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Crew Fails to Compute Crosswind Component, Boeing 757 Nosewheel Collapses on Landing

A crosswind component of approximately 35 knots existed for the runway in use at Schiphol Airport in Amsterdam, Netherlands. The report said that the flight crew did not calculate the crosswind component and had insufficient time, after disengaging the autopilot at 100 feet, to align the aircraft properly for landing.

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FSF Editorial Staff

At 2348 local time on Dec. 24, 1997, a Transavia Airlines Boeing 757-236 (B-757) was landed in strong and gusty wind conditions on Runway 19R at Schiphol Airport, Amsterdam, Netherlands. The fuselage was not aligned with the runway when the aircraft touched down hard, and the nose gear collapsed. The aircraft slid approximately 3,000 meters (9,843 feet) on the runway and came to a stop off the side of the runway. Three of the 213 occupants received minor injuries while evacuating the aircraft, and one passenger complained of heart problems.

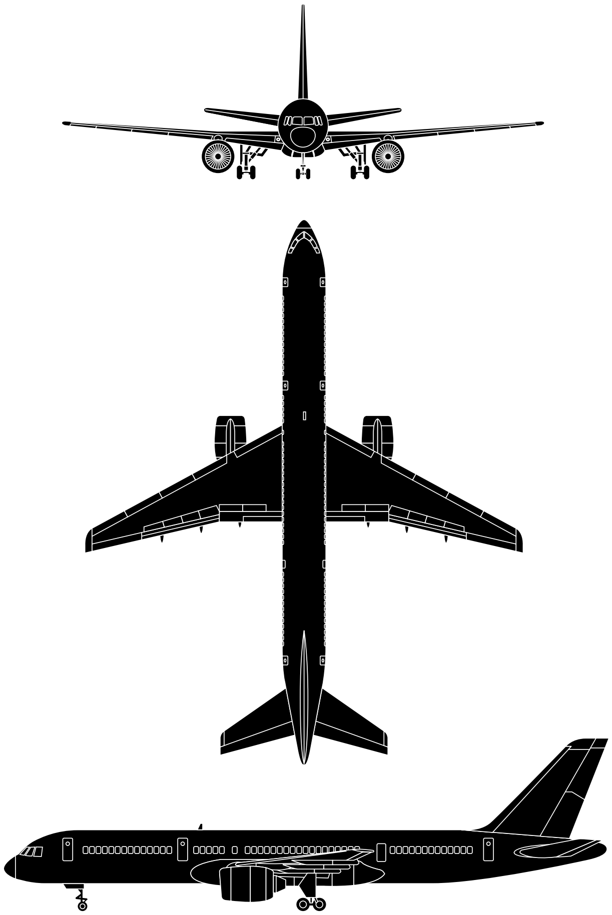
The Dutch Transport Safety Board, in its final report on the accident, said that the causal factors were the following:

- "[The] runway-allocation system at Schiphol Airport resulted in strong crosswind conditions for the landing runway in use;
- "By the omission to state clear and definite crosswind limitations in the Transavia Operations Manual, a defense barrier against unsafe operations was lost;
- "Non-calculation and/or discussion of [the] crosswind component resulted in continuing the approach in adverse weather conditions;
- "Disconnect of the autopilot in the 'align' mode under the existing wind conditions resulted in an out-of-trim condition of the aircraft;
- "The low altitude of the autopilot disconnect in relation to the existing wind conditions allowed the pilot insufficient time to gain complete control of the aircraft, which resulted in a hard, traversing landing; [and,]
- "The hard nosewheel touchdown, exceeding the certified design limits, resulted in a failure of the nose-gear construction."

The aircraft was operated as a charter flight to Amsterdam from Las Palmas, Canary Islands, Spain. The aircraft, manufactured in 1994, had 13,630 service hours and 4,645 cycles.

The flight departed from Las Palmas at 2003.

"Prior to departure, the crew had discussed the weather at Schiphol," the report said. "The forecast for Schiphol [for the estimated time of arrival included] a wind of 230 degrees [at] 26 knots, gusts [to] 40 knots, a visibility of more than 10 kilometers [6.2 statute miles], no significant weather, clouds scattered at 1,000 feet and broken [at] 2,500 feet."



Boeing 757

The Boeing 757-200 series is a medium-range airliner designed to carry 186 passengers in a typical mixed-class configuration. The B-757 can accommodate up to 239 passengers in charter service, putting its capacity between that of the Boeing 737-400 and the Boeing 767. A longer-range version and a freighter configuration of the B-757 also are available.

The B-757-200 is powered by two turbofan engines mounted in underwing pods. Engine pairs for the B-757 are provided by Pratt & Whitney (PW 2037 or PW 2040) and Rolls-Royce (535 series). The engines differ slightly in their static thrust.

The aircraft has a maximum takeoff weight of 104,325 kilograms (230,000 pounds) and engine thrust is rated between 170 kilonewtons (kN; 38,200 pounds) and 197.1 kN (43,100 pounds). At maximum takeoff weight with 186 passengers, the B-757 has a range of between 5,222 kilometers (km; 2,820 nautical miles [nm]) and 5,519 km (2,980 nm), depending on the engine installed. The B-757 has a top speed of Mach 0.86 and a normal cruising speed of Mach 0.80.

The two-pilot cockpit of the B-757 has a computerized, fully integrated flight management system (FMS) that can provide automatic guidance and control of the aircraft from immediately after takeoff to final approach and landing. The FMS controls navigation, guidance and engine thrust to ensure that the aircraft flies the most efficient route and flight profile.

Source: *Jane's All the World's Aircraft*

The captain was the pilot flying. The captain, 53, had an airline transport pilot (ATP) license and 23,197 flight hours, including 2,208 flight hours in type.

The first officer, 34, had an ATP license and 3,744 flight hours, including 1,074 flight hours in type.

The cabin crew included a purser (lead cabin attendant) and five cabin attendants.

"All cabin crewmembers had a valid recurrent training certificate," said the report.

[The report provided no information on the crew's duty time, rest time or activities before the flight.]

Before beginning the descent to Amsterdam, the flight crew was told that the surface winds at Schiphol Airport were from 220 degrees at 30 knots and that wind velocity varied from 19 knots to 40 knots.

"The cockpit crew expected turbulence in the approach and requested the purser to have the cabin ready early in the approach," the report said. "During the descent, the passengers were informed about the expected turbulence in the approach."

At 2333, the flight crew received the following automatic terminal information system (ATIS) message, which was issued at 2325:

> "Schiphol Arrival Information Echo: Main landing Runway 19R; transition level 045 [4,500 feet]; wind 220 degrees [at] 31 knots, maximum 41 knots, minimum 21 knots; visibility 10 kilometers; clouds few [at 2,200 feet], scattered [at 2,800 feet]; temperature 12 [degrees Celsius]; dew point 9 [degrees Celsius] … ."

At 2335, the ATIS message was changed to show that the surface winds were from 230 degrees at 33 knots, gusting to 45 knots, and that the wind direction varied between 200 degrees and 260 degrees. The message, however, was broadcast as Information Echo.

"This ATIS message was inadvertently transmitted under the same code as the previous [message]," the report said. "Because of the same letter code, ATC [air traffic control] as well as the cockpit crew were not alerted that the wind conditions had changed."

The report said that Schiphol Airport had a "noise preferential runway allocation system" to enhance aircraft-noise abatement. Table 1 (page 3) shows the system's order of preference of runway pairs for takeoff and landing. [The airport has five runways: Runway 01L-19R; Runway 01R-19L; Runway 04-22; Runway 06-24; and Runway 09-27. The report provided no information on approach aids for runways other than the approach aids for Runway 19R.]

Table 1
Preferred Runway Pairs at Schiphol Airport, Amsterdam, Netherlands, Dec. 24, 1997

Preference	Landing Runway	Takeoff Runway
1	06	01L
2	19R	24
3	06	09
4	27	24
5	01R	01L
6	01L	01L

Source: Dutch Transport Safety Board

The report said that the International Civil Aviation Organization (ICAO) recommends a crosswind limitation of 15 knots for noise-abatement runway allocation at night; the criteria for runway allocation at Schiphol Airport at night included crosswind limitations of 25 knots on a dry runway, 15 knots on a runway with a surface condition between dry and wet, and five knots on a wet runway.

"[The dry-runway crosswind limitation] is only marginally below the maximum allowable crosswind component of most aircraft," the report said. "Furthermore, ATC is free to exceed the established [noise preferential runway allocation system] wind criteria to extend the use of a runway combination with a higher preference … ."

At the time of the accident, the following notices to airmen (Notams) affected runway allocation at the airport:

- Notam A0622/97 said, "Due to noise-abatement procedures, use of a nonpreferential runway for takeoff or landing [is] not permitted; no restrictions for emergency operations";
- Notam A0764/97 said, "Turbulence forecasted on final approach area at wind direction [between] 180 [degrees] and 250 [degrees] and wind speed more than 20 knots"; and,
- Notam A0810/97 said, "Until Dec. 31 [at] 2359, due to noise-abatement procedures, landing [on] Runway 22 and Runway 24 with approach over the city is not permitted."

When the accident occurred, Runway 24 was being used for takeoffs and Runway 19R was being used for landings. Runway 19R is 3,300 meters (10,827 feet) long and 45 meters (148 feet) wide. The runway had a high-intensity approach-light system, runway-centerline lights and runway-edge lights. The asphalt runway surface was damp at the time.

The report said that the allocation of Runway 19R for landings was based in part on a 2138 forecast for winds from 230 degrees at 24 knots, gusting to 36 knots.

"The preferential runway allocation system, especially by excluding Runway 24 for landing, does not reflect the prevailing wind direction at Schiphol, thereby creating an increase in crosswind operations," the report said. "This, together with a crosswind criterion of up to 25 knots and the freedom to exceed this value, makes the present preferential runway allocation system, in potential, an invitation to unsafe operations."

The report said, "It must be noted that acceptance of an assigned runway is the final responsibility of the pilot-in-command [PIC]."

After receiving the information in the first broadcast of ATIS Information Echo, the flight crew conducted the approach checklist and decided to use 125 knots for V_{REF} (landing reference speed).

"The crew decided to determine the FAS (final approach speed) after a later wind check," said the report.

The estimated aircraft landing weight was 81,946 kilograms (180,658 pounds), and the center of gravity (CG) was 27.8 percent mean aerodynamic chord (MAC). The maximum landing weight was 95,254 kilograms/210,000 pounds, and the acceptable CG range for landing was 13.2 percent MAC to 33.6 percent MAC.

Approach control told the crew to conduct the instrument landing system (ILS) approach to Runway 19R. At 2344, the first officer told Schiphol Tower that the flight was established on the ILS approach to Runway 19R.

The Schiphol Tower controller acknowledged the first officer's report and said, "The wind is two four zero, maximum four three knots, cleared to land on one nine right."

The report said, "The crew discussed the wind and apparently had understood the gusts as 'forty' instead of 'four three.' The FAS was determined to be 140 knots."

The report said that the captain used a 15-knot wind-correction factor to calculate the FAS because he expected wind shear at lower altitude. The crew did not discuss the crosswind.

"The CVR [cockpit voice recorder] transcript did not show any discussion about the crosswind," the report said. "The crosswind component was not calculated."

The Transavia Operations Manual said that the maximum demonstrated crosswind component for the B-757 is 30 knots. The manual did not, however, specify 30 knots as a limit for crosswind landings, said the report.

The manual said, "This value is formally not limiting; however, actual crosswind components approaching (or even exceeding) these values should be treated as a strong incentive to divert to a runway with less crosswind."

Turbulence began to increase as the aircraft descended to 2,000 feet. Nearing 1,500 feet, the flight crew extended the landing gear, set flaps 20 and programmed the autopilot to maintain 165 knots.

After flying over the ILS outer marker, the crew set flaps 25, then flaps 30 and programmed the autopilot to maintain 140 knots.

"The landing checklist was completed," the report said. "The indicated airspeed varied considerably due to the gusty wind."

At 600 feet, the captain told Schiphol Tower that the aircraft's flight management system (FMS) showed winds from 240 degrees at 50 knots. The report said that this might not have been accurate.

"FMS wind calculation uses strong filtering, resulting in lagged data for the crew," the report said. "In addition, the calculation assumes zero sideslip. Therefore, the shown FMS wind may not be as accurate as is generally believed."

Nevertheless, the report said that the FMS wind calculation and the wind report by Schiphol Tower should have prompted the flight crew to calculate the crosswind component and to consider a go-around.

"As it [was], the crosswind was not discussed, and the crosswind component was not calculated by the cockpit crew," said the report.

At 500 feet, the autopilot began to transition the aircraft from a crab attitude to a forward slip. This resulted from the autopilot going into "align" mode.

"In the Boeing 757, the selection of an automatic approach will also include arming of the autoland function," the report said. "This results in aircraft alignment starting at approximately 500 feet. The corresponding aileron [control forces] and rudder control forces are not trimmed. Therefore, an autopilot disconnect below 500 feet may initiate destabilization [of the approach]."

The Transavia Operations Manual said that the maximum crosswind component for autoland operations was 15 knots. The manual said that the autopilot and the autothrottle system should be disconnected "not later than 100 feet RA [radio-altimeter altitude]."

The captain said that, before touchdown, the aircraft encountered a "head-on" gust that caused an increase in indicated airspeed and an increase in pitch attitude.

The aircraft was approximately 100 feet above the ground at 2347 when the captain disconnected the autopilot.

"When the autopilot is disconnected at a height of 100 feet, the pilot has only eight [seconds] to 10 seconds to touchdown, which gives him, especially in turbulent air, not enough time to observe, evaluate and control a highly dynamic situation," said the report.

The B-757's engines are mounted beneath the wings [the thrust line is below the CG]; thus, thrust changes result in pitch changes. The report said that this increases pilot workload in gusty wind conditions.

The report said that two flight-simulator studies showed that control problems were encountered in "adverse weather conditions" during the transition from automatic flight to manual flight.

"From both experiments, it could … be concluded that, at high crosswind speeds, it is essential to disconnect the autopilot at an altitude which allows for ample time to adapt to the demanding control tasks," said the report.

The captain inadvertently failed to disconnect the autothrottle system when he disconnected the autopilot. The report said that flight-simulator tests showed that the autothrottle system produced no significant adverse effects, because the system could be overridden manually when necessary.

When the captain disconnected the autopilot, the aircraft yawed five degrees to the right and began to drift to the left.

"The [captain] reacted with control inputs to bring the aircraft back on the required flight path," said the report.

At the time, weather conditions at Schiphol Airport included surface winds from 230 degrees at 33 knots, gusting to 46 knots, moderate-to-severe turbulence, few stratocumulus clouds with bases at 2,200 feet and scattered stratocumulus clouds with bases at 2,800 feet.

"Wind shears were not reported," the report said. "However, the existing wind conditions may have included small-scale up[drafts] and downdrafts, and local vortices close to the ground."

The captain said that, before touchdown, the aircraft encountered a "head-on" gust that caused an increase in indicated airspeed and an increase in pitch attitude.

"The [captain] pushed the nose down, and the DFDR [digital flight data recorder] showed an engine-power reduction, after which the crew recalled experiencing a violent wing dip to the left, followed by one to the right just prior to touchdown," said the report.

The aircraft's sink rate was approximately 400 feet per minute when the aircraft touched down on the right-main landing gear. The aircraft became airborne again, and the nose pitched up.

"The [captain] pushed the nose down, causing a pitch-down rate of at least nine degrees per second," said the report.

The aircraft had a crab angle of eight degrees when the left-main landing gear and the nose gear contacted the runway.

"[A] computer simulation showed that the nose gear used all 15 inches [38 centimeters] of its available stroke and bottomed on its endstop," said the report.

The report said that the load on the nose gear exceeded by approximately 20 percent the maximum load the nose gear was designed to withstand. The nose gear collapsed, causing damage to electrical systems and electronic systems. The cockpit-instrument lights extinguished, the cabin-emergency-lighting system activated, and the CVR and the DFDR stopped recording.

"Engine controls and flight controls were affected, the autobrake system disconnected, and the [leading-edge flaps and trailing-edge] flaps retracted," said the report.

The report said that failure analyses conducted by the National Aerospace Laboratory (NLR)–Netherlands showed the following results:

- "Fracture surfaces of broken parts of the [nose-landing-gear] structure showed no indications of preexisting cracks; [and,]
- "Examination of the fracture surfaces indicated overload as the cause of the collapse."

The aircraft veered right and struck several runway-edge lights. The captain brought the aircraft toward the runway centerline. At the captain's command, the first officer declared "mayday" to Schiphol Tower.

The aircraft slid approximately 3,000 meters and veered off the right side of the runway. The aircraft then traveled approximately 100 meters (328 feet) over soft terrain.

"When off the runway, the main-gear [assemblies] sank into the soft terrain and collided with the top covers of the runway-light transformer units," the report said. "Both main-landing gears incurred serious damage. Both engines were damaged by ingested concrete debris."

The aircraft came to a stop 50 meters (164 feet) beyond the runway edge. Overheated brakes on the left-main landing gear caused a small fire that was extinguished quickly by aircraft rescue and fire fighting (ARFF) personnel.

The report said that the cockpit was completely dark and that smoke had entered the cockpit.

"In the dark, the pilots performed the shutdown procedures by feel," the report said. "To prevent smoke entering the cabin, they decided to keep the cockpit door closed. The captain was unable to find the PA [public-address system] handset, and when he heard someone at the cockpit door, he shouted the order to evacuate."

The Transavia Operations Manual said that the flight crew should take the following actions during an aircraft evacuation:

- "After shutdown procedures, conditions permitting, the copilot will leave the aircraft via the forward door on the right-hand side as soon as possible. He/she will take control of evacuation outside the aircraft;
- "The PIC, conditions permitting, will visually check the aircraft for persons left behind and will leave the aircraft via the aft door on the left-hand side. The PIC will then take control of the evacuation; [and,]
- "If conditions are unfavorable, flight crewmembers will leave the aircraft via the nearest exit (e.g., cockpit side windows)."

The report said, "The pilots opened the cockpit side windows, which improved the visibility. They eventually, after they assumed that the cabin evacuation was completed because the noise that could be heard behind the closed cockpit door had stopped, evacuated the cockpit [through the cockpit side windows]."

The report said, "In retrospect, it could be argued that the smoke in the cockpit was not a condition preventing the copilot to immediately leave the aircraft via the side window. Also, the captain, after he assumed the evacuation was completed, could at least have checked if the conditions restricted him to visually check the cabin for persons left behind."

The captain said that, after he evacuated the aircraft, he was told by ARFF personnel that all of the passengers had evacuated the aircraft.

The purser and the cabin attendants had not heard the captain's shouted evacuation order.

"A number of passengers, alarmed by the sparks and flames during the rollout, expected a speedy evacuation, and a large number of them got up from their seats and started to move towards the exits," the report said. "Since no evacuation order had been received, the cabin attendants shouted the order to remain seated."

The purser then initiated the evacuation of the aircraft. The purser was in the forward section of the cabin and tried to use the PA system to tell cabin attendants in the aft section of the cabin to evacuate the aircraft. The PA system was not functioning, however; the aft-cabin attendants did not receive the order to evacuate and did not open the four aft-cabin exits.

"Passengers in the aft cabin, seeing forward-cabin passengers evacuate, either demanded that their exits should be opened as well or moved forward to evacuate through the forward exits," the report said. "Eventually, all exits were opened."

Two aft-cabin slides did not deploy automatically and had to be deployed manually by the cabin attendants. The wind moved the right-aft-cabin slide to an unusable position. The other aft-cabin slides deployed at steep angles because of the aircraft's tail-high attitude. Because of the wind, assistance from ARFF personnel was required to control the usable slides. Most passengers evacuated using slides at the forward exits.

"Three passengers were slightly injured by abrasion, and one passenger complained of heart problems," said the report. [The report provided no further information about the passenger who complained of heart problems.]

The report provided the following analysis as an introduction to recommendations made as a result of the accident investigation:

> "The consequences of the accident could have been far worse. The [investigation] identified the fact that the plane landed in a strong crosswind as one of the main causes of the accident. On the basis of the wind data available to the control tower, a crosswind component of 35 knots was calculated at the start of the investigation. Later, however, the [NLR] determined that, in reality, [the crosswind component] may have been 10 knots higher.
>
> "Most aircraft accidents occur during takeoff and landing, with landing entailing the most risks. 'Statistics over the last 10 years show that the major risk is during approach and landing. This is when 50 percent of all aircraft accidents occur.'[1] As far as other causal factors are concerned, wind is a circumstantial factor in one out of three accidents.[2] The combination of landing and weather conditions (a strong crosswind), therefore, warrants closer attention. Various studies have pointed to the risks associated with this combination. For instance, an NLR study states that, although the risk of accidents is very low, it increases sharply with a crosswind of 20 knots or more.

"Although the risk of accidents is very low, it increases sharply with a crosswind of 20 knots or more."

> "Aircraft manufacturers give limits for the maximum crosswind for each type of aircraft. They include a limit based on tests, the demonstrated crosswind and a limit based on simulations — the manufacturer's limit. [For] the Boeing 757, the manufacturer's limit is a crosswind of 40 knots (at an angle 90 degrees to the flight direction), and the demonstrated crosswind limit is, without gusts, 30 knots (also at 90 degrees). The latter limit is generally adopted by aircraft users. In the case of Transavia, [the following] note was included in the pilots' manual, though a great deal was left to the judgment of the pilots, themselves:
>
> > "'[Crosswind] means that the given component is the maximum demonstrated crosswind during aeroplane type certification; this value is formally not limiting; however, actual crosswind components approaching (or even exceeding) these values should be treated as a strong incentive to divert to a runway with less crosswind.'
>
> "After the accident, the Transavia manual was amended [to include] a crosswind limit of 30 knots … .
>
> "A complicating factor is the increasing use of runway-allocation systems. Certain runways may be closed for environmental reasons, especially in connection with noise nuisance, which increases the chance of having to land with a crosswind. For this reason, ICAO, of which nearly all countries are members, has advised its members to regulate runway usage so as to ensure that the crosswind component does not exceed 15 knots.
>
> "Since wind-speed-measuring systems are not always accurate — (because the measurements are made at locations other than the relevant landing zone, the measured wind speed may differ from the actual speed at the runway in question) — and the wind speed (and direction) may be constantly changing, the limit of 15 knots represents an in-built safety margin and can prevent the demonstrated crosswind limit [from] being exceeded. … If the airport has only one runway, then obviously no allocation can take place, and the demonstrated crosswind limit specified by the [aircraft] manufacturer should be used. If it is impossible to land within the stipulated limits, the aircraft will have to be diverted to another airfield.
>
> "In practice, there seems to be a tendency to allow aircraft to land in a strong crosswind despite the

attendant risks. Diverting aircraft to another airfield which has a runway with a less-strong wind or with a more favorable orientation in relation to the wind — e.g., head-on — is generally felt to be very inconvenient by all concerned, including passengers, crew and airlines; passengers are not at their destination and miss their connections, no replacement crew is available, technical inspection of the aircraft cannot be carried out, etc.

"The Transavia aircraft was allocated Runway 19R by [air] traffic control. The available wind data initially fell within the demonstrated limits, but the situation changed just before the landing [and] Runway 24 would have been the most suitable in terms of flight safety. Under the runway-allocation system, this runway is not used for landing purposes at night because the approach route passes over Amsterdam and causes noise nuisance. Exceptions are only made in an emergency. …

"Since landings with a strong and/or increasing crosswind entail risks, the question arises as to whether in such weather conditions (which are not unusual in the Netherlands) … it should be possible to use Runway 24. The case is strengthened by the fact that wind measurements are not always reliable and the wind direction and strength can suddenly change at the last moment. It is also possible for [demonstrated crosswind limits and manufacturer's crosswind] limits to be suddenly exceeded, as happened in the [accident]. … The runway-allocation system should adhere to the ICAO's recommended crosswind limit of 15 knots. …

"The fact that the pilot switched from automatic pilot to manual [aircraft control] — and, above all, the altitude at which this took place — played a role in the accident. The manuals only specify a minimum altitude of 100 feet (approximately 30 meters), which proved to be too low in the prevailing weather conditions. Airline companies should include a caution in the manuals on the minimum altitude at which the automatic pilot must be switched off in poor weather conditions. … "

The report made the following recommendation to the Netherlands Air Traffic Control Agency:

- "In addition to the wind information for landing, ATC should provide pilots with the actual tail[wind] and crosswind components."

The report made the following recommendation to the Dutch Minister of Transport and Public Works:

- "The preferential runway allocation system in use at [Schiphol Airport] should be reviewed with respect to:
  - "Recommended ICAO limitations;
  - "Uncertainty of present wind information;
  - "Potential risks of operating in (strong) crosswind conditions; [and,]
  - "Freedom by ATC to exceed the established [runway-allocation] criteria."

The report made the following recommendations to aircraft operators:

- "During training, pilots should be made aware of the uncertainty with regard to wind speed in the reported wind information;
- "Operations manuals should contain a 'caution' with regard to the minimum height for autopilot disconnect in adverse wind conditions, especially in relation to the 'align' mode; [and,]
- "Operators should review passenger-evacuation procedures with respect to:
  - "(Partial) failure of interphone and/or [PA] systems;
  - "Use of [evacuation] slides under high wind speeds; [and,]
  - "Further elaboration of the cockpit-crew evacuation duties during actual flight safety training."♦

[Editorial note: This article, except where specifically noted, was based on the Dutch Transport Safety Board *Final Report: 97-75A/A-26, PH-TKC, Boeing 757, 24 December 1997, Amsterdam Airport Schiphol*. The 144-page report contains appendixes, diagrams and photographs.]

References

1. The report attributed this quotation to Stuart Matthews, chairman, president and CEO, Flight Safety Foundation (FSF). Second World Congress on Transport Safety. Delft, Netherlands, Feb. 18–20, 1998.

2. The report attributed this statistic to the FSF Approach-and-landing Accident Reduction Task Force analysis of 76 approach-and-landing accidents, as reported in *Flight Safety Management, Measurement and Margins: Proceedings of the 11th annual European Aviation Safety Seminar*, Alexandria, Virginia, United States: Flight Safety Foundation, 1999.

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