Summary Report

A summary investigation, in accordance with Article 45 of the Ordinance on the Safety Investigation of Transport Incidents of 17 December 2014 (OSITI), as of 1 February 2015 (SR 742.161), was carried out with regard to the following serious incident. This report was prepared to ensure that lessons can be learned from the incident in question.

Aircraft	Airbus A330-343		HB-JHC	
Operator	Swiss International Air Lines Ltd., 4002 Basel, Switzerland			
Owner	Swiss International Air Lines Ltd., 4002 Basel, Switzerland			
Commander	Swiss citizen, born 1964			
Licence	Airline Transport Pilot Licence Aeroplane (ATPL(A)) according to the European Union Aviation Safety Agency (EASA), issued by the Federal Office of Civil Aviation (FOCA)			
Flying hours	**total**	14 931:22 h	**during the last 90 days**	140:03 h
	on the type involved in the incident	3933:21 h	**during the last 90 days**	133:34 h
Copilot	German citizen, born 1988			
Licence	ATPL(A) according to EASA, issued by the FOCA			
Flying hours	**total**	3889:48 h	**during the last 90 days**	97:48 h
	on the type involved in the incident	429:16 h	**during the last 90 days**	97:48 h
Location	Runway 32 of Zurich Airport (LSZH)			
Coordinates	---		**Altitude** ---	
Date and time	26 February 2020, 10:38 UTC (LT[1] = UTC[2] + 1 hour)			
Type of operation	Commercial flight			
Flight rules	Instrument Flight Rules – IFR			
Point of departure	Zurich Airport (LSZH)			
Destination	Nairobi Airport (HKJK), Kenya			
Flight phase	Takeoff and climb			
Art des schweren VorfallsType of serious incident	Tail contact with runway			

Injuries to persons	**Crew**	**Passengers**	**Third parties**
Minor	0	0	0
None	2/10	221	Not applicable

Damage to aircraft	Minor damage	Scratches and grinding marks on the lower part of the aircraft
Third-party damage	None	

[1] LT: Local Time

[2] UTC: Universal Time Coordinated

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Factual information

Prehistory

On 26 February 2020, the flight crew carried out a scheduled flight of an Airbus A330-343 commercial aircraft, registration HB-JHC and flight number LX294, from Zurich (LSZH) to Nairobi (HKJK), with a planned onward flight to Dar es Salaam (HTDA). There were 2 pilots, 10 cabin crew and 221 passengers on board. On this flight, the commander was Pilot Monitoring (PM) and the copilot was Pilot Flying (PF).

The flight was scheduled to start from Zurich at 08:55 UTC. At 08:56:58 UTC, the flight crew contacted the Air Traffic Control Officer (ATCO) on the Clearance Delivery Frequency (CLD) to obtain a Standard Instrument Departure route (SID). After refusing a possible takeoff on runway 28, they were cleared for departure on runway 16.

There were snow showers at the airport and the runway conditions for runways 28 and 16 were reported as full length 100% wet snow 3 mm thick. In the Automatic Terminal Information System (ATIS), which was valid for the expected departure at 09:13 UTC, runway 28 was notified as the takeoff runway and it was also announced that runway 16 would be closed from 09:30 UTC to 10:10 UTC due to snow clearance work. Owing to the planned aircraft de-icing and the air traffic control announcement at 09:35 UTC that runway 32 was now in operation for takeoffs, the flight crew requested a new departure procedure from CLD at 09:41:22 UTC. This was granted for runway 32 via SID «DEGES 4L». At that time, the 09:38 UTC ATIS was active, runway 32 was announced as the takeoff runway and the runway condition was indicated as 10% of the runway surface covered with slush 3 mm thick. The flight crew then carried out a takeoff power calculation on their Electronic Flight Bag (EFB)[3] in order to determine the optimal parameters for takeoff. The calculation indicated, among other things, a Configuration (CONF) of CONF 2 with a flex temperature[4] of 35 °C.

At 10:07 UTC, the flight crew again performed a takeoff power calculation on the EFB. At that time, the 09:50 UTC ATIS was active. The runway condition was cited as unchanged with 10% of the runway surface covered with slush 3 mm thick, wind from 280 degrees at 19 kt and gusts up to 32 kt, the temperature at 1 °C and the atmospheric pressure (QNH) reduced to sea level with the values of the ICAO[5] standard atmosphere was 1003 hPa. In addition, wind shear was reported at an altitude of approximately 3000 ft AMSL[6]. Because of this wind shear, the flight crew decided on a CONF 1+F takeoff. In addition, in view of the variable wind and the condition of the runway, the flight crew selected a wind input with a tailwind. For the same reason, they also selected a temperature of 34 °C, reduced by 1 °C compared to the maximum possible flex temperature. When doing so, for takeoff they planned to switch on the engine and wing anti-icing and to switch off the airconditioning packs.

The takeoff power calculation was carried out accordingly, with a tailwind component of 6 kt, a temperature of 1 °C and a QNH of 1001 hPa as ambient conditions. This resulted in the vital speeds (V-speeds) V1[7] = 136 kt, VR[8] = 148 kt and V2[9] = 153 kt (cf. Figure 1).

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[3] The EFB, the «Electronic Flight Bag», is the replacement for documents in a digital format that was usually carried in a heavy document bag in the cockpit.

[4] The flex temperature is higher compared to the actual outdoor temperature and is used for the takeoff power calculation. This results in reduced engine takeoff power, so they are subject to less wear.

[5] ICAO: International Civil Aviation Organization

[6] AMSL: Above Mean Sea Level, height above the mean sea level

[7] V1 refers to the takeoff decision speed. If an engine fails at this speed, the aircraft is capable of either continuing takeoff with a safe climb or aborting takeoff and stopping on the runway.

[8] VR refers to the rotation speed. At this speed, the pitch of the aircraft is increased to take off.

[9] V2 refers to the minimum takeoff safety speed. This speed ensures a safe climb with an engine that has failed at V1.

At 10:34:02 UTC, the flight crew received clearance to taxi to the takeoff position and at 10:36:01 UTC received clearance for takeoff on runway 32. The ATCO also reported wind from 260 degrees at 19 kt and gusts of up to 28 kt.

History of the flight

At 10:36:11 UTC on 26 February 2020, the crew pushed the thrust levers of the twin-engine Airbus A330 commercial aircraft, registration HB-JHC, into the «FLX»[10] detent and began the takeoff run. Acceleration was normal. At 10:36:53 UTC, the PF initiated rotation of the aircraft in gusty winds. The Knots Indicated Airspeed (KIAS), which just 2 seconds before had been 148 kt, i.e. VR, had dropped in the meantime to 142 kt. The PF pulled the stick back when rotating to approximately 3/4 of full deflection and then partially brought it back to a position which corresponded to about half deflection. Within 4 seconds, the aircraft attained a pitch angle of 11.2°. Two seconds later, at a pitch angle of 13.7° and a speed of 154 KIAS, the aircraft lifted off. Shortly before the main landing gear lifted off from the runway, the rear of the aircraft made contact with the runway (tailstrike); this was not noticed by the flight crew or the cabin crew.

The onward climb as well as cruising and descent were uneventful. HB-JHC landed in Nairobi at 18:06 UTC as planned.

Findings after landing

Before continuing the flight to Dar es Salaam, the station mechanic informed the flight crew that he had detected fresh scratches and grinding marks on the lower fuselage of the aircraft's rear, near the waste water door (see Annex 1). After consultation with the maintenance company in Zurich, the onward flight was cancelled.

After a detailed and extensive inspection by specialists from the airline's maintenance company who were flown to Nairobi, and in consultation with the aircraft manufacturer, a temporary repair was carried out (see Annex 1). This was completed on the evening of 9 March 2020 and the aircraft was subsequently cleared for operation.

Meteorological information

At the time of takeoff of HB-JHC the following Meteorological Aviation Routine Weather Report – METAR) applied:

“METAR LSZH 261020Z 26017KT 9999 VCSH FEW014 SCT029 BKN034 01/M03 Q1004 R88/6103// TEMPO 3000 SHSN=”

From this report, it is apparent that shortly before its time of issue at 10:20 UTC, the following weather conditions had been observed:

Weather	Showers at a distance of 8 to 16 km from the airport.
Cloud below 8000 ft AAE[11]	1/8 – 2/8 1400 ft AAE 3/8 – 4/8 2900 ft AAE 5/8 – 7/8 3400 ft AAE
Visibility	10 km or more
Wind	260 degrees, 17 kt
Temperature and dewpoint	1 °C / -3 °C
Atmospheric pressure (QNH)	1004 hPa

[10] In the case of the Airbus A330, the thrust lever can be transferred from the idle position to the «CL» detents for climb, «FLX» for takeoff at reduced engine power and «TOGA» for maximum engine power.

[11] AAE: Above Aerodrome Elevation

Runway condition	All runways: runway surface covered with 10% or less slush 3 mm thick. No information on braking conditions.
Trend	Visibility 3000 m and snow showers. This information describes an expected change in the weather conditions. The change persists for less than one hour and in total for less than half of the forecast period of two hours after the observation time.

Procedures

The company's operating procedures are set out in its Flight Crew Operation Manual (FCOM) on the one hand and in its Flight Crew Techniques Manual (FCTM) on the other hand.

Only those points from the FCOM and FCTM that are relevant to the serious incident are mentioned below. This concerns on the one hand the selection of the flap setting, the power setting for takeoff and the determination of the V-speeds, and on the other hand the procedure for rotation and lift-off of the aircraft after takeoff run and information concerning the tailstrike avoidance.

Selection of flap configuration and engine power for takeoff

According to the FCOM, three flap settings (Configuration – CONF) are permitted for takeoff, CONF 1+F, CONF 2 and CONF 3.

In order to reduce the load on the engines during takeoff, flight crews are advised according to the FCOM to adjust engine power using a flex temperature and not to apply the maximum permitted engine power (Takeoff/Go-Around thrust – TOGA thrust). This can extend the service life of the engines and reduce maintenance costs. At the same time, it is stated that in order to improve takeoff performance, the flex temperature can be reduced, deviating from the optimal flex temperature resulting from the takeoff power calculation, in order to achieve higher engine power on takeoff.

According to the FCOM, the procedure using a flex temperature is only permitted when taking off on a dry or wet, well paved runway. In the case of a contaminated runway, this is prohibited and the takeoff must be performed at the maximum permitted engine power (TOGA). A runway is considered to be contaminated only if more than 25% of its surface is covered with precipitation residues (slush, snow, ice, etc.).

In the case of expected windshear during takeoff, the company's FCTM recommends that the maximum permitted engine power TOGA must be set. In the case of a takeoff with reduced engine power, it is possible to push the thrust levers forward to TOGA at any time.

Rotation technique and lift-off of the aircraft

According to the FCOM and FCTM, rotation during takeoff should be initiated with a positive rearward deflection of the stick when VR is reached. A continuous rotation rate of 3 °/s (degrees per second) should be achieved up to a pitch attitude of 15°. The aircraft takes off from the runway approximately 4 to 5 seconds after rotation is initiated at a pitch angle of approximately 10°.

Tailstrike on takeoff

The FCTM discusses the subject of tailstrike avoidance in depth. In summary, the relevant factors are listed below:

- Tailstrikes can cause severe structural damage;
- Weather conditions with crosswinds, turbulence and windshear favour the occurrence of a tailstrike;

- The minimum ground clearance of the aircraft's rear in relation to the runway occurs before lift-off, before the rotating bogies of the main landing gear attained complete extension;
- Excessively early rotation of the aircraft before it reaches VR results in an increased pitch attitude on takeoff and therefore favours the occurrence of a tailstrike;
- An abrupt increase in the rotation rate just before lift-off increases the risk of a tailstrike;
- In order to reduce the risk of a tailstrike, in the FCTM the operating company explicitly recommends a takeoff with flap setting CONF 2.

Calculation of takeoff power values

Flight crews have an application at their disposal in the Electronic Flight Bag (EFB) to calculate takeoff power. The flight crew can calculate the optimal configuration and the maximum flex temperature under the given takeoff conditions or determine these parameters themselves and perform the corresponding calculations using them.

It is customary in practice to enter values with a certain safety margin (in aviation jargon these are termed "conservative values") with regard to environmental conditions (temperature, air pressure and wind), this is also done so as not to have to perform a new calculation immediately before takeoff in the event of short-term changes in these ambient conditions.

With regard to wind, the Flight Operations Manual states that the current mean wind should be taken into account for takeoff, and that gusts are only used for crosswind limit values.

The calculation of the takeoff performance values carried out by the crew of HB-JHC shortly before takeoff on runway 32 was displayed on the EFB as follows (cf. figure 1).

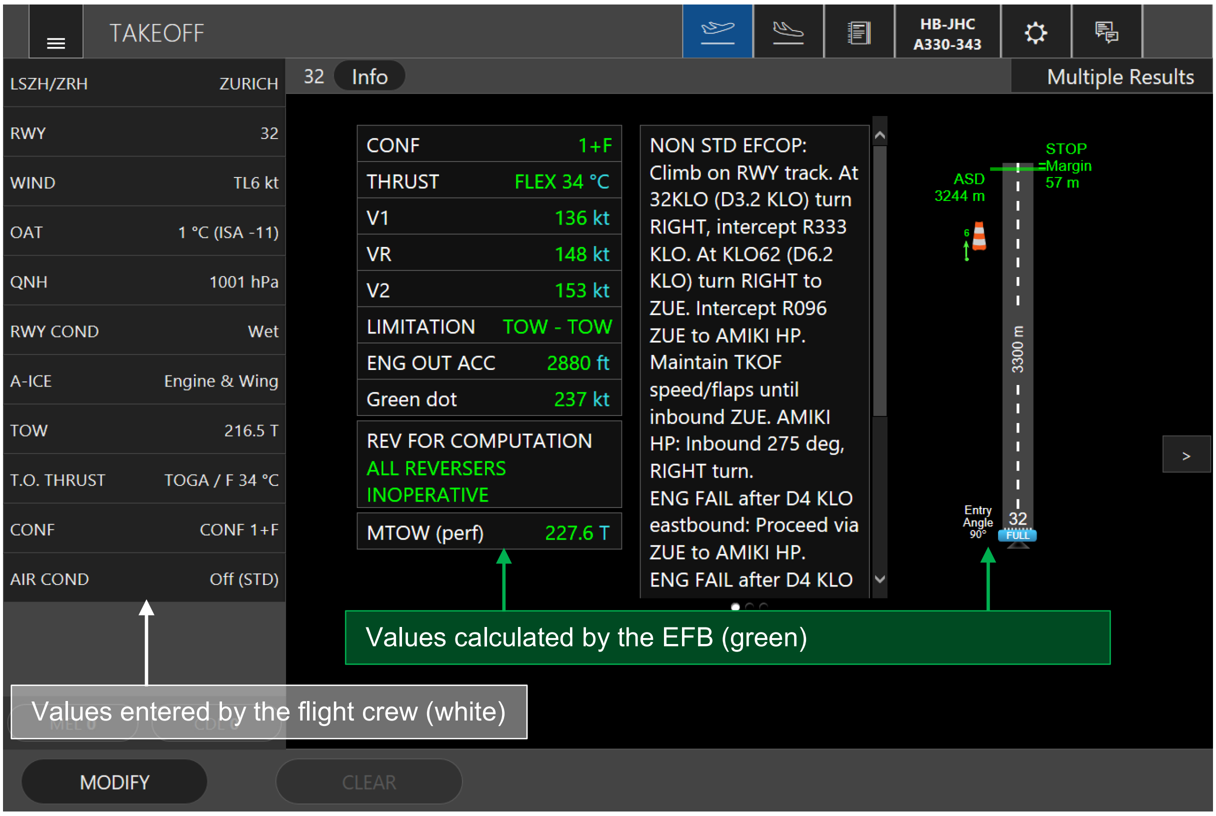

Figure 1: Representation of the calculation of the takeoff power values on the EFB, as carried out by the crew shortly before takeoff of HB-JHC on runway 32 in Zurich. The arrow on the right of the screen can be used to retrieve two further pages with additional information relating to takeoff.

Influence of wind inputs and flap setting on the takeoff power values

The wind inputs influence on the one hand the V-speeds and hence the minimum required runway distance (Accelerate Stop Distance[12] – ASD) and on the other hand they also affect the ratio of speed V2 to the stall speed V_{S1g}.[13] This ratio, which must be at least 1.13, is displayed to pilots on page 3 in the EFB as the «V2VSRatio».

In the following figures, the influence of wind input on the resulting V-speeds, on the «V2VSRatio» and on the ASD is shown graphically. The wind specified by the crew for the takeoff of HB-JHC, a Tailwind (TW) of 6 kt and the mean wind which was current during the takeoff run of HB-JHC and which corresponded to a Headwind (HW) of 16 kt, are highlighted in the figures.

The V-speeds change with different wind inputs and increase with an increasing headwind component. The Configuration (CONF) has almost no effect on the resulting V-speeds (cf. figure 2).

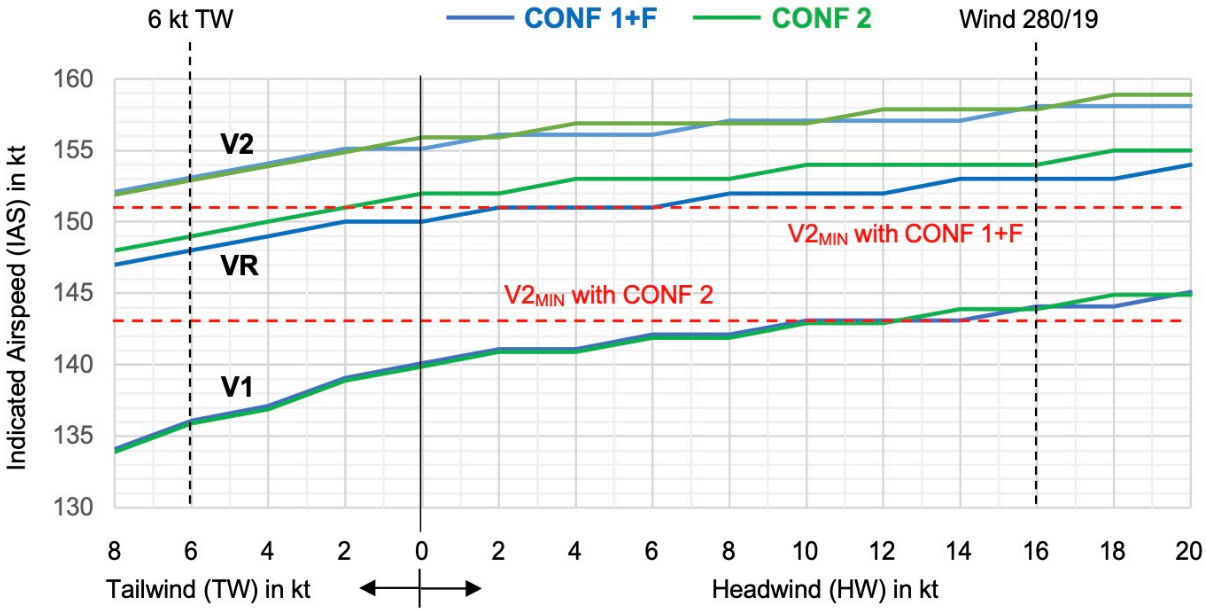

Figure 2: Influence of wind input in the EFB on the V-speeds at CONF 1+F and CONF 2. The other input parameters in the EFB correspond to the values chosen by the crew according to figure 1. $V2_{MIN}$ denotes the minimum prescribed V2 which corresponds to 1.13 times V_{S1g}.

[12] The ASD is required to accelerate the aircraft to speed V1 and after a takeoff abortion at V1 to stop the aircraft using the wheel brakes.

[13] V_{S1g}: stall speed at 1g load factor; the speed at which lift (perpendicular to the motion vector) can be generated equal to the weight force of the aircraft. In contrast, V_s (stall speed) is the speed at which the aircraft is still controllable, but the lifting force is less than the weight of the aircraft. V_S is therefore lower than V_{S1g}.

Since stall speed V_{S1g} increases with a lower flap setting, this results in a significantly lower «V2VSRatio» and thus a lower safety margin in relation to a stall (cf. figure 3). The aircraft is also rotated at a speed that is much closer to the stalling speed.

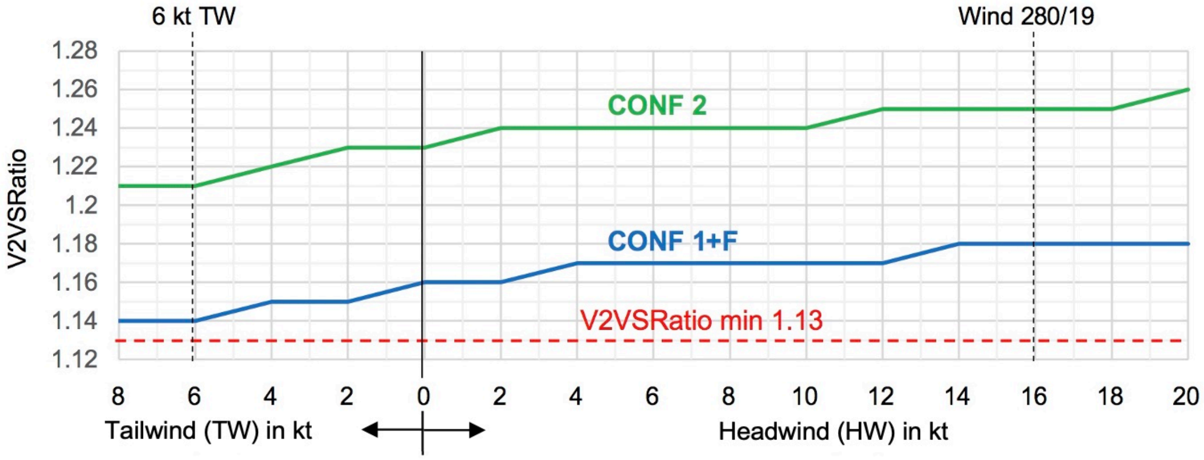

Figure 3: Influence of wind input in the EFB on the ratio between V2 and V_{S1g} for different configurations. The other input parameters in the EFB correspond to the values selected by the crew as shown in figure 1.

The ASD is significantly influenced by the wind input and decreases with increasing head-winds. The flap setting (CONF) has a negligible influence on the ASD (cf. figure 4).

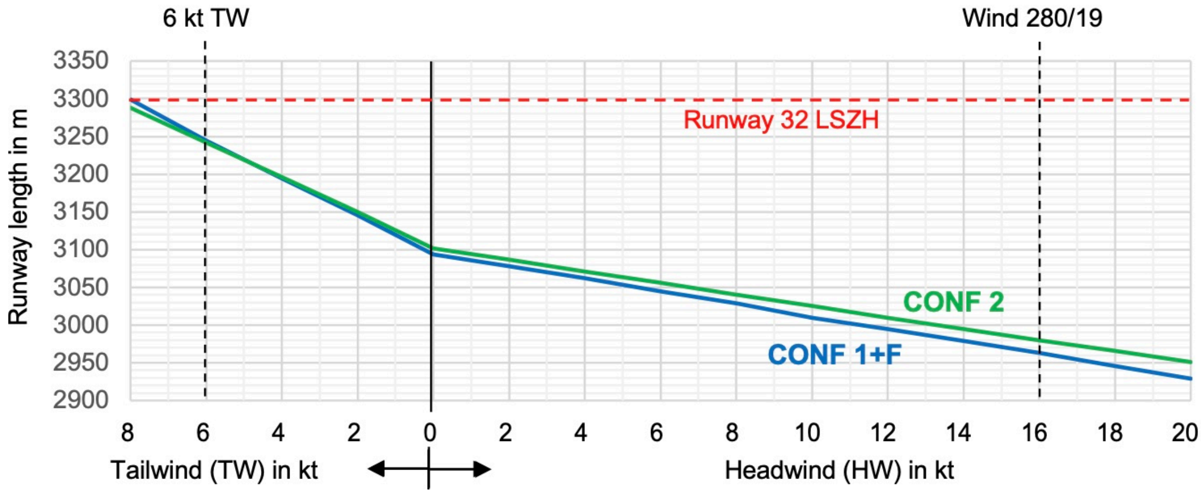

Figure 4: Influence of wind input in the EFB at different flap settings (CONF) on the ASD (runway length in m). The other input parameters in the EFB correspond to the values selected by the crew as shown in figure 1.

The dependence of the maximum possible flex temperature on the wind input can be seen in figure 5: with a larger headwind component, the optimal flex temperature increases.

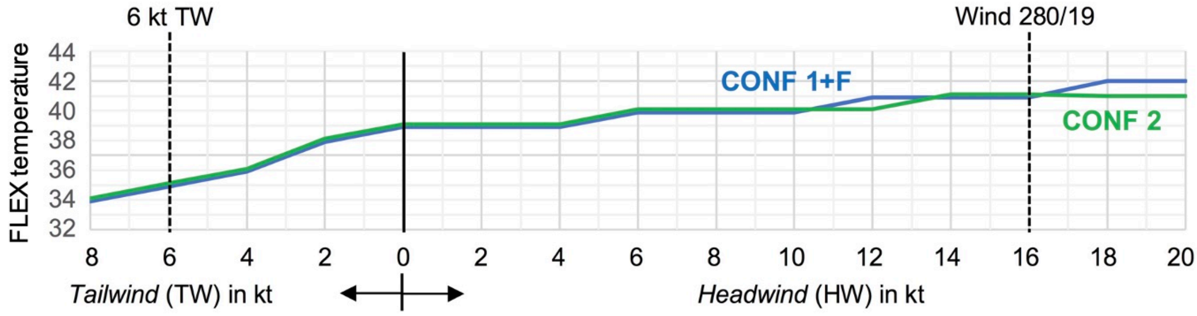

Figure 5: Influence of wind input in the EFB on the optimal flex temperature. The other input parameters in the EFB correspond to the values selected by the crew as shown in figure 1.

For a reduction by the flight crew of the flex temperature with otherwise constant inputs, the ASD decreases (cf. figure 6). The V-speeds are almost unaffected.

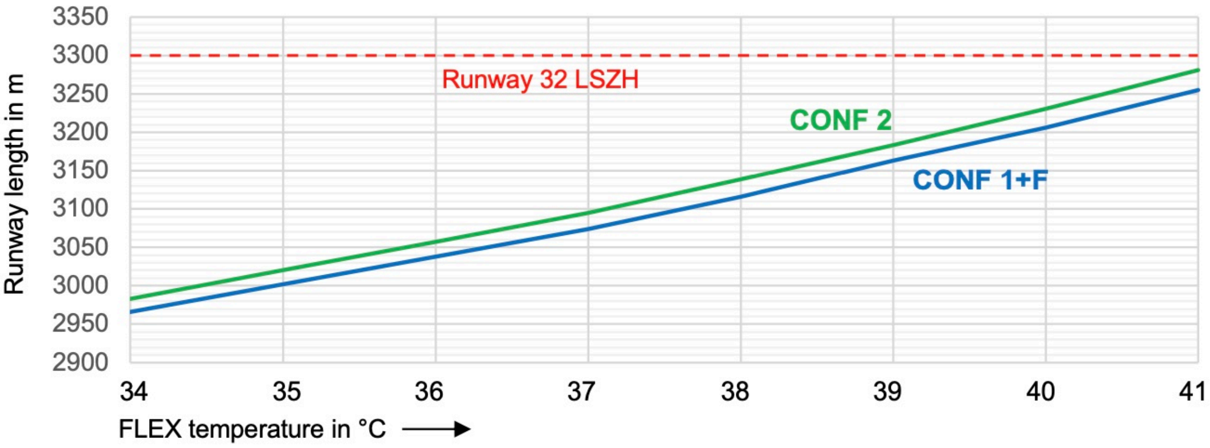

Figure 6: Influence of the flex temperature, or rather reduced takeoff power, on the ASD (runway length in m) taking into account a wind from 280° at 19 kt (HW 16 kt). The other input parameters in the EFB correspond to the values selected by the crew as shown in figure 1.

Evaluation of the flight data recorder

It was possible to read out the Digital Flight Data Recorder (DFDR) of HB-JHC and analyse its data (cf. figure 7).

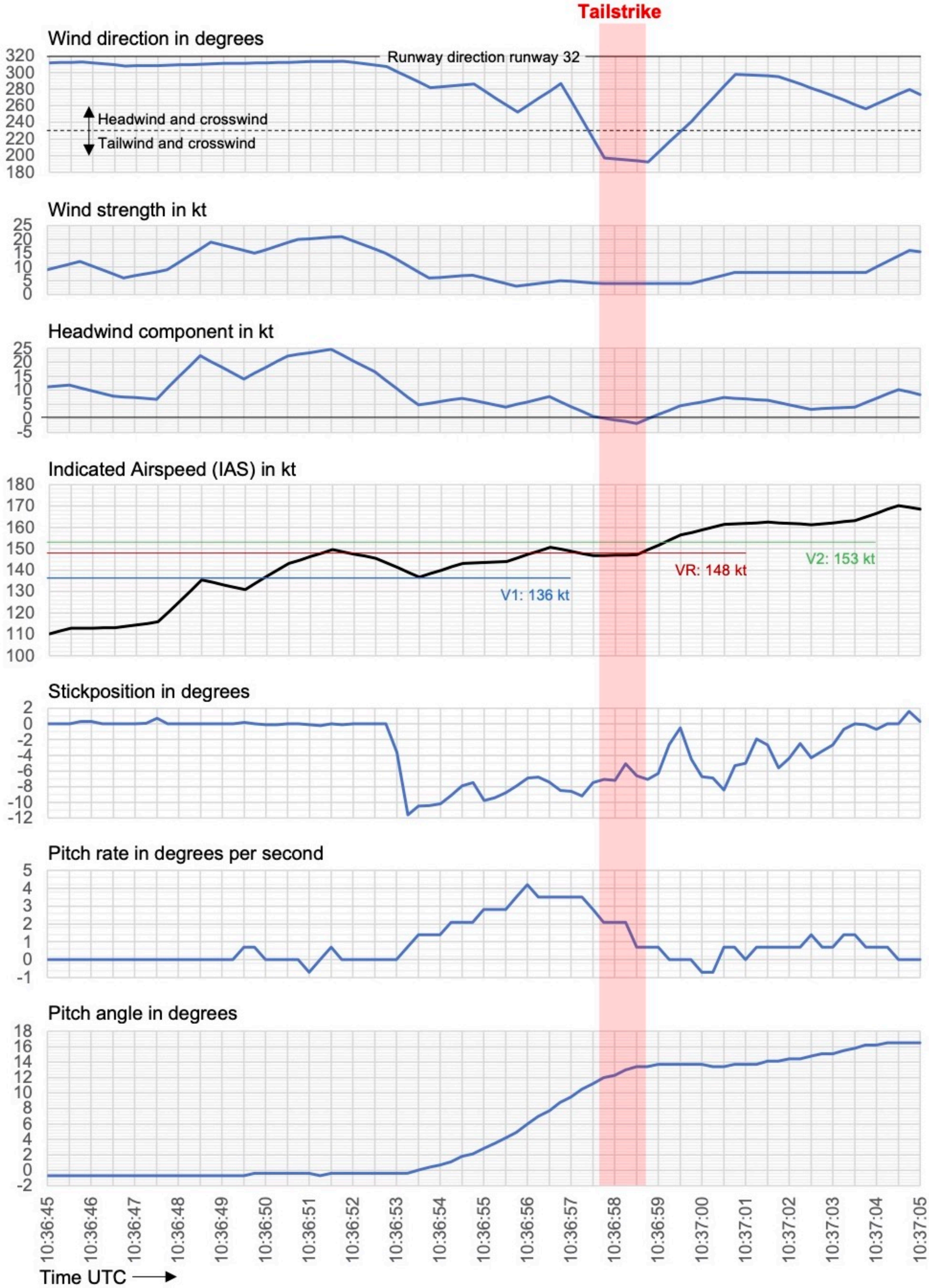

Figure 7: Recording of the DFDR data in the rotation and lift-off phase of HB-JHC. The headwind and pitch rate data were calculated.

The recordings indicate no abnormalities for the initiation and initial acceleration of the takeoff run until decision speed V1 is reached. Subsequently, it becomes apparent that the prevailing and recorded wind gusts significantly influenced the further course of events. With regard to the tailstrike, the rotation phase is of particular interest. The relationship between wind, Indicated Airspeed (IAS), pitch angle and pitch rate is shown in figure 7 above.

The fluctuations in the IAS due to wind gusts shortly before and during the initiation of rotation are significant: at 10:36:47 UTC, the IAS increased from 115 kt to 135 kt within 1.5 seconds. Subsequently, the IAS dropped again to 131 kt within 3 seconds and rose again to 150 kt. Only 1.5 seconds later the IAS decreased again to 139 kt and increased to 150 kt within the subsequent 3 seconds.

At 10:36:53 UTC, the PF initiated rotation. The IAS at that time was 142 kt. The stick was pulled back to approximately 3/4 of full deflection and then immediately returned to approximately half of full deflection. At 10:36:54 UTC, the IAS was 140 kt; it increased to 151 kt and dropped back to 147 kt (10:36:58 UTC). The IAS then increased continuously and was 154 kt when the aircraft took off (10:36:59 UTC).

The movements of the PF's stick resulted in a change in the pitch angle of the aircraft from 0° to 11.2° within 4 seconds and to 13.7° (10:36:59 UTC) in the following 1.5 seconds. The maximum pitch rate was 4.2 degrees per second (10:36:56 UTC).

Comparable incident

A comparable incident to the present one, in which a Lufthansa A330-300 was badly damaged during takeoff due to a tailstrike, occurred on the evening of 5 March 2013 in Chicago (KORD), from where the aircraft took off for a flight to Munich (EDDM) after prior de-icing. According to the flight crew, the runway was cleared except for small residues of snow and ice after the onset of winter with snowfall during the day.

The flight crew had selected configuration CONF 1+F for takeoff and reduced engine power by means of a flex temperature of 40 °C.

The investigation report «BFU 2X001-13» by the German Federal Bureau of Aircraft Accident Investigation (BFU) states that the tailstrike was, among other things, a consequence of the selected configuration and the dynamics of the rotation rate.

As a result, the BFU issued two safety recommendations:

«*Safety Recommendation 04/2016*

The manufacturer should improve the indications of a possible tailstrike risk in the documentation, especially in combination with the configuration of the lift surfaces during takeoff. Indication of the flight performance program's design should alert the cockpit crew whenever the provided flap configuration is not one with the highest level of tailstrike tolerance. »

Airbus provided at that time to the BFU the following answer to this Safety Recommendation, which is still valid today:

«The Flight Crew Techniques Manual (FCTM), Chapter PR-NP-SOP-120: PROCEDURES / NORMAL PROCEDURES / SOP / TAKEOFF / TAIL STRIKE AVOIDANCE / CONFIGURATION provides the detailed information with regards to tail clearance versus the flap configuration selection for take-off as requested by the Safety Recommendation.»

«Safety Recommendation 05/2016

The manufacturer should develop a strategy, which allows the crew to unambiguously detect a tailstrike in flight, if it actually did occur.»

Airbus provided at that time to the BFU the following answer to this Safety Recommendation, which is still valid today:

«*In case of tailstrike on A330, the following has been considered and agreed with the Certification Authority:*

- *A tailstrike may remain undetected due to structural flexibility and deformations;*
- *Heavy tailstrike with a perforated surface greater than 80 cm² will be indicated to the crew to the latest by cabin pressurization system advisory and alert;*
- *For light tailstrike with a perforated surface smaller than 80 cm², the structural profiles assure structural capability after an undetected tail strike.»*

In addition, the BFU states the following in the investigation report:

«The BFU decided to not issue a safety recommendation to the operator because in the course of the safety investigation appropriate measures were already taken. The crews were informed that compared to flap configuration 2, flap configuration 1+F poses an increased tailstrike risk.

In the course of the annual line checks the issue of "Avoidance of Tailstrike" was discussed with all crew members of the A330/340 fleet.»

Measures taken since the serious incident

On 2 April 2020, the operating company issued guidelines to flight crews in an «OPS flash» as follows (translated from German):

«*[...]*

The following statements can be made about this incident, which are corroborated by FDM analyses:

<u>Selecting Conf 1+F</u>

- *Selecting Conf 1+F for the TOF[14] reduces tail clearance by about 1 ft (a higher pitch is necessary for lift-off).*
- *With Conf 1+F, the A330 has a five times higher risk of a tailstrike than with Conf 2.*
- *In the last 12 months, TOFs have doubled with Conf 1+F on the A330.*
- *The number of «Risk of Tailstrike Events» correlates with the increasing number of Conf 1+F TOFs.*

*Selecting Conf 1+F involves a significantly higher tailstrike risk. It continues to be questionable why Conf 1+F TOFs have doubled in the last 12 months. It is striking, however, that the increase in Conf 1+F TOFs correlates with the cancellation of the Conf 2 recommendation on the A320. Accordingly, we would like to point out that this recommendation for A330/340 is still valid and **Conf 2 is the default configuration** (FCTM Tailstrike Avoidance). By this we mean that a plausible reason (e.g. performance) is required when selecting a different configuration. In addition, the substantially higher risks when choosing Conf 1+F must be part of the briefing in order to increase SAW.*

[...]

Learnings

- *Conf 2 is the recommended TOF configuration.*
- *When selecting Conf 1+F, the increased risks and their mitigation must be addressed in the briefing.*
- *A deliberate rotation according to FCTM and consistent monitoring are especially important in turbulent wind conditions.»*

[14] TOF denotes the *takeoff*, i.e. the takeoff and lift-off of the aircraft.

Analysis

General

The following analysis concerns not only the rotation technique at takeoff, but also the selection of aircraft configuration and the inclusion of weather, wind and runway conditions for an optimal takeoff.

Calculations for takeoff

In order to better understand the influence of the individual parameters such as temperature, atmospheric pressure, wind, FLEX temperature and flap setting on the takeoff calculation, their effect has been shown graphically in figures 2 to 6.

The EFB calculations show that the selection of the flap setting (CONF 1+F or CONF 2) in the present case leads to virtually identical V-speeds V1, VR and V2. This does not change if the outside temperature is 1 to 2 °C higher or the atmospheric pressure is 1 to 2 hPa lower, i.e. with a certain safety margin («conservative»). This approach is understandable as one does not wish to run the risk of having to carry out a new takeoff calculation in the event of a small change. It should be noted, however, that these small inputs have only a slight influence on the effective takeoff calculation.

On the other hand, the flap setting has a significant influence on takeoff power values (cf. figure 2):

- When flap setting 2 (CONF 2) is selected, rotation speed VR for all headwind or tailwind components is above $V2_{MIN}$, which is 1.13 times the stalling speed.
- With flap setting 1+F (CONF 1+F), the rotation speed VR is higher than $V2_{MIN}$ only from a headwind component of 6 kt.

Although the flap setting has no significant influence on the V-speeds (V1, VR and V2), with CONF 1+F it leads to a significantly lower stall margin than with CONF2, and also has an impact on the «V2VSRatio» (cf. figure 3). This «V2VSRatio» is the only information available to flight crews from the takeoff calculation concerning the stall margin. However, it is only displayed in the EFB on a sub-page of the takeoff calculation, which is purely informative and is not required for the necessary entries in the Flight Management System (FMS).

In the present case, the calculations in the EFB indicate an optimal flap setting 2 (CONF 2) for takeoff, which is also recommended by the operating company and specified in the EFB as standard. Compared to the CONF 1+F position selected by the flight crew, the calculation with CONF 2 shows a «V2VSRatio» which at 1.21 is significantly higher than the 1.14 with CONF 1+F (cf. figure 2).

Essentially, it can be said that with a higher flap setting, greater aerodynamic lift is available and thus a lower pitch angle and a lower speed is required for lift-off. This reduces the risk of a tailstrike. Since the rotation speed VR for CONF 2 is almost identical to VR at CONF 1+F (cf. figure 2) for an Airbus A330, an even lower pitch angle is required for lift-off. This further reduces the risk of a tailstrike.

In addition to the selection of the flap setting, the selection of wind input is also an important factor. With the selected tailwind component of 6 kt, the flight crew created a safety margin for an aborted takeoff of 278 m ASD (cf. figure 4). However, as the present case shows, the tailwind input had a significant influence on rotation speed VR. This was reduced to 148 kt. Taking into account the current wind, VR would have been 153 kt (cf. figure 2). At the lower rotation speed, the risk of a tailstrike increased. In addition, this reduced the stall margin (cf. figure 3).

If, as in the present case, windshear can be expected immediately after takeoff, the selection of a configuration generating less resistance (CONF 1+F compared to CONF 2) is basically advantageous and therefore plausible. On the other hand, it is incomprehensible why the flight crew envisaged a takeoff with reduced engine thrust under these conditions, if windshear is expected, given that the operating company also recommends a takeoff at maximum permitted engine power (TOGA).

The flight crew wanted to increase safety reserves by entering the «conservative» values with a safety margin in the EFB; this ultimately produced undesirable effects, namely an increase in the risk of a tailstrike and the reduction of the stall margin. An effective safety reserve can be created by setting maximum permitted engine power (TOGA). The choice of whether to take off at full or reduced engine power is ultimately nothing more than a balancing of safety reserve against economy (safety versus economy).

Rotation technique

As the analyses of the DFDR indicate, the greatly fluctuating wind gusts during the takeoff run, especially during the rotation phase, had a decisive influence. At 10:36:51 UTC, the IAS indicated the rotation speed set for rotation of 148 kt, after which the PF initiated rotation with the corresponding stick movement to approximately three-quarters of full deflection and an immediate gradual return to approximately half of full deflection. At this stage, the IAS dropped to 137 kt due to the fluctuating wind, before rising again. The average rotation rate was approximately 3 degrees per second and decreased again shortly before the tailstrike (cf. figure 7). The rotation process therefore complied in principle with the operating company's procedural requirements.

Conclusions

The serious incident, in which the rear of the aircraft touched the ground during takeoff (tailstrike) was due to a combination of the following factors which favoured the occurrence of a tailstrike:

- Owing to forecast windshear, the flight crew selected a configuration generating low resistance (CONF 1+F) for takeoff;
- Owing to the fluctuating ground wind for the takeoff calculation, the flight crew selected a tailwind component incorporating a safety margin instead of the actual headwind. This resulted in a significantly lower rotation speed VR;
- The takeoff occurred with reduced engine thrust, which slowed the increase in speed during the takeoff run and especially during the rotation phase;
- When the aircraft rotated, windshear resulted in a decrease in the Indicated Airspeed (IAS) to below the rotation speed VR.

As it is unlikely that further investigative action would provide additional useful findings, the Swiss Transportation Safety Investigation Board is concluding the investigation of this serious incident in accordance with article 45, para. 1 of the Ordinance of 17 December 2014 on the Safety Investigation of Transportation Incidents (OSITI) with a summary report.

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

Bern, 18 October 2021 Swiss Transportation Safety Investigation Board

Annex 1: Damage to aircraft HB-JHC