

Tail strike on runway during night landing

⁽¹⁾Except where otherwise stated, the times shown in this report are expressed in Universal Time Coordinated (UTC). One hour should be added to obtain the legal time applicable in metropolitan France on the day of the accident.

Airplane	McDonnell Douglas MD-81 registered OY-KHP
Date and time	6 February 2010 at 18h25 ⁽¹⁾
Operator	Scandinavian Airlines System (SAS)
Site of accident	AD Grenoble-Isère (38)
Type of flight	Public transport of passengers Unscheduled international flight
Persons on board	Captain (PNF); Co-pilot (PF); 4 PNC; 127 passengers
Consequences and damage	Rear part of fuselage seriously damaged

Note: this document has been translated by the BEA to make its reading easier for English speaking people. As accurate as the translation may be, the original text in French is the work of reference.

1- HISTORY OF FLIGHT

The following elements are taken from FDR data and interviews.

The crew took off from Copenhagen airport at 16 h 34 for Grenoble. At approximately 17 h 53, the crew began the descent for an ILS approach on runway 09. The meteorological conditions on arrival were VFR conditions, at night with an easterly wind of 8 kt. The moon was still below the horizon at the time of arrival and there was cloud cover hiding the stars, making it a particularly dark night. The runway and approach light system were set at the dimmest level.

The crew was established on the localizer at approximately 10 NM from the runway threshold and had the runway in sight.

At 18 h 23, at a height of 1,500 ft approximately, the airplane was on the ILS final approach path at an indicated speed (IAS) of 157 kt, landing gear extended, in "28"⁽²⁾ configuration, with autopilot and auto-throttle engaged. The selected Vapp speed was 137 kt. The lighting switch for the nose landing gear lights was set at low intensity ("DIM" position).

At a height of approximately 1,000 ft, the crew disengaged the autopilot. The airplane was stabilised at a speed slightly greater than Vapp on the glide path and with a vertical speed of -700 ft/min.

At a height of approximately 200 ft, the captain disengaged the auto-throttle. The position of the levers moved back slightly and the EPR also decreased. From this moment until the passage to reverse position, the position of the thrust levers did not change.

The approach remained stabilised on the glide path of 3° at a speed equal to Vapp + 3 kt and a rate of descent of 700 ft/min until reaching a height of 100 ft.

⁽²⁾28° of flap deflection and slats extended.

At 100 ft, the IAS started to decrease and went below Vapp. The rate of descent increased and reached 850 ft/min. The pitch attitude was 4° nose up and began to increase slightly.

At a height of 30 ft, the airplane went slightly below the glide path and the IAS was Vapp - 4 kt.

At a height of 15 ft, the elevator was sharply moved to nose up, leading to a swift increase in pitch attitude.

Two seconds later, the rear of the fuselage touched the runway, with a pitch attitude of 10.7°. The marks left on the runway indicated a point of contact 166 metres before the touchdown zone. The vertical acceleration value reached a maximum of 1.95g. Two seconds later, the thrust levers were retarded and the thrust reversers were deployed. The airplane then taxied to the parking ramp.

2 - ADDITIONAL INFORMATION

2.1 Crew experience:

- Captain: 12,720 flying hours, including 6,294 on type
- Co-pilot: 3,441 flying hours, including 666 on type

The co-pilot had been on sick leave during the months of October and November 2009 because of unfitness linked to stress. He had been informed of his redundancy in the weeks preceding the flight and was to stop work on 1 March 2010. On the morning of the day of the accident, the co-pilot had received a letter concerning the details of his redundancy.

The crew had never landed at Grenoble airport before the day of the accident.

The captain indicated in his interview that he preferred to land with the auto-throttle engaged.

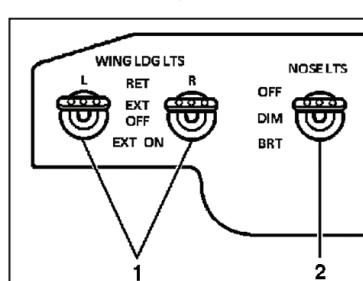
The co-pilot indicated in his interview that he would disengage the auto-throttle to land when "everything is looking normal".

The two pilots indicated in their interviews that the environment around the airport was very dark on the evening of the accident.

2.2 Landing lights

The MD-81 is fitted with landing and taxiing lights on the nose wheel and retractable landing lights on the wings.

The nose wheel light switch has 3 positions:



- OFF position: lights off
- DIM position: lights on, dimmed
- BRT position: lights on, bright

According to the pilots' interview, SAS crews are encouraged to favour the "DIM" position for the lights, as the lights in "BRT" position undergo considerable wear and tear. Most night landings are carried out with lights in "DIM" position. However, the operating manual allows the crew to judge the level of lighting best adapted to external conditions.

On the day of the accident, the choice of lighting level was not part of the standard approach briefing described in the operating manual.

2.3 Use of auto-throttle during approach

The MD-81's Auto Throttle System (ATS) automatically positions the thrust levers to maintain speed, Mach, or engine thrust.

For an ILS approach, the recommended auto-throttle mode is the speed select mode (SPD SEL). In this mode, the target speed selected by the crew is maintained by automatic regulation of the thrust down to 50 ft radio-altitude. The system then moves to RETD mode and the levers gradually move back to the flight idle position. The latter is reached at the time of the beginning of the flare, done by the crew at between 30 and 20 ft. The auto-throttle is disengaged when the thrust reversers are deployed.

On final approach, the crew must select Vapp speed which is the reference speed (Vref) compensated by at least 5 kt. For the accident flight, the MD-81 flight manual indicates a Vref of 132 kt⁽³⁾ and therefore a Vapp of 137 kt.

The SAS operating manual requires that Vapp speed be maintained until the start of the flare. Speed variations must be called out by the PNF if the speed is greater than Vapp + 10 kt or less than Vapp - 5kt.

If the ATS is disengaged, the crew must manage the thrust manually to maintain speed and carry out the thrust reduction before the flare.

2.4 Pitch attitude limitations on touch-down

Maximum pitch attitude on touchdown is indicated in the SAS operating manual.

For a no-roll and extended tail bumper, the rear of the airplane will touch the ground if the:

- Pitch attitude is greater at 7.5° if the main gear struts are compressed and the tyres flat;
- Pitch attitude is greater at 11.2° if the main gear struts are extended;
- On the day of the accident the pitch attitude on touchdown was 10.7°.

2.5 Radio-altitude auto call-outs

The MD-81 was fitted with an EGPWS system. One of the system's modes automatically generates voice call-outs of height when the airplane is descending. The call-outs are specifically made when radio-altitude reaches 50 ft, 40 ft, 30 ft, 20 ft and 10 ft.

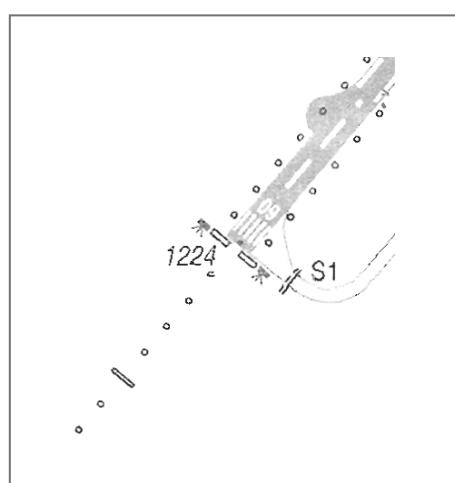
2.6 Aerodrome information

Grenoble-Isère aerodrome has a paved runway 3,050 metres long and 45 metres wide, oriented 09/27. Runway 09, the runway in use at the time of the accident, has an ILS and category 1 precision approach lighting system. It has a slope with a gradient of 0.8%.

Runway 09 has no axial lighting or visual approach slope indicator system.

French regulations allow for 4 possible configurations of category 1 precision approach lighting systems.

Grenoble airport's lighting is simplified approach lighting. It covers a distance of 420 metres and has a crossbar located 300 metres from the runway threshold, as indicated on the aerodrome chart published by the SIA (French Aeronautical Information Service).

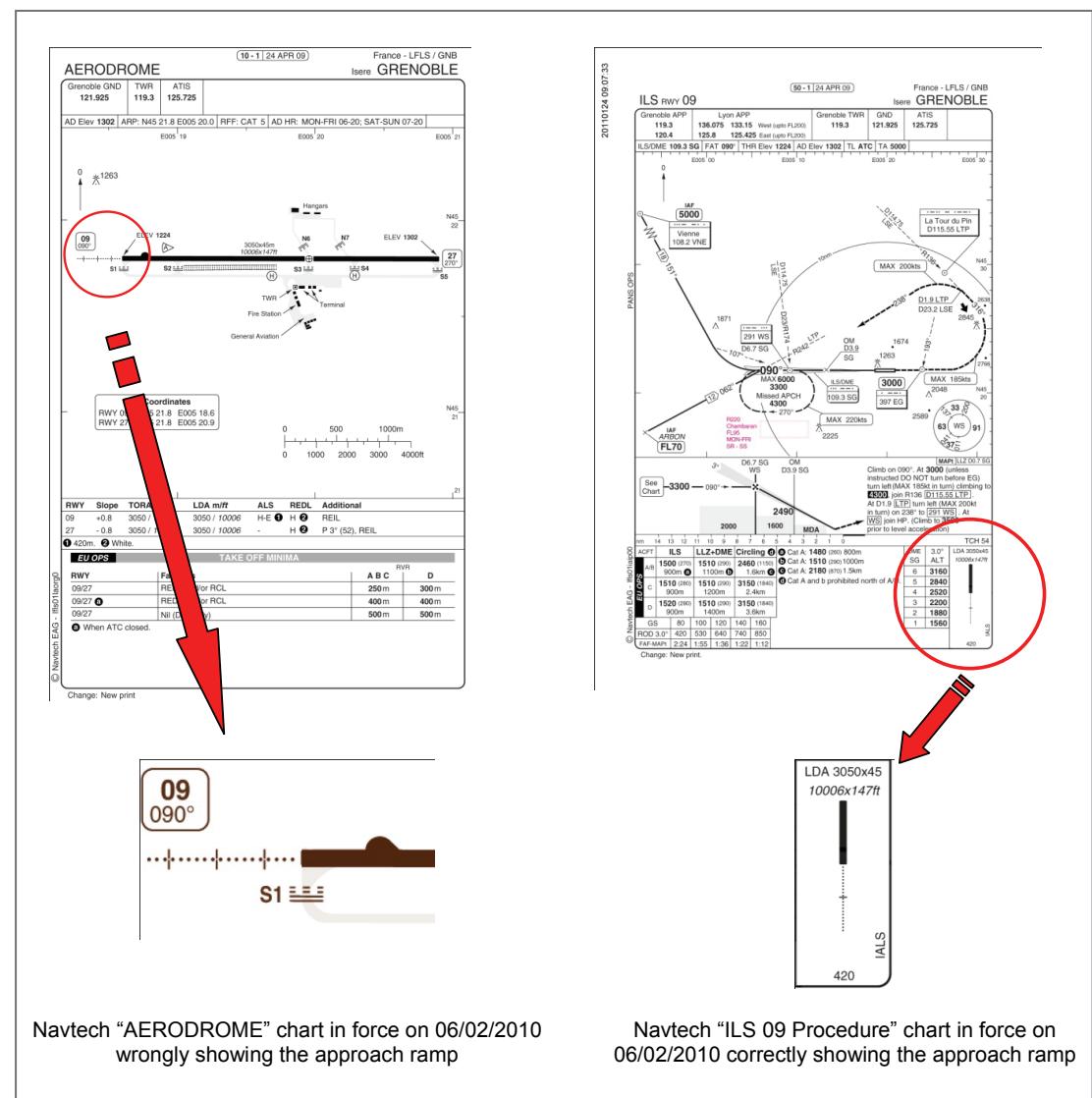


Symbol presented on the SIA aerodrome chart

SAS crews use charts published by Navtech EAG.

On the day of the accident, the "AERODROME" Navtech EAG chart indicated that the approach lighting system was at least 900 m long and had 3 crossbars, whereas in reality it was only 420 m and had only one crossbar.

The "ILS 09 Procedure" chart however showed the approach lighting system correctly.



Since the accident, this inconsistency has been corrected by Navtech.

On the evening of the event, the lighting was selected at the dimmest level. This level is usually chosen when the horizontal visibility is greater than 1,500 m. The meteorological conditions estimated in the area at the time of the incident indicated a horizontal visibility of 9,000 m.

It should be noted that the controller can modify the level of brightness of the lighting. This can be done:

- Either on the controller's own initiative according to any change in meteorological conditions,
- or at the request of the crew if the latter deem it necessary.

On the evening of the event, the crew did not request a modification of the level of brightness of the lighting.

2.7 Vertical path

The airplane's vertical path from 450 ft above the ground until touchdown was calculated from FDR data.

It shows that the airplane was on the glide path at 3° until approximately 250 ft. It then went slightly above the glide path and followed a parallel trajectory to the nominal glide path. Finally, at approximately 90 ft, the trajectory deflected then went slightly below the glide path at 30 ft. No flare appeared on the trajectory.

2.8 Black-hole effect

When a pilot has no visual references or when they are altered, visual illusions may occur. They can modify the pilot's perception of his position in space (in terms of height, distance and /or angle of interception) in relation to the runway threshold. Visual illusions are most serious at the time of transition between flying with instruments and visual flight and/or between the IMC/VMC transition.

Without lighting at night, a pilot's perception of depth is particularly affected, making it difficult to estimate distance and height in relation to the aiming point of the trajectory on short final. The black-hole effect is made particularly worse:

- On a long direct approach, in the direction of an airport situated alongside a town;
- If the airport is at a lower altitude than that of the surrounding terrain and if the runway has a different slope to the terrain;
- If the runway lighting is dim;
- If the lights of the town are located in an irregular way on the terrain away from the airport;
- If the runway has an unusual slope.

3 - LESSONS AND CONCLUSIONS

3.1 Accident scenario

The crew performed a flight between Copenhagen and Grenoble, with a night arrival. It was the first time that both pilots had landed at Grenoble.

During preparation for the approach, the crew consulted their chart of Grenoble-Isère aerodrome, which wrongly showed the approach lighting system type for runway 09. They were surprised by the length of the approach lighting system, which they thought was at least 900 m with 3 crossbars.

The runway lighting was set at the dimmest level. The crew did not ask the controller to increase the level of brightness.

At a height of about 1,000 ft, the PF disconnected the autopilot.

⁽⁴⁾The auto-throttle enables the approach speed to be kept constant and consequently the rate of descent also.

Reaching a height of 200 ft, the co-pilot decided to disengage the auto-throttle. The rate of descent started to increase and the speed started to decrease, going below the Vapp⁽⁴⁾.

The landing lights were set at the dimmest level ("DIM" position). The fact of being used to setting the lights in this position probably contributed to the crew deciding not to increase the brightness of their lights, even though they could. Maximum lighting would probably have allowed for an improved perception of distance and height in relation to the runway on short final.

These low lighting conditions associated with the fact that the airplane had been established on final for a long time generated a black-hole effect for the PF and the PNF. The crew's resources were then focused on flying visually and keeping on the approach slope. They did not manage to appropriately perceive the decrease in speed, the increase in the rate of descent and the auditory stimuli of the automatic radio-altitude callouts from the EGPWS from 50 ft onwards. The distance and the height in relation to the trajectory aiming point were not estimated correctly.

The crew's situational awareness was seriously impaired, which would have required a go-around. Nevertheless the PF continued with the landing, without this being questioned by the captain (PNF).

The crew did not perform any flare. At 20 ft from the ground, the PF, surprised by the runway's closeness, pulled sharply on the controls and the airplane consequently pitched up sharply. The pitch attitude exceeded the limit value on touchdown. The rear of the airplane then struck the runway violently, 166 m before the touchdown zone.

If the PF had not disengaged the auto-throttle, the crew would perhaps have noticed that the levers were moving back automatically at 50 ft. This would have been an indication for the crew that the ground was very close, and that the flare should be started.

The fact that the PF had learned of his redundancy shortly before the accident might have produced emotional disturbance that could have reduced his mental availability and aggravated the difficulties in acquiring visual references.

3.2 Visual approach slope indicator system

The presence of a visual approach slope indicator system would have facilitated the transition between flight with instrument references and flight with external visual references. This would have made it possible for the crew not to focus their resources on visual flying and keeping to the approach slope.

In addition, Annex 14 indicates that a visual approach slope indicator system “*shall be provided (...) if the runway is used by turbojet*”, which was the case for runway 09 at Grenoble-Isère.

3.3 Preserving CVR data

OPS article 1.160 of the EC Commission regulation 859/2008 of August 2008 stipulates that:

“Following an accident, the operator of an aeroplane on which a flight recorder is carried shall, to the extent possible, preserve the original recorded data pertaining to that accident, as retained by the recorder for a period of 60 days unless otherwise directed by the investigating authority.”

Article 13.3 of the European Regulation n°996/2010 of 20 October 2010 stipulates that in the case of accidents or serious incidents:

“Any person involved shall take all necessary steps to preserve documents, material and recordings in relation to the event, in particular so as to prevent erasure of recordings of conversations and alarms after the flight.”

The electrical system of the damaged airplane was switched on several times after the end of the flight for a combined time of more than 30 minutes, without the CVR circuit breaker being pulled. This caused the audio recording relating to the landing phase at Grenoble to be erased. Important data for understanding the accident was thus lost, in particular the environment in the cabin on short final and the automatic EGPWS radio-altitude voice callouts. Furthermore, analysis of the crew's teamwork could not be undertaken.

⁽⁵⁾These instructions may for example indicate pulling the CVR circuit breaker.

Following operational instructions indicating the steps to take to preserve the voice recordings⁽⁵⁾ would have prevented the operator from erasing data useful to the safety investigation.

3.4 Conclusion

The accident was due to continuing to land when the crew's situational awareness had deteriorated. This led to an erroneous appreciation of the height in relation to the trajectory aiming point and the absence of a flare.

The following factors contributed to the accident:

- The crew did not select the maximum lighting level for their landing lights;
- Runway 09 at Grenoble-Isère aerodrome did not have a visual approach slope indicator system;
- Thrust management in manual was inappropriate for the landing.

4 - RECOMMENDATIONS

Note: pursuant to European Regulation n°996/2010 on accident investigations, a safety recommendation in no way constitutes a presumption of fault or responsibility in an accident or incident. Article R.7312 of the French Civil Aviation Code and European Regulation n°996/2010 stipulate that the addressees of the safety recommendations inform the BEA (the French civil aviation accident investigation body), within 90 days of reception, of the actions they intend to take and, where no action is taken, the time necessary for its implementation.

4.1 Approach slope indicator

ICAO Annex 14 states that a visual approach slope indicator system must be provided if the runway is used by turbojets.

In addition, a visual approach slope indicator system would have facilitated the transition between instrument flying and visual flying and would have enabled the crew to avoid focusing its resources on keeping the approach slope visual.

Consequently, the BEA recommends that:

- **the DGAC ensure that paragraph 5.3.5.1 of ICAO Annex 14 is respected for all French aerodromes concerned.**

4.2 Preserving CVR data

No action to preserve the CVR recording after the accident was carried out by the aircraft operator. Data relating to the event was missing for the safety investigation. In addition, European regulations (EU-OPS n°859/2008 and n°996/2010) require that all the necessary measures be taken to prevent the recordings of conversations being erased in the event of accidents or serious incidents. Numerous identical cases have been noted in the past.

Consequently, the BEA recommends that:

- **the Danish Civil Aviation Administration (SLV) check that the instructions for operators under its oversight make it possible to ensure the rapid preservation of CVR recordings, after an accident or serious incident, in accordance with the obligations in EU-OPS n°859/2008 and European regulation n°996/2010 (article 13.3).**

Appendix

Graph of FDR parameters

