RUNWAY OVERRUN

The aim in the Netherlands is to reduce the risk of accidents and incidents as much as possible. If accidents or near-accidents nevertheless occur, a thorough investigation into the causes of the problem, irrespective of who is to blame for it, may help to prevent similar problems from occurring in the future. It is important to ensure that the investigation is carried out independently from the parties involved. This is why the Dutch Safety Board itself selects the issues it wishes to investigate, mindful of citizens' position of dependence with respect to public authorities and businesses. The Board recognizes a number of situations where (international) obligations require that the Board must perform an investigation.[1]

GENERAL INFORMATION

Identification number:	2010077
Classification:	Serious incident
Date, time[2] of occurrence:	2 October 2010, 19.06 hours
Location of occurrence:	Amsterdam Schiphol Airport
Aircraft registration:	TC-TJF
Aircraft model:	Boeing 737-4Y0
Type of aircraft:	Twin-engined passenger aircraft
Type of flight:	Passenger flight
Phase of operation:	Landing
Damage to aircraft:	Minor
Cockpit crew:	6
Passengers:	167
Injuries:	None
Other damage:	None
Lighting conditions:	Dusk

SUMMARY

On 2 October 2010 during landing at Amsterdam Schiphol Airport a Boeing 737-4Y0 overran Runway 22 by approximately nine metres. None of the crew and passengers onboard sustained any

[1] The purpose of the Dutch Safety Board's work is to prevent future accidents and incidents or to limit their after-effects. It is no part of the Board's remit to try to establish the blame, responsibility or liability attaching to any party. Information gathered during the course of an investigation – including statements given to the Board, information that the Board has compiled, results of technical research and analyses and drafted documents (including the published report) - cannot be used as evidence in criminal, disciplinary or civil law proceedings.

[2] All times in this report are local times unless otherwise specified.

injuries. The aircraft suffered minor nose wheel damage.

FACTUAL INFORMATION

History of the flight

The Boeing 737-4Y0 operated by Corendon Airlines made a scheduled passenger flight from Dalaman Airport (LTBS, Turkey) to Amsterdam Schiphol Airport (EHAM, the Netherlands). Onboard were 6 crew members and 167 passengers. At approximately 18.45 hours the aircraft entered Dutch airspace and Air Traffic Control (ATC) the Netherlands was contacted. The cockpit crew, consisting of a captain as 'pilot flying' and a first officer as 'pilot monitoring', had initially planned for an approach to Runway 18R. Due to the changing weather conditions, ATC changed the runway for landing to Runway 22. The change of runway was received by the crew at FL200 (approximately 20.000 feet), 15 minutes prior to landing.

The crew had calculated a reference landing speed[3] (V_{ref}) of 140 knots for Runway 18R with flaps 30. Using standard procedures, 5 knots was added and the approach speed was determined to be 145 knots. The crew did not change the reference landing speed for Runway 22. The crew selected position II of the auto brake system and flaps 30.

According to the crew the landing clearance was given at approximately 600 feet. This clearance did not contain information regarding the condition of the runway. The windscreen wipers were set to maximum speed but heavy rain reduced visibility and sight of the runway. At 200 feet the autopilot[4] (AP) was disconnected and the remainder of the flight was flown manually. The autothrottle[5] (A/T) remained engaged.

The aircraft passed the runway threshold and the landing flare was initiated. According to both pilots, the aircraft remained 'floating' above the runway at approximately 30 feet. After touchdown the auto-brake system activated, the spoilers and speed brakes were deployed and full reverse was selected. As the aircraft approached the end of the runway maximum manual braking was applied but the aircraft overran the runway by about nine metres. None of the crew and passengers onboard sustained any injuries. The aircraft suffered minor nose wheel damage.

Figure 1: TC-TJF after overrunning Runway 22 with its nose off the paved surface (Source: Amsterdam Airport Schiphol)

[3] The reference landing speed is defined as the speed of the aeroplane in a specified landing configuration, at the point where it descends through the landing screen height (50 feet) in the determination of the landing distance for manual landings.
[4] A system which automatically maintains the heading, altitude or the flight path, selected by the crew.
[5] A system which automatically regulates the engine thrust by moving the thrust levers.

Landing distance required
The landing distance required depends among other things of the following factors: the aircraft landing mass, the aircraft configuration, the surface wind and temperature, the runway surface condition, the landing speed and the available aircraft braking systems.

Weather conditions
At the time of the event a rainy weather front was moving at approximately 20 knots from the southwest to the northeast of the Netherlands. In the region of Schiphol Airport light to moderate rain was present. The crew received the automatic terminal information service (ATIS) Charlie (C) of 18.25 hours. The ATIS information indicated drizzle with few clouds at 600 feet, the wind coming from 130 degrees, varying between 100 and 160 degrees, with a speed of 9 knots.

As the aircraft landed, the wind direction and wind speed were recorded by meteorological sensors next to the runway threshold. Those sensors registered a wind coming from 135 degrees with a speed of approximately 7 knots.

Weather information reported by ATIS Delta (D) at 18.55 hours (just before the occurrence) showed low clouds (400, 700 and 1100 feet) and the presence of rain (drizzle). See table 1.

Code	**Time**	**Message**
C -	021625Z	13009KT 100V160 4500 DZ FEW006 BKN011 BKN025 16/15 Q1007 TEMPO 2500 BKN008
D -	021655Z	14009KT 2500 DZ FEW004 SCT007 BKN011 16/15 Q1007 RADZ TEMPO BKN007=
E -	021725Z	14007KT 110V170 3200 RADZ FEW003 SCT005 BKN007 16/15 Q1007 RERADZ BECMG 6000=

Table 1: ATIS weather information

Available systems for stopping an aircraft on a runway
The following devices are available to reduce the speed of an aircraft after landing and reach taxi speed or a final stop at the end of the runway or sooner:
- Speed brakes;
- Wheel brakes (including auto brake and anti-skid system);
- Thrust reversers.

The speed brakes, which include both flight and ground spoilers on the ground, are the primary factor in providing deceleration capability to the airplane. This system is armed before landing and will automatically activate upon main landing gear touchdown. The system provides two aerodynamic effects. First it increases the aerodynamic drag of the aircraft which contributes to the deceleration and secondly the spoilers dump the lift from the wing which increases both the weight on the wheels and significantly improves the amount of wheel-brake force that can be applied to a given braking surface.

The second system is the use of brakes on the main landing gear wheels. Braking action is a result of friction between the tyres and the runway surface. Several factors influence the braking actions including the runway surface condition and the load applied on the wheels. The auto brake system aims to achieve a steady deceleration rate and applies the brake pressure to achieve this. This rate of deceleration can be set by the flight crew. An electronic system (anti-skid system) prevents wheel lock during braking and generates the best possible performance.

The thrust reversers are the third system, which reverse some of the engine air flow to help decelerate the airplane. Thrust reversers are most effective at high speed and/or with a contaminated runway surface. At low speed or on a dry runway brakes are much more effective. At lower speeds reverse thrust use is not recommended as engine damage may occur by the ingestion of a foreign object or the engine may stall. However, in an emergency situation maximum reverse may be maintained to a full stop.

INVESTIGATION AND ANALYSIS

Dutch Safety Board investigators were dispatched to the scene following the overrun. Initial interviews were made with the flight crew and the flight recorders were removed for the investigation.

Investigation and analysis of recorded information
The flight data recorder (FDR) and cockpit voice recorder (CVR) were read-out and analysed. The CVR records 30 minutes of conversations and background noise in the cockpit in an endless loop. Because electrical power was left on after the event and the circuit breaker of the CVR was not pulled, it continued to record. As a consequence, the approach and overrun event was not available on the CVR. The absence of a CVR recording hampered the investigation and made reconstructing the event difficult.

The data retrieved from the FDR was of poor quality. The aircraft was also equipped with a quick access recorder (QAR), which recorded the same data as the FDR. This data was of good quality and subsequently used for the investigation.

Details of the radio communication between Air Traffic Control and the flight were received from Air Traffic Control the Netherlands. A transcript of the communication was created and correlated with the flight data. Data from the ground radar at Schiphol Airport was also received for investigative purposes.

According to the flight data, at 18.54:30 hours the aircraft flew with Autopilot 1 engaged at 8.000 feet at a speed of 240 knots. During descent the flaps were extended to 10 degrees at 6.600 feet. At 3.000 feet the instrument landing system (ILS) signals were captured.

At 2.600 feet radio height the flaps were selected to 15 degrees and at 1.200 feet flaps 30 degrees were selected. At 1.000 feet radio height the aircraft was configured with gear down and flaps 30 degrees with ILS localizer and glide slope captured with minimal deviation and thus stabilized.

The runway controller made contact with TC-TJF with the following clearance: “Corendon 603 Runway 22 cleared to land, vacate at the end to the right and remain on this. The wind is 120 degrees at 8 knots”. The crew replied at 19.02:34 hours at a radio height of 520 feet: “Cleared to land Runway 22, vacate at the end and stay on this frequency”.

At 19.02:41 hours at a radio height of 300 feet and 147 knots computed airspeed, the MCP SPD[6] was disengaged and the autothrottle was set to the ARM mode. Eight seconds later the autopilot was disengaged. Glide slope deviation was zero at the time that the autopilot was disconnected.

At 19.03:00 hours the pitch of the aircraft was approximately 1 degree. At that moment an elevator input was given and the pitch of the aircraft increased. One second later, at 53 feet radio

[6] Mode control panel speed, a mode that commands the aircraft to fly at a speed selected by the crew on the mode control panel. This mode is indicated with ‘MCP SPD’.

height, a maximum groundspeed of 154 knots was recorded with a maximum computed airspeed of 153 knots. This airspeed was 8 knots above the calculated approach speed of 145 knots.

At 19.03:02 hours the throttles were moved to the idle position and the aircraft airspeed decreased. The pitch of the aircraft continued to increase while the aircraft was descending. Six seconds later the pitch of the aircraft was approximately 5 degrees at 15 feet radio height. At 19.03:10 hours at 9 feet radio height the MIN SPD and RETARD mode of the autothrottle were activated.

At 19.03:15 hours ground sensing was recorded at 136 knots computed airspeed. Four seconds later the thrust reversers were deployed and reverse thrust was selected with 80% N1 (engine RPM). At the same time a maximum brake pressure of 3.000 psi[7] was recorded. The automatic speed brake handle was only partially extended and reached 40 degrees (in-flight detent). A maximum longitudinal aircraft acceleration of -0.4486g was recorded.

At 19.03:39 hours the pitch of the aircraft decreased and a nose-down attitude of -2.81 degrees was recorded. Three seconds later the aircraft was motionless with no accelerations recorded. After the engines were shut down the recorder stopped recording.

Analysis of the landing
The crew was of the opinion that the landing clearance was given late. The clearance was given at a height of approximately 600 feet, 45 seconds prior to touchdown at Runway 22. It is not uncommon, as in this case, that a preceding aircraft tends to stay long on Runway 22 because there are no high-speed exits available. Furthermore exit G5 (figure 2), at the far end of the runway, is the most favourable exit for taxiing because of its shortest taxi route to the airport terminal. Therefore a delay in final landing clearance can be expected. As the aircraft was already stabilized from around 1000 ft AGL, this relatively late landing clearance did not influence the aircraft position related to the flare and landing.

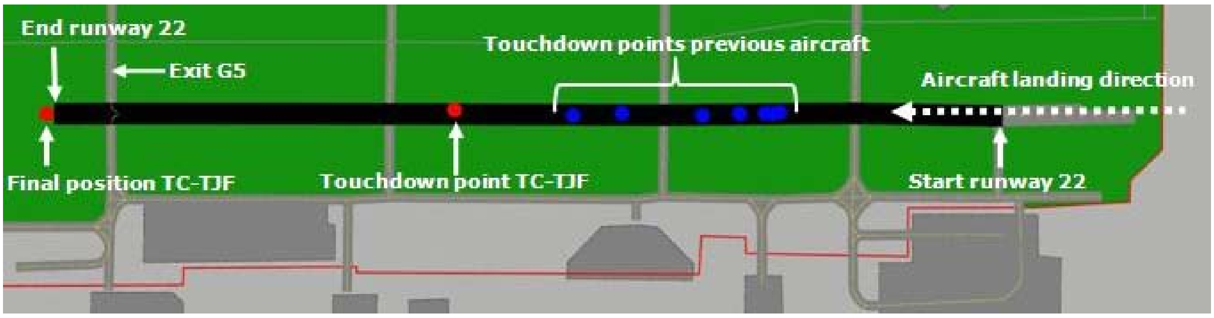

Figure 2: runway 22 at Amsterdam Schiphol Airport with the touchdown points of aircraft (blue) which landed prior to the event flight (red)

Analysis of the weather data and the precipitation radar showed that a low cloud base and rain were present during the final stages of the approach. The precipitation radar showed that the aircraft was descending from 500 feet while it crossed an area of moderate to light precipitation. (figure 3). According to calculations performed by the Royal Netherlands Meteorological Institute (KNMI) the presence of clouds and rain would make the visual range (slant visibility) around 2 kilometres at an altitude of approximately 500 feet. This, together with the light conditions, influenced the visual range of the flight crew.

[7] Psi stands for pound per square inch = 0.0689 bar.

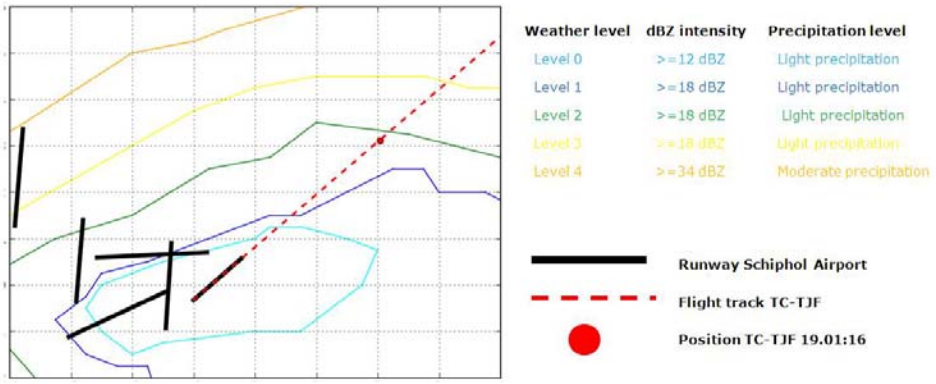

Figure 3: weather radar at 19.01:16 hours with TC-TJF flight track and runways at Amsterdam Schiphol Airport

The flight data showed that at approximately 200 feet radio height the autopilot was disconnected and the autothrottle remained engaged. According to the operator's Operations Manual, Part A, during the approach the flight director, autopilot and autothrottle should be used to the maximum extent practical. This is in order to relieve the workload of the flight crew and give them more time to monitor instruments and weather conditions. When the use of autopilot and/or autothrottle becomes unproductive they should be disengaged. During all other phases of flight, autothrottle use is recommended only when the autopilot is engaged. By choosing to disconnect the autopilot and autothrottle the workload by the pilot flying was not relieved.

The recorded flight data showed that at a radio height of approximately 50 feet the aircraft was pitched up slightly. This pitch-up could be considered an early flare manoeuvre, which normally occurs around 20 feet above the runway touchdown zone (figure 4). Because of the pitch manoeuvre the aircraft's rate of descent decreased and this resulted in a touchdown further down the runway. It also gave the crew the feeling that the aircraft was floating over the runway.

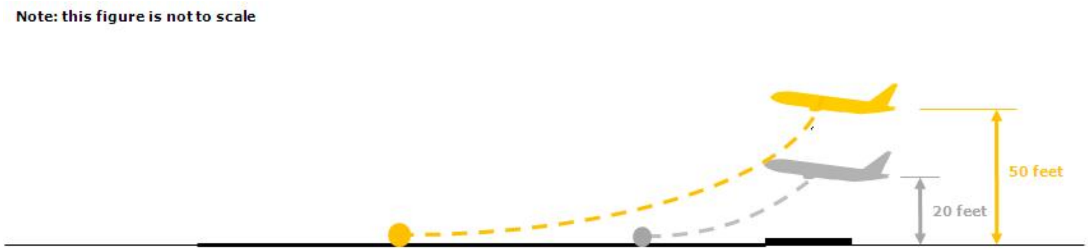

Figure 4: schematic reproduction of the flare manoeuvre at 20 feet (grey) and the flare manoeuvre at 50 feet (yellow) of the event flight with the touchdown points on the runway

The recorded wind direction and wind speed onboard the aircraft at approximately 20 feet were 110 degrees and 6 knots. This data shows there was a slight tail wind. The meteorological sensors near the runway recorded a wind direction and wind speed of 135 degrees and approximately 7 knots. This means there was a slight head wind. Both recorded values of the wind were within the certified crosswind limits of the aircraft.

Analysis of the touchdown point of the aircraft on the runway

Ground radar data was used to determine the point where the aircraft touched down on the runway. Previous aircraft landed on Runway 22 approximately a third along the runway (figure 2). According to radar data, the touchdown of TC-TJF was approximately 860 metres before the runway end, approximately half the runway length.

After touchdown, both the left and right thrust reversers were deployed and high engine power was applied. In addition, maximum brake pressure was recorded (3.000 psi). The flight data showed that the speed brake handle did not reach full deflection and, as a consequence, the landing distance increased. The partial deployment could not be explained with the information available.

The recorded longitudinal deceleration was analysed and the aircraft braking coefficient was calculated. From this calculation the surface condition, or friction coefficient, was classified as 'GOOD'.[8] The analysis further showed that the aircraft became friction-limited, which means that the deceleration of the aircraft became limited by the available surface friction. Because of this more runway was required than available.

CONCLUSIONS

The investigation can be summarised with the following conclusions:

- As a result of an early flare manoeuvre, the aircraft landed approximately halfway down the runway.
- The partially deployed speed brakes reduced braking performance.
- The remaining runway and braking performance with partial speed brakes were insufficient for the aircraft to stop prior to the end of the runway.
- The visual conditions and rain at the time of landing may have impaired the crew's visual depth perception on the runway.

This report has been published in Dutch and English. If there are differences in interpretation the Dutch text prevails.

[8] GOOD aircraft braking coefficient lies between 0.2 and 0.4μ which is indicative for a wet runway.

APPENDIX A: DATA FROM THE QUICK ACCESS RECORDER

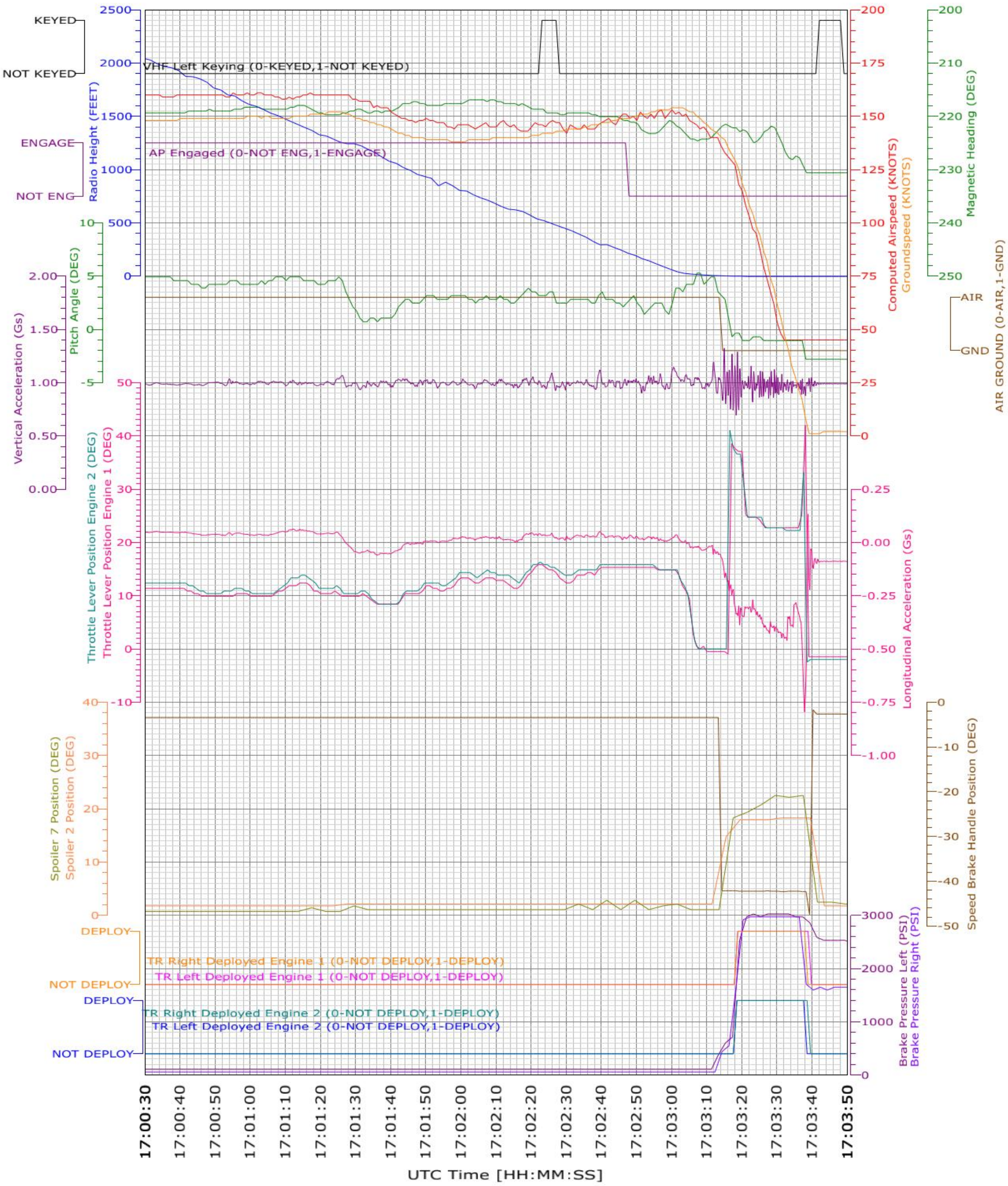

Figure 4: graph of 21 relevant parameters from the quick access recorder

APPENDX B: RECEIVED COMMENTS INVOLVED PARTIES

A draft report was submitted to the parties directly involved in accordance with the Kingdom Act concerning Safety Investigation Board in order to review the report on factual inaccuracies.

The draft version of this report has been submitted to the following parties:
- The captain
- The first officer
- Turkish Directorate General of Civil Aviation, Turkey
- Operator Corendon Airlines, Turkey
- National Transportation Safety Board, United States of America
- Boeing Commercial Airplanes, United States of America

In so far as non-textual, technical aspects and factual inaccuracies are concerned, the Board has incorporated the comments received into the final report. The verbatim remarks are mentioned in this appendix with reasons why the Board has not amended the report on these points.

Comments from Operator Corendon Airlines

Remark:
In investigation and analysis part, Analysis of the flown approach to runway 22 section. The DSB has noted that recorded wind speeds both on board and meteorological sensors showed crosswind around 7 knots. But QAR data shown us, aircraft was having tailwind from 3000 feet to touchdown with subsiding trend. You can see wind component chart in the attachment. This light tailwind component might have been a contributing factor as well.

Board response:
The operator has drawn up an investigation report. The Dutch Safety Board compared the results of the report with the own analysis. Differences were observed with regard to the analysis of the wind conditions during the approach.

The Dutch Safety Board has conducted an analysis of the flight data using conversion factors provided by the aircraft manufacturer. These conversion factors are very precise. The analysis of the available data (groundspeed, airspeed and wind data) showed no indication of data irregularities or mismatch. Analysis of the data (wind sensors next to the runway) and performance calculations performed by the manufacturer showed data consistency. The difference between the analysis results of the operator and the Board (in cooperation with Boeing and the NTSB) is probably the result of the conversion factors used by the operator. Those factors are probably less accurate or different than the factors used by the Board.

The analysis by the Dutch Safety Board showed that the aircraft experienced head wind conditions during the approach. Near the runway the wind conditions at the time of the occurrence measured 135 degrees with 7 knots. This resulted in a slight head wind.