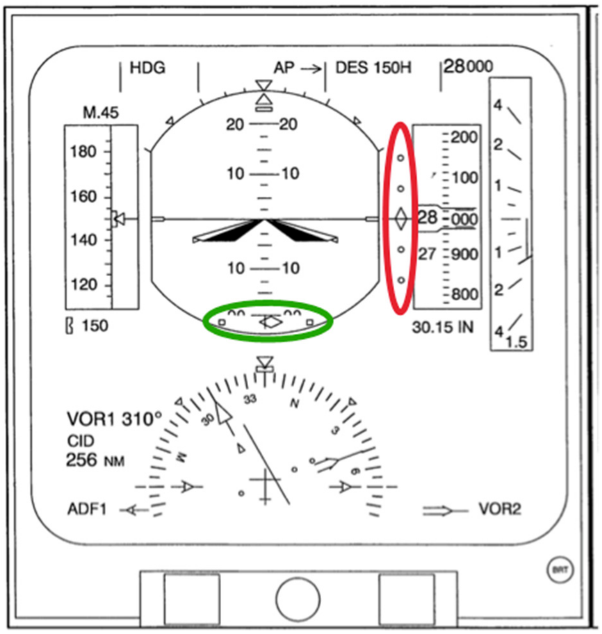


Illustration 3: This illustration of the PFD shows the artificial horizon with the landing course indicator (circled in green) and the glideslope indicator (circled in red) in the upper

half. The position of both the localiser and the glideslope is displayed as a diamond shape. If the diamond shape for the glideslope is displayed above the centre line, the aircraft is below the nominal glide angle. If the symbol is displayed below the centre line, the aircraft is flying above the nominal glideslope. The glideslope display has deviation scales above and below the centre line and each has two dots (here displayed with small circles). If the symbol for the glideslope is at the first dot above the centre line, this is called 'one dot, fly up'. A display is called 'two dots, fly up' when the symbol is at the second dot above the centre line. The equivalent expressions for displays below the centre line, are '...dot(s), fly down'.

For redundancy reasons, large parts of the avionic system are provided twice. The EFIS receives data from these duplicate systems and compares most of the data for discrepancies. If there are differences between these data, the crew is warned through appropriate notifications (see illustration 4). In this investigated incident, the discrepancies of the glideslope indicators caused by the fluctuation of the glideslope signal during the first approach led to a glideslope comparator caution warning being displayed on the PFD.

The position of the aircraft in relation to the artificial horizon can be read at any time on the PFD, however, it is not possible to display the aircraft vector in 3D-space. The ILS glideslope signal and programmed or manually entered glide angles can be displayed on the PFD and thus provide information on the vertical position of the aircraft during an approach.

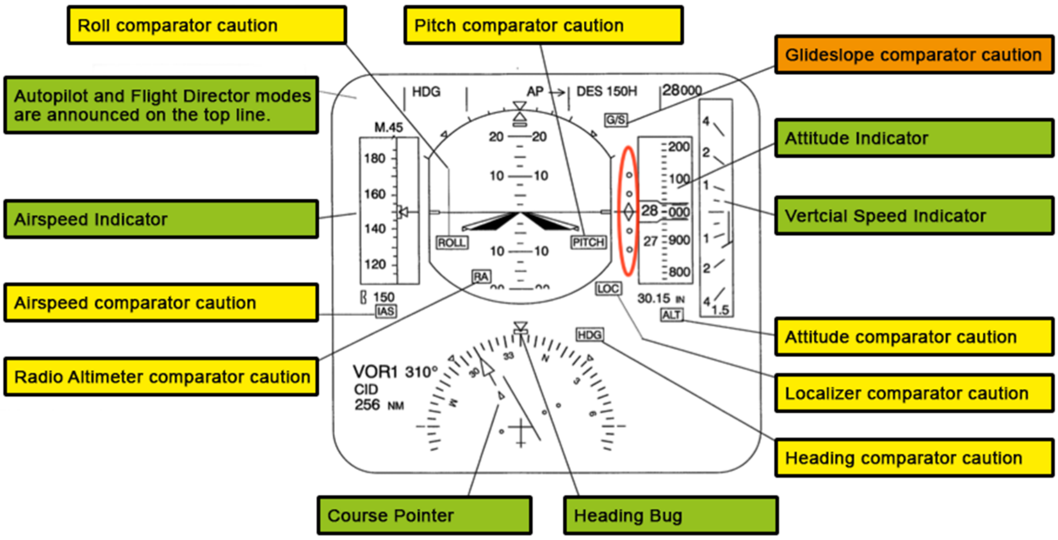


Illustration 4: The PFD with various indicators (green boxes), possible warnings regarding a discrepancy between the redundant systems (yellow boxes) and the above-mentioned warning regarding the glideslope (orange box).

In the top left corner, the ND always shows the ground speed (GS), the wind direction and the wind speed.

1.6.2.3 Data concentrator unit

The data concentrator units (DCU) are interfaces between the various aircraft systems and the engine indicating and crew alerting system (EICAS), which shows the crew engine data and warnings, amongst other things. Two DCUs performing identical functions are fitted to the avionic rack of the SAAB 2000. The duplicate design was selected for redundancy reasons.

The DCUs receive analogue signals, time-discrete signals and various digital signals from the engines and other systems. They convert and concentrate these signals for the EICAS indicators. In addition, the DCU generate system-related warning messages and the related visual and acoustic notifications for the pilots.

The DCUs are connected to the ILS receiver via the integrated avionics processing system (IAPS), which collects and checks data from various systems (see illustration 5).

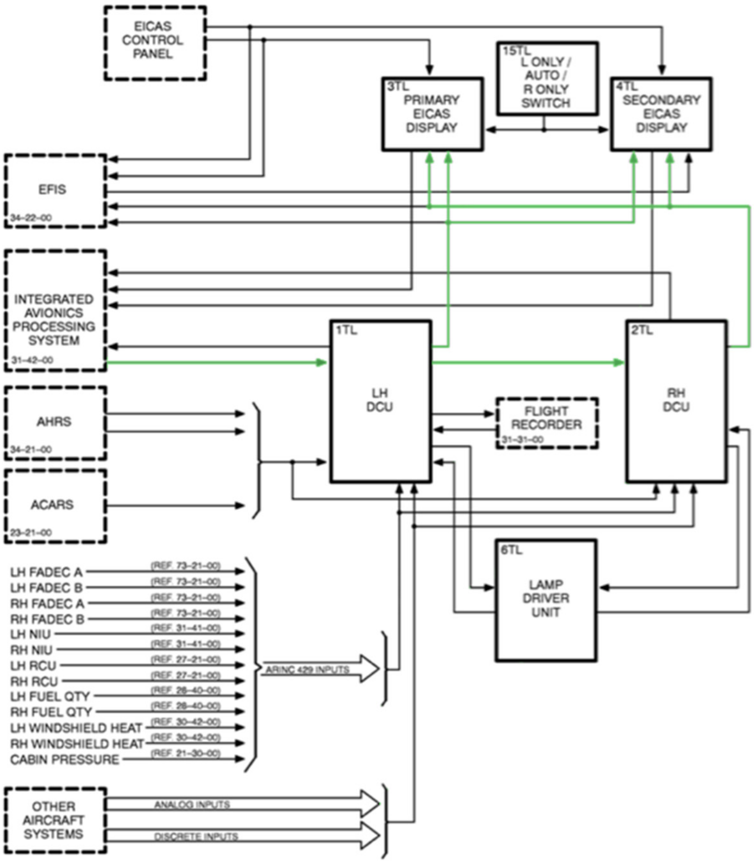


Illustration 5: The glideslope signal’s data flow (green arrows) from the IAPS via the DCUs to the primary EICAS display.

1.6.2.4 Flight management system

The Collins 4200 flight management system (FMS) is used for navigation and flight planning. With this system, the desired horizontal flight path can be programmed or retrieved from a database. For easier understanding, these data are then displayed on the ND and the PFD. The SAAB 2000’s FMS can display approach and departure paths both horizontally and vertically. If not already available in the database, vertical altitude limits can be programmed manually and displayed on the ND. On the PFD, it is possible to display a freely selectable glide angle starting from a navigation point. However, this function only serves to increase awareness, as it cannot be coupled to the autopilot.

In this investigated incident, all horizontal and vertical data had already been available in the FMS’s database. This could have made the vertical aircraft position in relation to the desired glide angle visible to the PM on the PFD. However, the airline had neither described this function in its OM B operating manual nor provided any training on it. Furthermore, it is also possible to couple these data to the autopilot. However, due to the lack of redundancy this is not permitted on SAAB 2000 aircraft.

1.6.3 Aircraft maintenance

1.6.3.1 Measures taken after the serious incident

As the avionics' error storage had not saved any fault recordings, the first measure was to exchange the two DCU. In the troubleshooting manual for the SAAB 2000 the manufacturer does not provide any instructions that would offer the mechanics guidance for problems with the avionics. Workshop books such as the SAAB 2000's wiring diagram manual (WDM) and technical expertise are the foundations that are applied when troubleshooting. Accordingly, there are no official documents which would stipulate exchanging the DCU in the event of ILS fluctuations. According to the Etihad Regional maintenance department, it is common to exchange redundant systems to find the cause of a problem when troubleshooting. This was common practice in particular with regards to intermittent faults. In this investigated incident, an operational test was carried out after the exchange, which did not reveal any problems. According to the maintenance department, proper operation was also confirmed by the absence of any error messages in the maintenance diagnostic computer (MDC) or the aircraft's status display (CAT III INOP).

1.6.3.2 Previous events

There are no records of similar cases prior to this event in the files of the maintenance company.

1.7 Meteorological information

1.7.1 General weather conditions

Denmark was on the warm side of an open wave on the polar front.

1.7.2 Weather at the time and location of the serious incident

The following information about the weather conditions at the time and location of the serious incident are based on a spatial and chronological interpolation of observations from various weather stations.

With stormy high winds from the southwest, humid and mild air crossed Jutland. The cloud base was at 600 ft AAE. The model data suggest that this was followed by a compact cloud layer with the top of the cloud reaching at least 8000 ft AMSL. In accordance with the models used, the wind speed was 50 kt at 5000 ft AMSL, 45 kt at 1800 ft and 18 kt on the ground.

The weather models used showed that the approach took place in stormy southwesterly winds in the clouds and was accompanied by moderate turbulence. The airport weather report from 13:20 UTC showed a visibility of 2700 metres along the runway. The meteorological visibility at Billund Airport increased slightly between 12:00 and 14:00 UTC and was approximately 2000 m.

Weather	Overcast with drizzle and humid mist
Cloud	8/8 at 600 ft AAE
Visibility, measured automatically	2,700 m in runway direction
Meteorological visibility observed	14:00 UTC 2100 m 13:00 UTC 2000 m 12:00 UTC 1800 m
Wind 10 m AGL	220 degrees, 18 kt, gusts up to 30 kt
Temperature / dew point	8°C / 8°C

Atmospheric pressure (QNH)	1018 hPa, pressure reduced to sea level, calculated with the values of the ICAO standard atmosphere

1.7.3 Astronomical information

Light conditions	Daytime
Position of the sun	Azimuth: 209 degrees Elevation: 7 degrees

1.7.4 Airport weather report

The following meteorological aerodrome report (METAR) was valid from 13:20 UTC until the serious incident.

METAR EKBI 101320Z AUTO 22018G30KT 2700NDV DZ BR OVC 006/// 08/08 Q1018

The following airport and weather information from the Automatic Terminal Information Service (ATIS) was available to the crew:

"Billund airport information W, 1252Z, expect radar vectors for ILS approach, runway in use 27, runway wet, transition level 40, wind 220 degrees 18 knots, maximum 29 knots, minimum 11 knots, visibility 3700 meters, drizzle, mist, overcast 600 ft, temperature 8, dew point 8, QNH 1018."

In full, this means:

On 10 December 2015 the following weather conditions were observed at Billund Airport shortly before the dispatch time for the airport weather report from 12:52 UTC:

Wind	From 220° at 18 kt, gusts up to 29 kt
Meteorological visibility	3,700 m
Rainfall	Drizzle, humid mist
Clouds	8/8 with a cloud base at 600 ft AAL
Temperature	8°C
Dew point	8°C
Atmospheric pressure (QNH)	1018 hPa, pressure reduced to sea level, calculated with the values of the ICAO standard atmosphere
Runway condition report	100% of the runway surface is wet
Landing weather forecast	None

1.8 Navigational aids

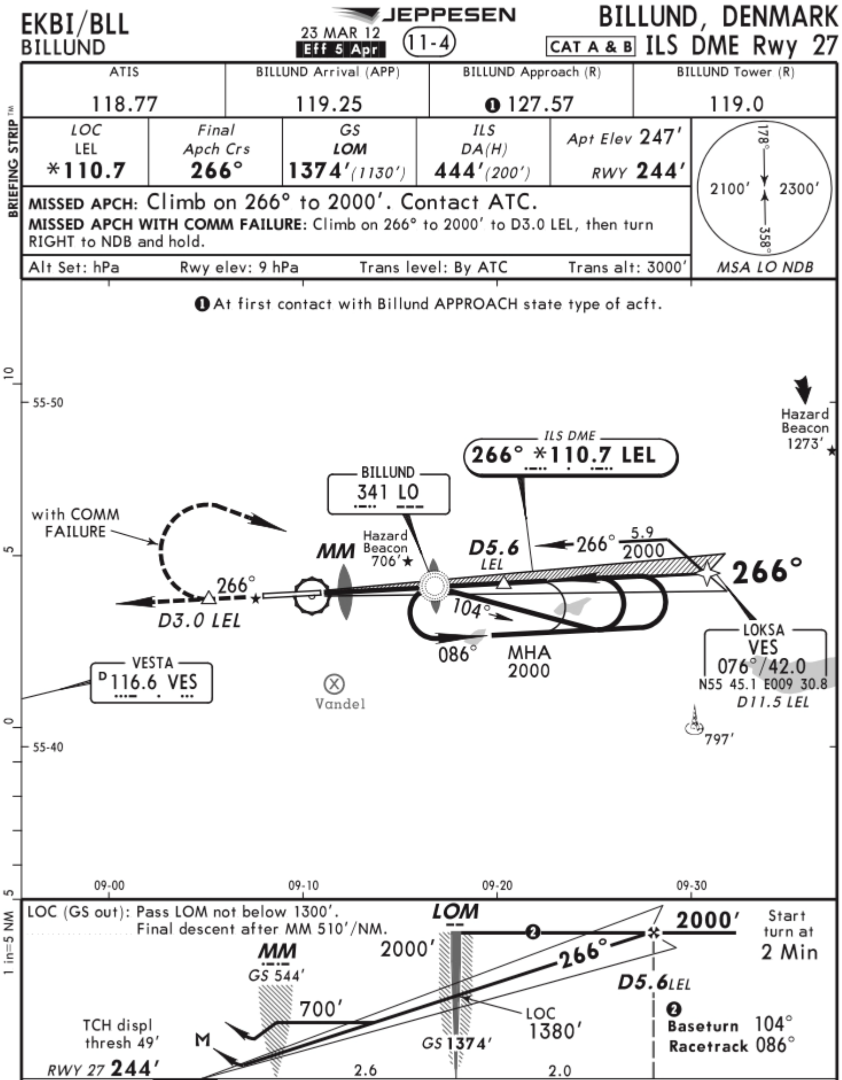
1.8.1 Information on the navigational and landing aids

The instrument landing system for a precision approach to runway 27 at Billund Airport was used for the first approach.

For the second approach, only the localiser was used. At the time of the serious incident, no relevant restrictions were published for Billund Airport or for flight AB 8054.

A check of the ILS and the DME for an approach to runway 27 carried out after the serious incident did not indicate any malfunction that could have contributed to the incident.

1.8.2 Approach chart for the ILS and LOC approach to runway 27 at Billund Airport



Gnd speed-Kts		70	90	100	120	140	160
GS	3.00°	377	485	539	647	755	862
LOM to MAP	3.4	2:55	2:16	2:02	1:42	1:27	1:17

Standard

STRAIGHT-IN LANDING RWY 27

	ILS DA(H) 444' (200')			LOC (GS out) DA(H) 550' (306')		CIRCLE-TO-LAND		
	FULL	Limited	ALS out		ALS out	Max Kts	MDA(H)	VIS
A	RVR 550m	RVR 750m	RVR 1200m	RVR 1000m	RVR 1600m	100	780' (533')	1500m
B						135	780' (533')	1600m
C	SEE 11-3			SEE 11-3		C	SEE 11-3	
D						D		

Not authorized South of airport

PANS OPS 4

CHANGES: Missed approach.

Illustration 6: ILS/LOC approach chart for runway 27 at Billund Airport (copy of the Jeppesen chart EKBI 11-4, 23 MAR 12, eff 5 Apr, valid at the time of the serious incident)

Both the ILS and the LOC approach to runway 27 at Billund Airport begin at an altitude of 2,000 ft AMSL[10] and with the DME showing 5.6 NM.

For the LOC approach, an altitude of at least 1300 ft AMSL should be adhered to at the outer marker (LOM) before descending to the decision altitude of 550 ft AMSL.

For planning the vertical flight path, the Jeppesen approach chart for Billund Airport shows the vertical speed for a three-degree approach angle that matches the ground speed in a conversion table.

Gnd speed-Kts		70	90	100	120	140	160
GS	3.00°	377	485	539	647	755	862
LOM to MAP	3.4	2:55	2:16	2:02	1:42	1:27	1:17

Illustration 7: Conversion table, ILS/LOC approach chart runway 27 at Billund Airport (section from illustration 6)

A recommended altitude descent table is not displayed in this chart.

LOC (GS out)	IKL DME	8.0	7.0	6.0	5.0	4.0	3.0	2.0
	ALTITUDE	3940′	3620′	3300′	2990′	2670′	2350′	2030′

Illustration 8: Example of a recommended altitude descent table (section from the Jeppesen chart LSZH 11-1, ILS/LOC approach chart runway 14 Zurich, 6 Feb 15)

1.9 Communication

The appropriate radio communication between the pilots and the air traffic controllers took place in English and without difficulties.

1.10 Airport information

1.10.1 General

Billund Airport is located approximately one nautical mile north-east of Billund. It is the second-largest airport in Denmark. In 2014, the passenger volume was 2.9 million people.

The airport reference altitude is 247 ft AMSL, the reference temperature is defined as 19.6°C.

1.10.2 Runway equipment

The runways of Billund Airport have the following dimensions:

Runway designation	Dimensions	Altitude of runway thresholds
09/27	3,100 x 45 m	215/244 ft AMSL

In both directions, the runway thresholds are displaced by 150 m, meaning the length of runway available for landing is 2950 m. At the time of the serious incident, this entire length of 2950 m was available for use.

1.10.3 Emergency and fire services

Billund Airport was equipped with category 7 firefighting equipment.

[10] AMSL: Above mean sea level

1.10.4 Runway 27 approach aid

Runway 27 has a category 3b instrument landing system which allows for automated landings in case of low visibility. At the time of the incident, the system was not operated under the criteria for a low visibility approach. In the configuration used during the incident, the critical zones are not protected which can lead to interference to the glideslope and locator signals being caused by aircraft and vehicles.

1.11 Flight recorders

The aircraft was fitted with digital flight data and voice recorders. The digital flight data recorder (DFDR) saved the flight data from the last 25 hours of operation. The cockpit voice recorder (CVR) saved the communication in the cockpit, the ambient noise and the radio communication from the last 2 hours of operation. Both devices operate following the principle of digital ring memory, whereupon older data that no longer fall within the desired storage period are continuously overwritten with newer data.

After the serious incident, the crew concerned made a telephone call to the aviation company to inform them that they had to execute a go-around during the approach to Billund Airport due to receiving a false warning from the EGPWS. The aviation company’s safety manager only realised that the incident had been a serious incident during the routine flight data monitoring (FDM) of the day’s operations and reported it to the Swiss Transportation Safety Investigation Board. By this time, the DFDR and CVR recordings had already been overwritten and could no longer be used for the investigation. The FDM recordings were used instead.

In this case, the FDM data were completely consistent with the DFDR data and exhibited the same level of recording accuracy. The data appeared plausible and could be evaluated.

1.12 Information on the wreckage, the impact and the accident site

Not applicable

1.13 Medical and pathological findings

Not applicable

1.14 Fire

Fire did not break out.

1.15 Survival aspects

There were no extraordinary accelerations or health-threatening influences affecting the occupants of the aircraft during the serious incident.

1.16 Tests and research results

Not applicable

1.17 Information on various organisations and their management

1.17.1 Aviation company

1.17.1.1 General

The aviation company has recorded the operating procedures for crews in various operating manuals. These include the operating manuals (OM) OM A and OM B. Whilst OM A contains general operating procedures, specific procedures for the

SAAB 2000 aircraft type are recorded in OM B. These are based on the aircraft manufacturer's operating manual.

The following only addresses those sections within the above operating manuals that are relevant to this investigated serious incident.

1.17.1.2 Precision approach procedure

General explanations regarding a precision approach can be found in section 1.18.1.

1.17.1.2.1 Operating manual OM A

In OM A section 8.4.5.15 "*approach path tracking on precision approach"* the following is stated regarding the maximum deviation from the glide path:

"Glide path:

Once established, the glide path deviation may not exceed one dot as shown on the PFD/ND. The glide path should, however, be flown as accurately as possible and the deviation must be virtually "zero" upon reaching DH/A."

This means that, as soon as the aircraft is stable on the ILS's glide path, the maximum permissible deviation is one dot.

In addition, section 8.0.5.4.7 states the criteria for a stabilised approach. This section states, among other things, that a go-around must be initiated if the deviation is more than ±1 dot for the glideslope or ±100 ft for a non-precision approach below 1,000 ft AAL[11].

1.17.1.2.2 Operating manual OM B

The ILS approach procedure is described using an illustration in section 2.2.13.5 "*AEO ILS approach / AEO CDA non-precision approach*" of OM B (see illustration 9).

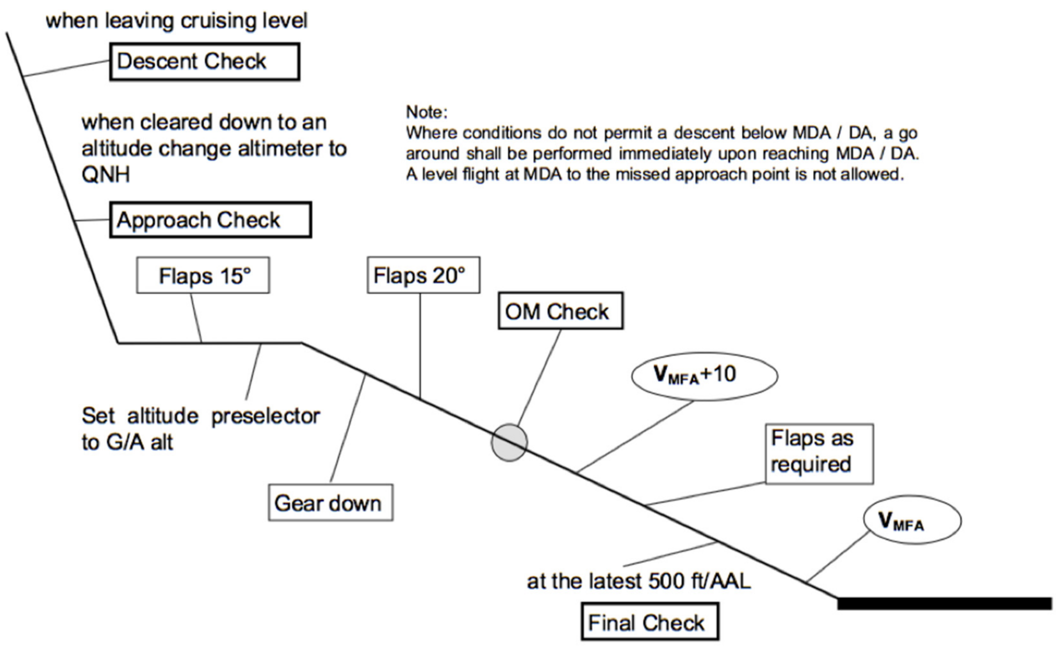


Illustration 9: AEO ILS approach / AEO CDA non-precision approach, OM B section 2.2.13.5

[11] AAL: Above aerodrome level

There is no further information regarding the execution of a precision approach.

1.17.1.3 Non-precision approach procedure

General explanations for a non-precision approach can be found in section 1.18.2.

1.17.1.3.1 Operating manual OM A

OM A section 8.4.5.16 "*approach path tracking on non-precision approach*" stipulates that a continuous descent final approach (CDFA)[12] is to be flown in the event of a LOC approach to runway 27 at Billund Airport.

Section 8.4.5.16.1 "C*FDA flight technique"*, which describes the continuous descent final approach in detail, reads as follows:

"The CDFA technique should ensure that an approach can be flown on the desired vertical path and track in a stabilized manner, without significant vertical path changes during the final segment descent to the runway. This technique applies to an approach with no vertical guidance and controls the descent path until the DA/DH. This descent path can be either:

- *a recommended descent rate based on estimated ground speed;*
- *a descent path depicted on the approach chart; or*
- *a descent path coded in the flight management system in accordance with the approach chart descent path.*

The target rate of descent (ROD) should be in line with the approach angle and the ground speed and the ROD deviations or corrections should not exceed ± 300 fpm, except under exceptional circumstances which have been anticipated and briefed prior to commencing the approach; for example, a strong tailwind. Zero ROD may be used when the descent path needs to be regained from below the profile. The target ROD may need to be initiated prior to reaching the required descent point, typically 0.3 NM before the descent point, dependent upon ground speed, which may vary for each type/class of aeroplane.

During the descent the pilot monitoring should announce crossing altitudes as published fixes and other designated points are crossed, giving the appropriate altitude or height for the appropriate range as depicted on the chart. The pilot flying should promptly adjust the rate of descent as appropriate.

The required descent path should be flown to the DA/H, observing any step-down crossing altitudes if applicable.

DA/H is defined by MDA/H plus an add-on to compensate for initial altitude loss during a missed approach procedure. The altitude loss is aircraft specific and includes pilot reaction time and inertia from the aircraft. The value is defined in the OM Part B.

The descent path shall be arranged in a way that little or no adjustment of attitude or thrust/power is needed after the DA/H to continue the landing in the visual segment.

The missed approach should be initiated no later than reaching the MAPt or at the DA/H, whichever comes first. The lateral part of the missed approach should be flown via the MAPt unless otherwise stated on the approach chart."

[12] Continuous descent final approach (CDFA): Non-precision approach procedure with a continuous descent to the decision altitude.

The criteria for a stabilised non-precision approach can be found in section 8.0.5.4.7. This section states, amongst other things, that a go-around procedure must be initiated if the deviation is more than ±100 ft below 1,000 ft AAL.

1.17.1.3.2 Operating manual OM B

For a non-precision approach, the same illustration applies as for the precision approach (see illustration 9).

There are no further explanations regarding the execution of a non-precision approach.

1.17.1.4 Go-around

1.17.1.4.1 Operating manual OM A

In accordance with section 8.4.5.20.5 of OM A, "*Other Reasons for a Missed Approach*", the reasons to initiate a go-around procedure include:

- *"if it appears to any of the pilots that the success of the approach is in doubt or flight safety is jeopardised, i.e. approach not stabilized;"*
- *"if any element of the ground navigation system or the required airborne equipment becomes inoperative according OM Part A Section 8.1.3.2.13 or is suspected to be malfunctioning. This is no longer relevant after passing the alert height during a CAT III approach;"*

1.17.1.4.2 Operating manual OM B

The go-around procedure is described in section 2.2.13.2 "*standard AEO missed approach sequence (OEI)*" as follows and complemented in section 2.2.13.10 by the "*AEO go-around"* illustration shown below.

"2.2.13.2 Standard AEO missed approach sequence (OEI)

1. *Palm switch..press*
2. *PWR / pitch..detent position / 7° ANU*
3. *Flaps..7° / 20°*
4. *Gear..positive rate, up*
5. *Attitude..12° - 15° ANU (7°)*
6. *HDG, IAS..engage*
7. *At minimum acc. altitude..select IAS to Vfc + 10 (Vfc)*
8. *At Vfc – 10..flaps up*
9. *Climb power (MCP)..set*
10. *Bleedair..on*
11. *Climb check..perform*
12. *ATC, C/C, pax..inform"*

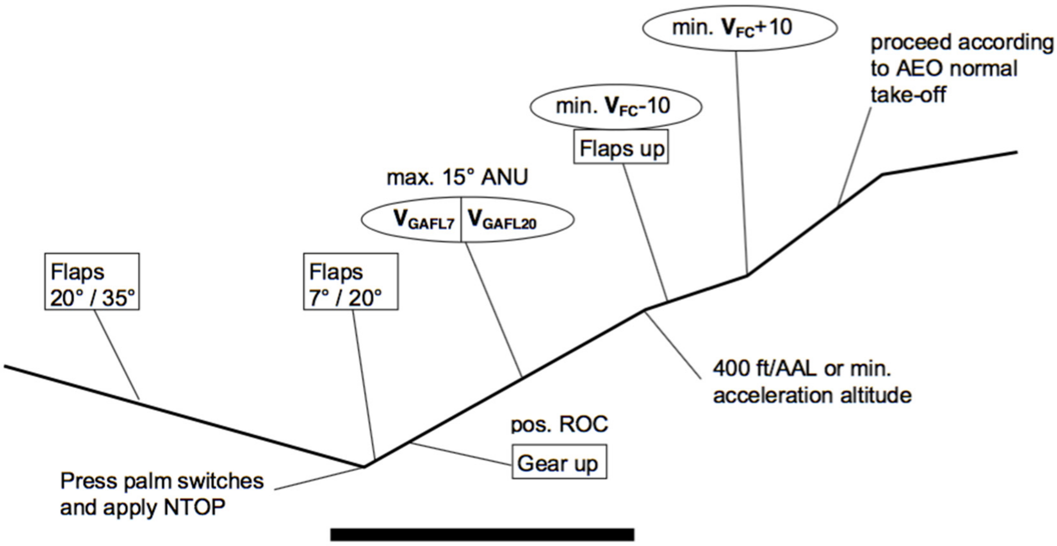


Illustration 10: AEO go-around, OM B section 2.2.13.10

1.17.1.5 Ground proximity system and emergency climb procedure

In its manuals, Saab describes the ground proximity warning system that is based on the Honeywell EGPWS MkV system with the term "*terrain awareness warning system*" *(*TAWS).

1.17.1.5.1 Operating manual OM A

Section 8.3.5.2 "*Policy"* of OM A reads as follows:

"As a general policy no GPWS/TAWS warning shall be ignored, proper action shall be taken immediately. GPWS/TAWS hard warnings and unexpected soft warnings in IMC or at night require the crew to react immediately accordingly. Any activation must be reported in writing to the flight operations."

In accordance with section 8.4.5.16.2 "*Non-precision approach without applying CDFA technique*", the TAWS system display on the navigation screen must be active. There is no similar instruction for the CDFA approach procedure.

1.17.1.5.2 Operating manual OM B

OM B section 3.2.15.1 "*terrain avoidance procedure*" includes the following [capital print as per original]:

"The MAXIMUM PERFORMANCE CLIMB PROCEDURE shall be applied immediately whenever a TAWS hard or soft warning is given, that is not excluded by the definition above. Check the aircraft position with respect to terrain using conventional navigation only. Pilots are authorised to deviate from their current ATC clearance to the extent necessary to comply with a GPWS/TAWS warning."

The "*maximum performance climb*" procedure (section 3.2.16) contains the following [bold print as per original]:

"Apply for microburst / windshear recovery and terrain avoidance

1. *Autopilot .... disengage*
2. *Wings .... level*
3. *MTOP .... set*
4. *APR .... on*

5. *Pitch attitude ....pull up into intermittent stick shaker as the upper limit, once the acft is climbing, airspeed should be increased by cautious reduction in pitch.*
6. *Configuration .... no change until a safe altitude is achieved with a sustained positive rate of climb.*

NOTE:	*Due to the following reasons no configuration change may be done until the aeroplane is fully recovered to a safe flaps retraction speed and positive rate of climb:* *No gear retraction due to unexpected touch down.* *If the aeroplane is flown at stick shaker speed, any flaps setting change will trigger the stick pusher."*

1.17.1.6 Terrain clearance

OM A section 8.3.3.1.4.4 "C*hecking of terrain clearance*" includes the following under the heading "*Departure/approach"*:

- *"When ensuring safe terrain clearance during flight the minima as published in the OM Part C has to be used. The published minimum altitudes must be applied conservatively whenever difficulties regarding navigation accuracy are to be expected, e.g. unreliability of navigation aids, detours due to weather etc."*

1.17.1.7 Crew resource management[13]

OM A section 8.0.1.2 "*CRM – Principles*" includes the following under the heading "*Communication*":

- *"Established and maintain an environment for open communication with a fluid, clear, and direct flow of information. Promptly verbalize errors, problems, deviations, and limitations"*

1.17.1.8 Monitored approach technique

OM B section 2.2.16.2 "*Monitored Approach Technique*" mentions the possibility of a so-called monitored approach, during which the first officer flies the approach and the pilot takes over as soon as he/she has sufficient visual references. This may be carried out for both precision and non-precision approach procedures. The following is stipulated in OM B:

"A monitored approach should be performed if one of the following conditions prevail:

- *Ceiling and/or RVR/visibility/CRVR close to minimum, i.e. the CMD shall carefully evaluate the situation if the reported values are below approx. 150 % of the required minima*

[13] Crew resource management: Describes the non-technical skills of a flight crew (communication, leadership, situational awareness, division of work, decision-making etc.).

- *Severe weather conditions such as: heavy precipitation, moderate or severe turbulence *
- *Critical visibility conditions such as: drifting snow, approach into sunset/sunrise, etc...*

Monitored approaches may be performed as a precision approach (CAT I) as well as for a non-precision approach.

The autopilot shall be used during a Monitored approach.

The landing after a monitored approach must always be conducted by the PiC.”

1.17.1.9 Automatic 500-foot notification

OM B section 2.0.3.15 “*Landing*” describes the procedure at 500 ft AGL as follows [bold print as per original]:

“	***PF***	***PM***
At 500 ft RA	*Only when there is no GPWS call:* ***“500”***	
		Acc stabilized approach criteria respond to GPWS or PF: ***“Stable”*** *or “**Go Around!”***
	“Checked”	

NOTE: The 500 call serves as a pilot incapacitation check and as a reminder for the stabilized approach philosophy according OM-A. Furthermore it shall serve as a reminder for the 500ft decision point when applying low visibility procedures. The 1000 call from the GPWS shall not be answered but still serve as reminder for the decision point in case of a HGS approach.”

1.18 Additional information

1.18.1 Precision approach procedures

Precision approach procedures are instrument approach procedures with lateral and vertical precision guidance. An approach using the instrument landing system (ILS) is considered a precision approach if both the control level of the localiser and of the glideslope transmitter are used for the approach. Instrument landing systems are very often complemented with distance measuring equipment (DME), which allows a continuous display of the distance to the runway threshold.

1.18.2 Non-precision approach procedures

Non-precision approach procedures are instrument approach procedures where lateral but no vertical guidance is available. If only the localiser is used for an ILS approach, the approach is considered a non-precision approach procedure.

In contrast to the ILS approach, where the glideslope is precisely followed up to the decision altitude (DA), the localiser (LOC) approach must be flown without precise vertical guidance. In this case, compliance with prescribed minimum altitudes – which guarantee the required ground clearance – is ensured by adhering to the minimum altitudes that are drawn in the approach chart’s vertical profile or described as text.

1.19 Useful or effective investigation technique

Not applicable

2 Analysis

2.1 Technical aspects

The cause of the inaccurate display on HB-IZW's glideslope transmitter indicator could not be determined with certainty.

According to statements made by the Danish authorities, at the time of the incident the instrument landing system was functioning properly and was not being operated under the criteria for a low visibility approach. Given these conditions, interference to the glideslope and locator signals can occur if vehicles or aircraft are located in the protected areas.

A faulty glideslope indicator generally has no influence on a localiser approach and is thus of no significance to the course of this serious incident.

2.2 Human and operational aspects

2.2.1 History of the flight

The first approach was carried out using runway 27's instrument landing system. The glideslope indicator fluctuated severely from the start. At an altitude of 1,000 ft AAL, the aircraft was at a DME distance of 4.5 NM. The glideslope indicator was still severely fluctuating between 2 dots 'fly up' and 1 dot 'fly down'. The go-around took place 21 seconds later at an altitude of 663 ft AAL and a DME distance of 3.9 NM.

At an altitude of 1,000 ft AAL, the criteria for a stabilised approach in accordance with OM A were not fulfilled. Under these circumstances, a go-around must be initiated; this did not happen in this investigated incident. An altitude of 1,000 ft AAL had already been reached at a DME distance of 4.5 NM. That is approximately 500 ft below the stipulated glideslope for an instrument approach. From this, it can be concluded that the crew did not verify the glideslope indication in a timely manner.

According to OM A, an approach should also be aborted if it must be assumed that a component of the instrument approach system or a required avionics component is exhibiting a fault.

The final approach was initiated 0.7 NM before the final approach fix. Because of this, the aircraft was below the stipulated vertical profile right from the beginning of the final approach. According to the OM A guidelines, the descent is to be initiated 0.3 NM before the final approach fix.

In order to perform a continuous descent final approach as stipulated in OM A, the rate of descent should have been approximately 550 ft/min for an average ground speed of 103 kt. The chosen rate of descent of 800 ft/min was too high for the wind conditions prevailing at this time, which obviously was not noticed by the crew. As a result, the aircraft continued to deviate even further from the stipulated vertical profile. In the briefing, a ground speed of 140 kt had been anticipated. The current ground speed display on the ND, which is available at all times, was not considered during the final approach.

The commander delegated the task of monitoring the vertical profile to the PM and concentrated exclusively on piloting. However, the PM was not able to do this and did not communicate that fact. Therefore, the two crew members did not notice the deviation from the stipulated vertical profile in good time. The tasks of the PF include monitoring the lateral and vertical navigation, and should therefore not be left entirely to the PM.

Every member of an aircrew is obliged to speak out if an allocated task cannot be fulfilled. However, in this investigated incident the PM failed to inform the commander that he was unable to monitor the vertical profile.

At a DME distance of 5.5 NM, the aircraft was at an altitude of 1,240 ft AMSL or 1,000 ft AGL. That is approximately 750 ft below the stipulated vertical profile. At this time, the aircraft was already below the outer marker's minimal flyover altitude of 1,300 ft AMSL. Consequently, the criteria for a stabilised approach according to OM A were not adhered to. In a situation such as this, a go-around must be initiated; this did not happen in this investigated incident.

The decision to perform a go-around was only made 38 seconds later, at an altitude of 757 ft AMSL or 404 ft AGL, shortly before the EGPWS warning sounded. The EGPWS warning sounded at approximately the same time as the go-around manoeuvre was initiated. The go-around was continued as normal. The OM B stipulates a maximum performance climb procedure in the event of an EGPWS warning. Due to the go-around coinciding with the EGPWS warning, the crew did not exercise the maximum performance climb procedure. As a result, the maximum climb performance that can be achieved in a short period of time was not available, which might be necessary in a situation such as this.

According to OM B, a monitored approach would also have been possible. This might have increased the commander's mental capacity and thus would have made it easier to monitor the final approach better.

2.2.2 Background

The pilot was scheduled to have a day off in Prague on the day before the incident. On this day, he went to a private appointment in Berlin. He flew on Air Berlin AB 8243 from Prague to Berlin Tegel. The flight's departure time was 09:39 UTC and the arrival time was 10:28 UTC. For the return flight in the evening, he took flight AB 8240 which left Berlin Tegel at 20:36 UTC and landed in Prague at 21:32 UTC. The next day, he was collected from the hotel at 04:20 UTC to commence his flying duties. During this period of time, the pilot travelled to the hotel, he had to check in and then he could go to bed. The time between getting up and being collected from the hotel the next morning must also be deducted from his actual night's rest, thus the pilot barely had more than 5 hours' sleep, which possibly led to a dip in performance due to tiredness on the day of the serious incident.

2.3 Organisational aspects

2.3.1 Documentation and training

All horizontal and vertical data for a localiser approach to runway 27 at Billund Airport had already been programmed into the FMS. This would have allowed the PM to make the stipulated vertical profile visible on the PFD and thus to easily monitor the vertical position of the aircraft. This procedure was not known to the pilots because it was not mentioned in OM B and was not included in their training.
The description of the ILS and localiser approach procedures solely consists of a profile displayed in OM B without any more detail on the procedures.

2.3.2 Billund approach chart

The Jeppesen approach chart for an ILS/LOC approach to runway 27 at Billund Airport (version 23 MAR 12), which was valid at the time of the serious incident, did not have a recommended altitude descent table. This would have made it easier for the pilots to monitor the vertical profile.

2.3.3 First officer

Since 2010, the first officer had a history of shortcomings in the areas of systematics, communication and compliance with standard operating procedures (SOP). The training department tried to correct the identified shortcomings through supporting measures over the course of four years. However, this incident shows that this had not been successful.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The aircraft had the required permissions to fly under instrument flight rules (IFR).
- At the time of the serious incident, both the mass and centre of gravity of the aircraft were found to be within the permissible limits of the AFM.
- No technical cause for the aircraft's fluctuating glideslope indicator could be found. The indicator had no influence on the further course of the serious incident.

3.1.2 Crew

- The pilots possessed the necessary licences for the flight.
- There is no evidence of impairment to the pilots' health during the incident flight.
- The pilot flying probably experienced a drop in his performance caused by fatigue due to the short night's sleep.

3.1.3 History of the flight

- On 10 December 2015 at 12:14 UTC, the SAAB 2000 aircraft registered as HB-IZW took off from Berlin Tegel Airport (EDDT) for a scheduled flight to Billund Airport (EKBI) with 3 crew members and 26 passengers on board.
- Following an uneventful cruise flight, a first approach to runway 27 was carried out using the instrument landing system. Right from the beginning of this approach, the glideslope indicator fluctuated intermittently between 'full fly up' and 'full fly down'.
- At a DME distance of 3.9 NM and an altitude of 1050 ft AMSL (800 ft AGL), the commander initiated a go-around.
- During the go-around, the maximum speeds with extended landing gear and with extended landing flaps were exceeded by 5 kt and 4 kt respectively. 5 kt. In addition, the go-around altitude was exceeded by 600 ft.
- A localiser approach was chosen for the second approach.
- The aircraft was already aligned to the localiser at 13 NM and was configured for the final approach at 10 NM.
- At a DME distance of 9.4 NM, the commander selected a vertical speed of 800 ft/min. The published beginning of the final approach was at a DME distance of 8.7 NM. For the chosen approach, at a ground speed of 140 kt the target approach angle of -3° results in a rate of descent of 800 ft/min. The average ground speed was 103 kt and the average vertical flight angle was -4.2 degrees.
- At a DME distance of 5.5 NM and an altitude of 1240 ft AMSL, the auto-callout 'one thousand' sounded. 31 seconds later, the auto-callout 'five hundred' sounded.

- Another 7 seconds later, at an altitude of 757 ft AMSL (404 ft AGL), the commander decided to initiate a go-around. At the same time, the EGPWS 'terrain ahead, pull up' warning sounded. The aircraft's lowest altitude during the go-around was 700 ft AMSL (346 ft AGL).
- The standard go-around procedure was used instead of the EGPWS escape procedure.
- The crew thereafter decided to fly back to Berlin Tegel Airport (EDDT).

3.1.4 General conditions

- Both final approaches were performed in clouds with stormy south-westerly winds involving speeds of up to 50 kt. The wind on the ground was blowing from 220 degrees at speeds of 18 kt, with gusts of up to 30 kt. The closed cloud base was at an altitude of 600 ft AAL.
- The approach chart did not have a recommended altitude descent table.

3.2 Causes

The serious incident emerged from the aircraft's descent below the stipulated minimum altitude for a non-precision approach. Therefore, a safe altitude above the obstacles was no longer guaranteed.

The crew's poor monitoring of the vertical flight path has been identified as the direct cause of the incident.

The following factors have been identified as directly contributing to the serious incident:

- Deficient approach planning with regards to the vertical flight path.
- Reduced performance of the pilot flying, probably due to tiredness.

The approach chart, which had no distance/altitude table and thereby impeded the monitoring of the approach, systematically contributed to the serious incident.

Although it did not influence the development and course of the serious incident, the following risk factor was identified during the investigation:

- The procedure following a warning from the enhanced ground proximity warning system (EGPWS) was not consistently applied.

4 Safety recommendations, safety advice and measures taken since the incident

4.1 Safety recommendations

None

4.2 Safety advice

None

4.3 Measures taken since the serious incident

The measures known to the STSB are listed without comment below.

4.3.1 Etihad Regional

According to its own statement, the aviation company Etihad Regional has taken the following measures in the aftermath of the serious incident involving the SAAB 2000 HB-IZW on 10 December 2015:

1. The pilot and first officer were no longer rostered for scheduled flights during the course of the internal investigation.
2. The minimum equipment list (MEL) has been adapted for the time being. Additional restrictions have been defined for flights without EGPWS and GPS.
3. An additional call-out of 'one thousand – on profile' has been added to the Darwin standard operating procedures (SOP) for the criteria of a stable approach.

   The *"Operational Memo"* dated 12/01/2016 contains a revision of OM A with immediate effect. Section 8.0.5.4.7 *"Stabilized Approach"* has been adapted or expanded upon as follows [bold print as per original]:

   "According to SOP's and applicable Stabilized Approach Criteria, for all instrumental approaches regardless of meteorological conditions, the following "call out's" shall be performed:

AAL	***PF***	***PM***
1000 ft	*"One thousand"*	*"ON PROFILE" or "GO AROUND"*
500 ft	*"Five hundred"*	*"STABLE" or "GO AROUND"*

   Note: For Visual and Circling approaches, as per OM A 8.0.5.4.7.2 latest stabilization is at 500ft, "One Thousand" call out must be disregarded.

   According to the Stabilized Approach Criteria listed on OMA 8.0.5.4.7.3 are to be performed in a stabilized manner.

   At 1000ft AAL PF calls "One thousand" and PM checks and verifies the following items:

   - *All Briefings and checklists are completed;Note: except SB20 Final checklist / landing clearance*
   - *A/C Configuration established for landing (Landing gear, Flaps, Speed brakes);*
   - *Vertical: Position within +/- 1 dot for precision approaches; Position within +/- 100 feet of defined steps for Non Precision approaches;*
   - *Lateral: Position within +/- ½ scale for ILS or LOC approaches; Position within +/- 5° for VOR/NDB approaches; Established on approach path according prescribed tracks or special airport procedure for other approaches;*

- *Vertical Speed: Max 1200 fpm for a 3° slope, or as required according approach procedure;*
- *IAS max: V_{REF} (or V_{REFC}) +25kts (including wind increment) IAS min: V_{REF} (or V_{REFC}); (Minor, short term deviations are acceptable in gusty conditions on final approach; Target threshold speeds still apply and overrule the above defined IAS limits on short final); Note: A later stabilization in speed, meaning latest at 500ft, is acceptable if required by ATC.*
- *Reasonable pitch attitude according approach procedure and aircraft characteristics; (SB20 +5° to -3° for 3° slope; AT75 +2° to -5°) (Minor, short term deviations are acceptable in gusty conditions on final approach);*
- *Reasonable power setting according approach procedure and aircraft characteristics; (SB20 10-35PU for 3° F20; AT75 15-35 % TQ); Significant changes are only allowed for gust compensation. Max. thrust except one engine out [SB20 ≤70% PUs], [AT75 ≤80% Torque];*
- *Max bank angle 15°, or as required according approach procedure.*

In case of all items are within the limits PM will answer "ON PROFILE".

Where these criteria cannot be met a ***Go Around*** *shall be flown.*

At 500ft AAL PF calls "Five hundred" and PM checks and verifies the following items:

- *IAS max: V_{REF} (or V_{REFC}) +25kts (including wind increment); IAS min: V_{REF} (or V_{REFC}); (Minor, short term deviations are acceptable in gusty conditions on final approach;Target threshold speeds still apply and overrule the above defined IAS limits on short final);*

In case of all items are within the limits PM will reply "STABLE".

Where these criteria cannot be met a ***Go Around*** *shall be flown.*

Strict adherence to all Stabilized Approach Criteria is mandatory from the moment when the PM calls out "ON PROFILE" and "STABLE" to the flare."

4. Implementation of the stable approach policy through the safety performance index (SPI) for stable approaches using flight data monitoring (FDM). The relationship between unstable approaches and go-arounds will thereby be analysed.
5. This serious incident is discussed in detail at safety seminars.
6. The simulator programme has been adapted and has had an additional exercise added to it that simulates conditions similar to those found in this serious incident.

4.3.2 Jeppesen

The approach charts are now provided with recommended altitude descent tables.

This final report was approved by the Swiss Transportation Safety Investigation Board (Art. 10(h) of the Ordinance on the Safety Investigation of Transport Incidents of 17 December 2014).

Bern, 13 November 2018 Swiss Transportation Safety Investigation Board