Havarikommissionen
Accident Investigation Board Denmark

BULLETIN

Accident

8-2-2019

involving

Airbus 321-251N

SE-RKA

FOREWORD

This bulletin reflects the opinion of the Danish Accident Investigation Board regarding the circumstances of the occurrence and its causes and consequences.

In accordance with the provisions of the Danish Air Navigation Act and pursuant to Annex 13 of the International Civil Aviation Convention, the safety investigation is of an exclusively technical and operational nature, and its objective is not the assignment of blame or liability.

The safety investigation was carried out without having necessarily used legal evidence procedures and with no other basic aim than preventing future accidents and serious incidents.

Consequently, any use of this bulletin for purposes other than preventing future accidents and serious incidents may lead to erroneous or misleading interpretations.

A reprint with source reference may be published without separate permit.

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BULLETIN

General

File number:	2019-57
UTC date:	8-2-2019
UTC time:	18:07
Occurrence class:	Accident
Location:	Billund (EKBI)
Injury level:	None

Aircraft

Aircraft registration:	SE-RKA
Aircraft make/model:	Airbus 321-251N
Current flight rules:	Instrument Flight Rules (IFR)
Operation type:	Scheduled
Flight phase:	Landing
Aircraft category:	Fixed wing
Last departure point:	Lanzarote (GCRR)
Planned destination:	Billund (EKBI)
Aircraft damage:	Substantial
Engines make/model:	CFMI LEAP-1A

SYNOPSIS

Notification

All times in this report are UTC.

Because of third part reporting of a potential accident, the Aviation Unit of the Danish Accident Investigation Board (AIB) contacted the operator on 11-2-2019 at 08:18 hours.

The operator confirmed that an accident had occurred.

The Danish AIB notified the Danish Transport, Construction and Housing Authority (DTCHA), the French Accident Investigation Board (BEA), the Swedish Accident Investigation Authority (SHK), the European Aviation Safety Agency (EASA), the Directorate-General for Mobility and Transport (DG MOVE), and the International Civil Aviation Organization (ICAO) on 11-2-2019 at 13:02 hours.

The BEA and the SHK accredited non-travelling representatives to the AIB safety investigation.

Summary

Local meteorological conditions (like gusting and strong crosswinds, moderate turbulence and downdrafts on short final to runway 27) combined with unintended deviations from standard operating procedures resulted in an initial hard landing, a bounce, a second hard landing, and a tailstrike.

The accident occurred in dark night and under instrument meteorological conditions (IMC).

FACTUAL INFORMATION

History of the flight

The accident flight was a commercial IFR flight from Lanzarote (GCRR) to Billund (EKBI).

On board were 7 crewmembers and 205 passengers.

There were no remarks to the aircraft pre-flight checks.

The commander was the pilot flying and the first officer was the pilot monitoring.

The en route flight, the descent and the initial approach for runway 27 at EKBI proceeded uneventfully, with the aircraft being radar vectored for an Instrument Landing System (ILS) approach.

On final approach to runway 27, Billund Tower cleared the aircraft to land and reported the wind conditions to be 200° 12 knots (kts), maximum 29 kts, and minimum 5 kts.

Throughout the approach, the flight crew experienced moderate turbulence.

The flight crew modified final approach speed (VAPP) was 148 kts (the flight crew added 2 kts the calculated VAPP of 146 kts).

At 1000 feet (ft), and at 500 ft Radio Height (RH), the first officer made calls on stabilized approach.

The aircraft was configured for landing, with flap position 3, stabilized, and the autopilot engaged and the autothrust engaged and activated in *SPEED mode*.

At approximately 700 ft RH, the flight crew got visual contact with the runway.

The Calibrated Air Speed (CAS) from 500 ft RH down to initial touchdown varied between approximately 160 kts CAS and 145 kts CAS. The aircraft remained stabilized on both localizer and glidepath down to 100 ft RH.

On short final, the first officer informed the commander of a displayed crosswind of 36 kts.

At approximately 190 ft RH, the commander disconnected the autopilot and flew the final approach manually with the autothrust engaged and activated in *SPEED mode*.

At 100 ft RH, the first officer made a standard operating call on aircraft pitch attitude: *Pitch 2.5*.

From approximately 100 ft RH until 35 ft RH, the vertical speed increased from approximately 700 ft/minute (min) to approximately 1100 ft/min.

At approximately 25 ft RH, the commander used an abrupt and progressive aft sidestick input and pulled back on the sidestick to full aft deflection to stop the rate of descent.

The synthetic voice calls *TWENTY*, *RETARD* and the initial touchdown occurred almost simultaneously.

Before recorded activation of both main landing gear squat switches (weight on wheels - WOW), the commander advanced the thrust levers forward of the climb detent position.

The aircraft made an initial touchdown at approximately 148 kts CAS, with a recorded pitch angle of 5.63°, a rate of decent of approximately 750 ft/min, and a vertical acceleration of 2.59 g. Upon initial touch down, the ground spoilers did not extend, and the autothrust deactivated.

The aircraft lifted off the ground and up to 12 ft RH.

During the bounce, the commander repeatedly voiced his surprise on the lack of flare.

In the air, the engines spooled up, and the CAS increased to approximately 156 kts. Two synthetic voice calls on excessive pitch (*PITCH)*, and one thrust lever retarding synthetic voice call (*RETARD)* sounded.

The commander retarded the thrust levers to flight idle resulting in ground spoiler extension.

The aircraft made a second touchdown at approximately 154 kts CAS, with a recorded pitch angle of 9.49° and a vertical acceleration of 2.56 g.

The aircraft tail section struck the runway.

Upon landing, neither of the pilots perceived that a tailstrike might have occurred, and the flight crew continued taxiing to the apron.

During taxi to the apron, the commander briefed the passengers on the hard landing.

Injuries to persons

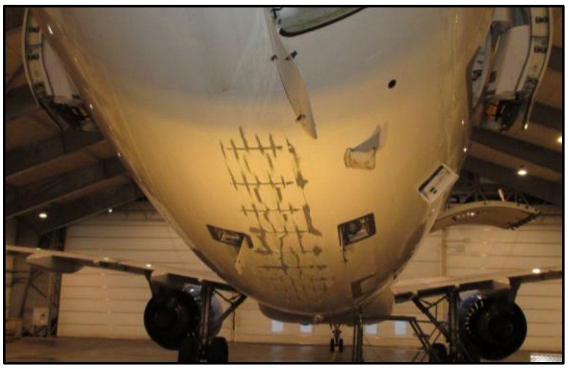
Injuries	*Crew*	*Passengers*	*Others*
Fatal			
Serious			
None	7	205	

Damage to aircraft

The aircraft tail section was substantially damaged.

The aircraft struck the runway at a recorded pitch angle of 9.49° and at a recorded G-load of 2.56 resulting in the following damages:

- The lower part of the aft fuselage skin was damaged between frame (FR) 60 and FR 69.
- The impact deformed several of the above-mentioned frames.
- Several floor beams cracked at their attachments to the frames.
- A vertical support strut attached to FR 65 sheared and indicated a significant vertical displacement.



Personnel information

License and medical certificate

a. The commander

The commander - male, 54 years - was the holder of a valid Air Transport Pilot License (ATPL) issued on 4-6-2002.

The type rating A320 was valid until 31-5-2019.

The medical certificate (class 1) was valid until 21-3-2019.

b. The first officer

The first officer - male, 38 years – was the holder of a valid Commercial Pilot License (CPL) issued on 2-12-2008.

The type rating A320 (copilot) was valid until 31-5-2019.

The medical certificate (class 1) was valid until 4-6-2019.

Flying experience

a. The commander

	Last 24 hours	Last 90 days	Total
All types (hours)	-	91	15846
This type (hours)	-	91	7600
Landings this type	-	11	-

b. The first officer

	Last 24 hours	Last 90 days	Total
All types (hours)	-	81	6748
This type (hours)	-	81	5300
Landings this type	-	13	-

Recent flying experience

At this operator.

a. The commander

Month/year	Block hours
2018 - February	25.58
2018 - March	12.18
2018 - April	35.33
2018 - May	56.48
2018 - June	53.10
2018 - July	61.77
2018 - August	37.03
2018 - September	19.63
2018 - October	36.92
2018 - November	20.55
2018 - December	22.15
2019 - January	40.80
In total	421.52

b. The first officer

Month/year	Block hours
2018 - February	0
2018 - March	0
2018 - April	0
2018 - May	0
2018 - June	69.75
2018 - July	53.32
2018 - August	38.20
2018 - September	47.18
2018 - October	26.73
2018 - November	20.47
2018 - December	38.77
2019 - January	24.62
In total	319.04

Flight and duty time

Prior to the flight to EKBI, the flight crew had a rest period of 91:10 hours at GCRR, and the flight crew felt well rested.

Operator Proficiency Check (OPC)

a. The commander

On 1-10-2018, the commander performed the latest OPC. The OPC was valid until 31-5-2019.

b. The first officer

On 26-9-2018, the first officer performed the latest OPC. The OPC was valid until 31-5-2019.

Flight crew anti tailstrike training

When the operator introduced the Airbus A321 in year 2004-2005, the conversion training contained anti tailstrike training including training on bounced landings.

When introducing the Airbus A321 Neo in year 2017, the operator presented a tailstrike awareness briefing to their flight crews.

Aircraft information

General information

Manufacturer:	Airbus S.A.S.
Type:	A321-251N.
Serial number:	7746.
Airworthiness review certificate:	Valid until 28-6-2019.
Engine manufacturer:	CFM International.
Engine type:	LEAP-1A.
Maximum crosswind:	The maximum crosswind demonstrated for landing (including gusts) was 38 kts.
Technical status:	Before the flight, there were no technical remarks.

Mass and balance

The operator forwarded a mass and balance calculation to the AIB - see appendix 1.

Characteristic speeds

The lowest selectable speed (VLS) represented the lowest selectable speed providing an appropriate margin to the stall speed, and for landing VLS was equivalent to 1.23 VS1G (the stall speed demonstrated by flight tests) of the selected landing configuration.

VLS was represented by the top of an amber strip along the airspeed scale on the Primary Flight Display.

The recorded VLS on final approach to runway 27 at EKBI was 141 kts.

The Flight Management and Guidance System calculated the final approach speed (VAPP) using flight crew entered weight data and headwind component. It was displayed on the Multipurpose Control and Display Unit and could be modified by the flight crew.

VAPP represented VLS + wind correction. The wind correction was limited to a minimum of 5 kts and a maximum of 15 kts.

The recorded target speed (VAPP) on final approach to runway 27 at EKBI was 148 kts.

Speed mode in approach phase

The below is an extract of the Flight Crew Operating Manual (FCOM).

When the aircraft flies an approach in managed speed, the managed speed target, displayed by the magenta triangle on the PFDs, is variable. This managed speed target is displayed on the PERF APPR page, corrected by the "Ground Speed Mini" function.

The objective of the "Ground Speed Mini" function is to take advantage of the aircraft inertia, when the wind varies during the approach.

During approach, the FG continuously computes the managed speed target in order to take into account the gusts or the wind changes, in order to keep the ground speed at, or above, the "Ground Speed Mini".

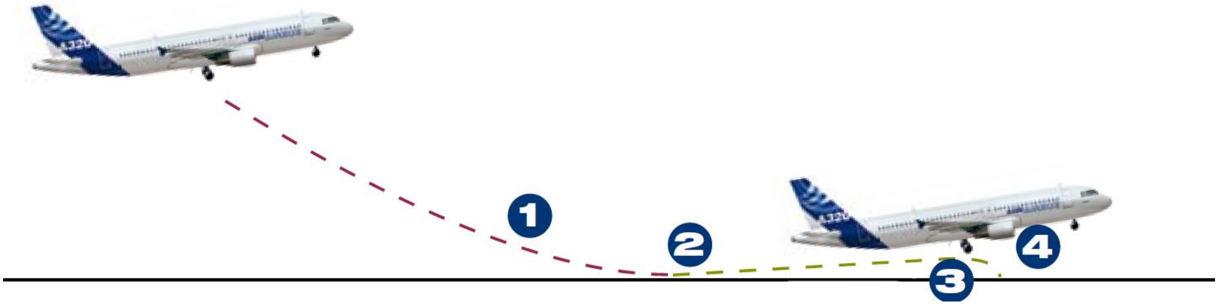
If the A/THR is active in SPEED mode, it will automatically follow the speed target, ensuring efficient thrust management during approach.

Ground spoiler operation

According to the aircraft manufacturer, ground spoiler partial extension conditions were with Spoiler Elevator Computer (SEC) standard 120 and subsequent:

- *Ground spoilers armed*
- *Both main landing gears seen on the ground*
- *Both thrust levers at or below the Climb notch (ATHR).*

Landing scenario with SEC 120



1. *No engine throttle reduction (retard) during the flare - No ground spoiler extension.*

2. *With the SEC 120 modification, the ground spoilers will extend partially at touchdown, as long as both engines levers are at or below the Climb notch (ATHR). Lift is decreased and the bounce is reduced or cancelled.*

3. *As soon as the thrust lever conditions are fulfilled (for instance engine throttle reduction to Idle), the ground spoilers extend fully (if achieved within 3 seconds of the initial touchdown).*

4. *As the height of the bounce is significantly reduced, the vertical speed at the second touchdown is largely reduced as well.*

Aircraft systems for tailstrike prevention

The aircraft was fitted with tailstrike prevention systems:

- *PITCH PITCH* Auto-Callout [MOD 37445].

- Tailstrike pitch limit indicator [MOD 37444].

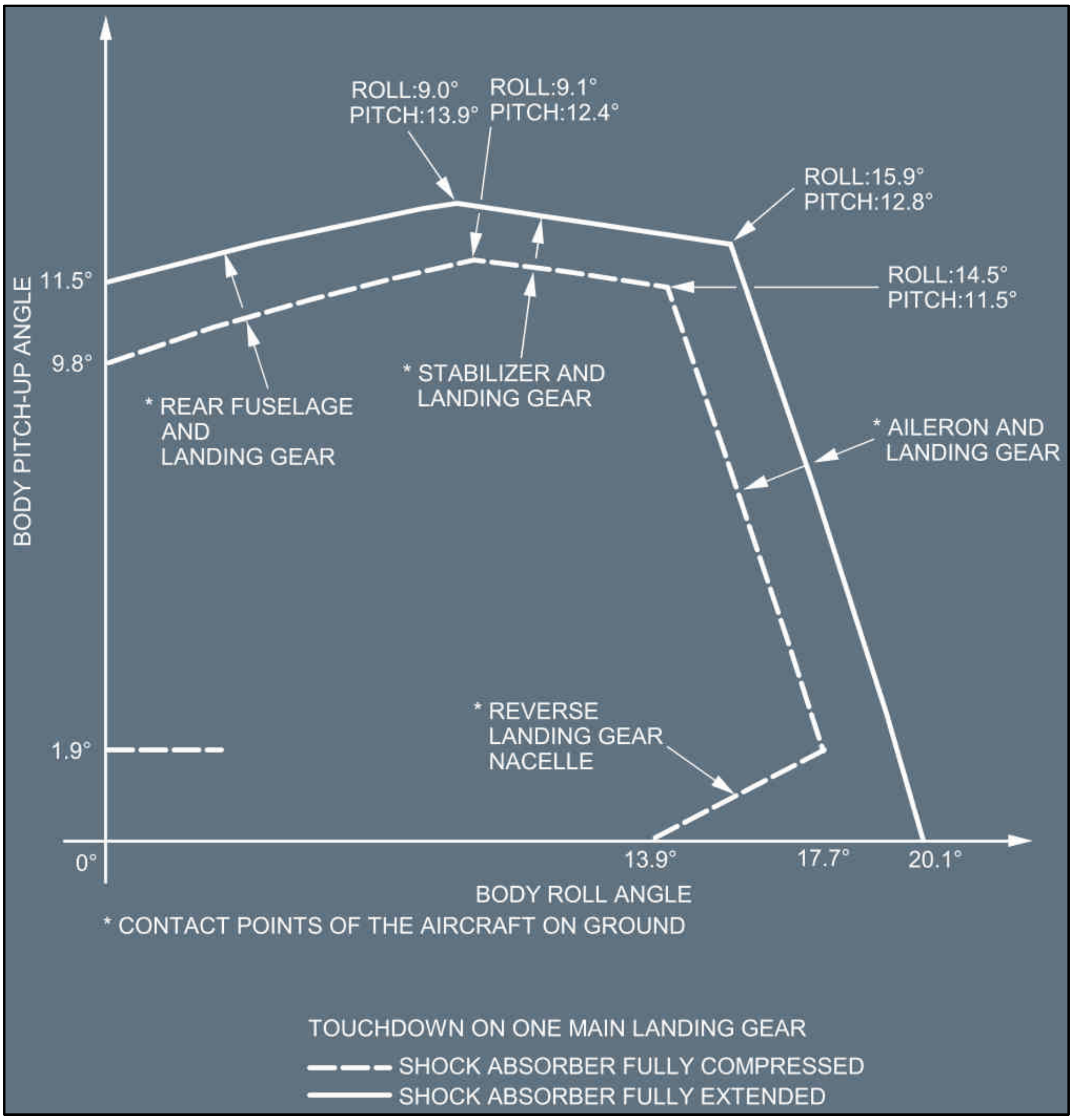
The below is an extract of the operator's Flight Crew Techniques Manual (FCTM).

The following aircraft systems help to prevent tailstrike occurrence:

- *A "PITCH-PITCH" synthetic voice sounds when the pitch attitude becomes excessive,*
- *A tailstrike pitch limit indicator appears on the PFD to indicate the maximum pitch attitude to avoid a tailstrike.*

<u>Ground clearance diagram</u>

The below diagram is an extract of the operator's FCTM.



Note by the aircraft manufacturer.

The FCOM ground clearance diagram is geometrically based. It indicates a pitch of +9.8° with a null roll and main landing gear compressed to have contact with rear fuselage.
This diagram does not take into account any combination of tolerances associated to the flexibility effect experienced by structure / landing gear / inertial reference system during the dynamic of hard landing motion and/or associated to the local slope or bump of the runway.

Meteorological information

Low Level Forecast

An extract of the Low Level Forecast valid for the area Denmark on 8-2-2019 between 13:00 and 21:00 hours:

General:	In the afternoon and in the evening, a weather front crossed Denmark and the southern part of Sweden.
Visibility:	Below 5 kilometers (km) and a cloud ceiling below 1000 ft.
Icing:	Moderate or severe icing.
Surface wind:	South - southwest 12-22 kts gusting up to 39 kts.
Turbulence:	Moderate or severe turbulence.

Terminal Aerodrome Forecast (TAF) - EKBI

ekbi 080512z 0806/0906 21015kt 9999 bkn020 tempo 0806/0811 bkn008 becmg 0811/0813 3000 ra br bkn005 tempo 0813/0902 20020g32kt 6000 -radz sct005 bkn010 becmg 0902/0904 9999 nsw sct020 tempo 0904/0906 shra bkn008 sct015cb=

ekbi 081122z 0811/0912 21015kt 9999 bkn008 tempo 0811/0815 20015g25kt 3000 ra br bkn004 tempo 0815/0901 20020g32kt 3000 ra br bkn015 tempo 0901/0906 20015g25kt bkn015=

ekbi 081659z 0818/0918 21015kt 9000 -ra bkn012 tempo 0818/0903 20020g32kt 3500 radz br bkn004 becmg 0903/0905 nsw sct020 tempo 0905/0911 21015g25kt 4000 shra bkn012tcu tempo 0911/0918 22025g42kt 4000 shra bkn010tcu=

Aviation Routine Weather Report (METAR) - EKBI

ekbi 081650z auto 19016g28kt 7000 -ra ovc007/// 06/06 q0998=

ekbi 081720z auto 19019g32kt 9000 -ra ovc008/// 07/06 q0998=

ekbi 081750z auto 19018g30kt 9999 -ra ovc007/// 07/06 q0997=

ekbi 081820z auto 19019g32kt 9999 -ra ovc008/// 07/06 q0997=

Aftercast - EKBI

The aftercast was valid for EKBI at 18:08 hours.

General:	A weather front with a massive cloud layer and widespread rain crossed Denmark from the west. At 18:08 hours, EKBI was located in the warm sector of the weather front. Because of a deep low-pressure area north of Scotland and a high-pressure area above the southeastern Europe, strong south and southwesterly winds were current above Denmark.
Visibilty at surface and weather:	5-10 km and rain.
Clouds and icing:	Broken to overcast stratus at 600-800 ft and upwards overcast of nimbostratus (cloud top above 15 000 ft). Zero degree Celsius isotherm at 4000-5000 ft. Probably moderate icing in clouds from the zero degree Celsius isotherm up to flight level 160.
Surface wind at 10 meters height:	EKBI auto-SYNOP at 18:00 hours - 186° 20 kts gusting up to 36 kts. EKBI auto-SYNOP at 18:10 hours - 185° 19 kts gusting up to 32 kts.
Turbulence and wind shear:	Moderate turbulence from sea level up to 2000 ft. The wind conditions changed from 200° 50 kts at 2000 ft above mean sea level to 185° 20 kts gusting up to 32 kts at surface. For that reason, a risk of light wind shear (3 kts /

	100 ft) at certain layers below 2000 ft or moderate wind shear (4-7 kts / 100 ft) at a single layer below 2000 ft might have been present.

Automatic Terminal Information Service (ATIS)

This is Billund airport information Romeo. Automatic observation. 1750. Expect radar vectors for ILS Z approach. Runway in use 27. Runway wet. Transition level 45. Wind 190 degrees 12 knots. Variable between150 and 240 degrees. Maximum 28 knots minimum 5 knots. Visibility 9 kilometres. Light rain. Overcast 700 feet. Temperature 7. Dewpoint 6. QNH 997. This was Billund airport information Romeo.

Communication

The flight crew were in radio contact with Billund Approach (127.575 MHz) and Billund Tower (119.000 MHz).

The AIB obtained the involved Air Traffic Control voice recording. The recordings were of good quality and useful to the AIB safety investigation.

Aerodrome information

General information

Aerodrome Reference Point:	55 44 25.16N 009 09 06.40E
Elevation:	247 ft
Runway directions:	Runway 27 (263.8° magnetic) Runway 09 (083.8°magnetic)
Runway dimensions	3100 meter (m) x 45 m
Runway surface:	Asphalt

Approach and runway lighting

Extract from the Aeronautical Information System - Denmark.

14. Approach and Runway Lighting

RWY	APCH LGT: Type Length Intensity	THR LGT: Colour WBAR	PAPI: Angle MEHT	TDZ LGT Length	RWY centre line LGT: Length, Spacing, Colour, Intensity	RWY edge LGT: Length, Spacing, Colour, Intensity	RWY end LGT: Colour WBAR	SWY LGT: Length Colour
09	CAT II and III 900 M LIH	Green	3° 52 FT	900 M White	3100 M 15 M White; FM 2200 M - 2800 M Red/White; FM 2800 M Red; LIH	3100 M 60 M White; FM 0 M - 150 M Red; FM 150 M - 2500 M White; FM 2500 M - 3100 M Yellow; LIH	Red	-
27	CAT II and III 900 M LIH	Green	3° 51 FT	900 M White	3100 M 15 M White FM 2200 M - 2800 M Red/White; FM 2800 M Red; LIH	3100 M 60 M White; FM 0 M - 150 M Red; FM 150 M - 2500 M White; FM 2500 M - 3100 M Yellow; LIH	Red	-

Instrument approach chart for the ILS to runway 27

Extract from the AIP Denmark.

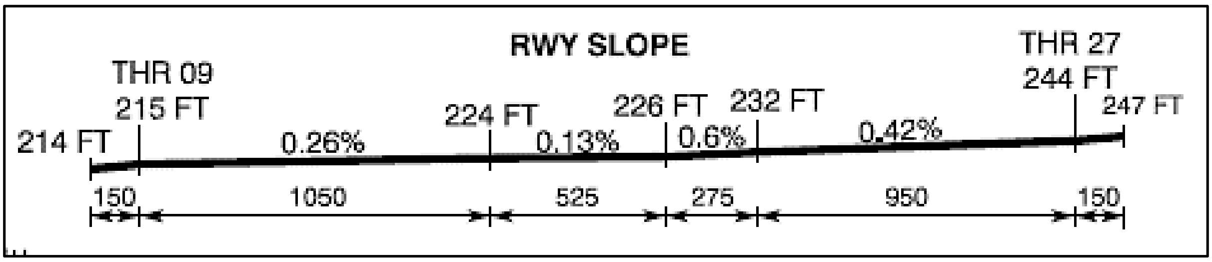
See appendix 2.

Notice to airmen (NOTAM)

(A3814/18 NOTAMN
Q) EKDK/QFFCH/IV/NBO/A /000/999/5544N00909E005
A) EKBI B) 1812191300 C) PERM
E) CHANGES TO AIP AD 2 - EKBI - 1 6. RESCUE AND FIRE FIGHTING SERVICES AND VFG AD 2. EKBI - 1 9. RESCUE AND FIRE FIGHTING SERVICE:
AD CATEGORY FOR FIRE FIGHTING CAT 7. OUTSIDE AD HOURS. SEE ITEM 3.1. SERVICE PROVIDED TO FLIGHTS HOLDING CONFIRMED AIRPORT SLOT PPR 72 HOURS, ACCORDING TO AIRCRAFT CATEGORY AND TO STA. THE FOLLOWING OPS TYPES CAN BE CONDUCTED H24 WITHOUT RFFS READINESS, PROVIDED THE OPERATORS PROCEDURES ALLOW THAT: NCC, NCO, SPO, HEMS, EMS, SAR AND ATO IF A/C LENGTH IS LESS THAN 18 METERS).)

(A3756/18 NOTAMN
Q) EKDK/QFATT/IV/BO /A /000/999/5544N00909E005
A) EKBI B) 1901310000 C) 1902132359
E)
TRIGGER NOTAM - PERM AIP AIRAC AMDT 01/19 AND VFG AIRAC AMDT 01/19 WEF 31 JAN 2019. REMARKS REGARDING USE OF TWY G AND TWY G2 ADDED.)

Runway slope



Flight recorders

The BEA downloaded the Quick Access Recorder (QAR) and the Cockpit Voice Recorder (CVR).

The downloaded data were of good quality and useful to the AIB safety investigation.

Appendix 3: From 160 ft RH, initial touchdown, bounce and final touchdown (plot).

Additional to extracted QAR data for the accident flight, the plot represents in shadowed lines recorded QAR data from another flight for comparison (Radio Height [Ft], A/C pitch angle [Deg], Vertical speed [x100 Ft/min], Eng1 Throttle lever angle [Deg], and Eng1 N1[%]).

Note. The AIB has deliberately omitted recorded airspeed data for the comparison flight.

Additional information

Airbus A321 tailstrike statistics

The aircraft manufacturer shared with the AIB the latest statistics related to the Airbus A321 tailstrikes at landing.

The AIB did not notice any significant rate of occurrences or adverse trends.

Guidance material by the aircraft manufacturer

The aircraft manufacturer has published guidance to address tailstrike occurrences during landings.

Flight Operations Briefing Note (2005) entitled *Bounce Recovery - Rejected Landing* cited a number of common reasons for tailstrikes, including the response to a bounced landing. The advice given in the event of a bounce is (extract):

Recovery from a light bounce

In case of a light bounce, the following typical recovery technique can be applied:

- *Maintain a normal landing pitch attitude:*
  - *Do not increase pitch attitude as this could cause a tailstrike; and,*
  - *Do not allow the pitch attitude to increase, particularly following a firm touchdown with a high pitch rate.*

Note:
Spoiler extension may induce pitch up effect.

- *Continue the landing;*
- *Keep thrust at idle; and,*
- *Be aware of the increased landing distance.*

Recovery from a high bounce

In case of a more severe bounce, do not attempt to land, as the remaining runway length might not be sufficient to stop the aircraft.

The following generic go-around technique can be applied:

- *Maintain a normal landing pitch attitude;*
- *Initiate a go-around by triggering go-around levers and/or advancing throttle/thrust levers to the go-around thrust position (depending on aircraft type);*
- *Ignore the takeoff configuration warning, if any;*
- *Maintain the landing gear and flaps configuration;*
- *Be ready for a possible second touchdown;*
  - *Do not try to avoid a second touchdown during the go-around. Should this happen, the second touchdown would be soft enough to prevent damage to the aircraft, if pitch attitude is maintained;*
- *When safely established in the go-around and no risk of further touchdown exists (i.e., with a steady positive climb), follow normal go-around procedures; and,*

- *Reengage automation, as desired, to reduce workload.*

<u>The operator's FCOM</u>

Flight parameters.

During the approach, the PM announces:

- *"SPEED" if the speed decreases below the speed target -5 kts or increases above target +10 kts.*
- *"SINK RATE" when the descent rate exceeds 1 000 ft/min.*
- *"BANK" when the bank angle becomes greater than 7°.*
- *"PITCH" when the pitch attitude becomes lower than -2,5° or higher than +7.5°.*
- *"LOC or "GS" when either localizer or glide slope deviation is:*
    - *½ dot LOC*
    - *½ dot GS*

Note: The PM announces the attitude deviations until landing.

<u>The operator's FCTM</u>

a. Tailstrike avoidance

Although most of tailstrikes are due to deviations from normal landing techniques, some are associated with external conditions such as turbulence and wind gradient.

DEVIATION FROM NORMAL TECHNIQUES

Deviations from normal landing techniques are the most common causes of tailstrikes. The main reasons for this are due to:

- *Allowing the speed to decrease well below VAPP before flare*

    Flying at too low speed means high angle of attack and high pitch attitude, thus reducing ground clearance. When reaching the flare height, the pilot will have to significantly increase the pitch attitude to reduce the sink rate. This may cause the pitch to go beyond the critical angle.

- *Prolonged hold off for a smooth touch down*

    As the pitch increases, the pilot needs to focus further ahead to assess the aircraft's position in relation to the ground. The attitude and distance relationship can lead to a pitch attitude increase beyond the critical angle.

- *Too high flare*

  A high flare can result in a combined decrease in airspeed and a long float. Since both lead to an increase in pitch attitude, the result is reduced tail clearance.

- *Too high sink rate, just prior reaching the flare height*

  In case of too high sink rate close to the ground, the pilot may attempt to avoid a firm touchdown by commanding a high pitch rate. This action will significantly increase the pitch attitude and, as the resulting lift increase may be insufficient to significantly reduce the sink rate, the high pitch rate may be difficult to control after touch down, particularly in case of bounce.

- *Bouncing at touch down*

  In case of bouncing at touch down, the pilot may be tempted to increase the pitch attitude to ensure a smooth second touchdown. If the bounce results from a firm touch down, associated with high pitch rate, it is important to control the pitch so that it does not further increase beyond the critical angle.

BOUNCING AT TOUCH DOWN

In case of light bounce, maintain the pitch attitude and complete the landing, while keeping the thrust at idle. Do not allow the pitch attitude to increase, particularly following a firm touchdown with a high pitch rate.

In case of high bounce, maintain the pitch attitude and initiate a go-around. Do not try to avoid a second touchdown during the go-around. Should it happen, it would be soft enough to prevent damage to the aircraft, if pitch attitude is maintained.

Only when safely established in the go-around, retract flaps one step and the landing gear. A landing should not be attempted immediately after high bounce, as thrust may be required to soften the second touchdown and the remaining runway length may be insufficient to stop the aircraft.

CUMULATIVE EFFECTS

No single factor should result in a tailstrike, but accumulation of several can significantly reduce the margin.

b. Flare and touchdown (extract)

Prior to flare, avoid destabilization of the approach and steepening the slope at low heights in attempts to target a shorter touchdown. If a normal touchdown point cannot be achieved or if destabilization occurs just prior to flare, a go-around (or rejected landing) should be performed.

The PM monitors the rate of descent and should call "SINK RATE" if the vertical speed is excessive prior to the flare.

From stabilized conditions, the flare height is about 30 ft.

This height varies due to the range of typical operational conditions that can directly influence the rate of descent.

If the flare is initiated too late then the pitch changes will not have sufficient time to allow the necessary change to aircraft trajectory. Late, weak or released flare inputs increase the risk of a hard landing.

At 20 ft, the "RETARD" auto call-out reminds the pilot to retard thrust levers. It is a reminder rather than an order. When best adapted, the pilot will rapidly retard all thrust levers: depending on the conditions, the pilot will retard earlier or later. However, the pilot must ensure that all thrust levers are at IDLE detent at the latest at touchdown, to ensure ground spoilers extension at touchdown.

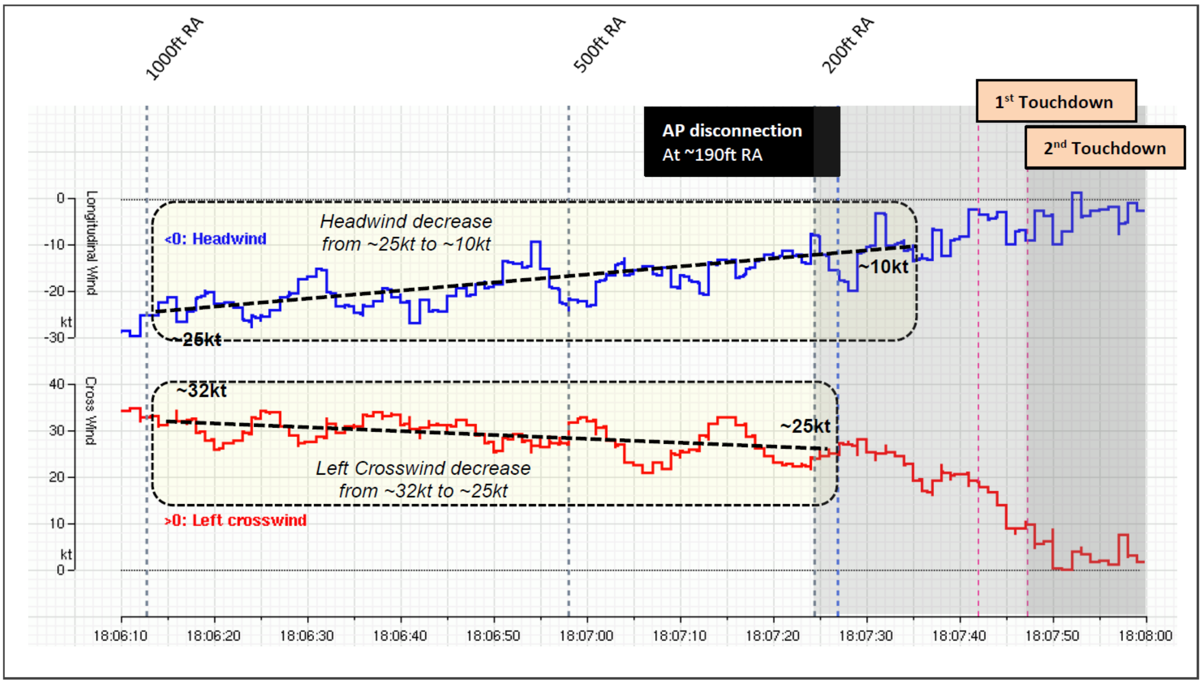
c. Decision making (extract)

The approach is unstable in speed, altitude, or flight path in such a way that stability is not obtained by 1 000 ft AAL in IMC or (500 ft AAL in VMC), or is not maintained until landing.

<u>Wind evolution during final approach</u>

The aircraft manufacturer made a computation on wind evolution during the final approach.

The wind information computed by the Air Data Inertial Reference Unit (ADIRU), recorded by the FDR and projected on aircraft axes was as follows:



Note.
On ground - wind information not reliable.
Below 200 ft - wind information for trend only.

The longitudinal and lateral wind evolutions highlighted:

Between 1000 ft RA (18:06:12 UTC) and 100 ft RA (18:07:35 UTC), the average wind recorded by the FDR comes from 195° with variations between 172° and 205° at 33 kts with gust at 42 kts.

By projection on aircraft axes it led to:

On the longitudinal axis:
- *A headwind component decreasing from 25 kts to 10 kts with gusts (up to 8 kts/s).*

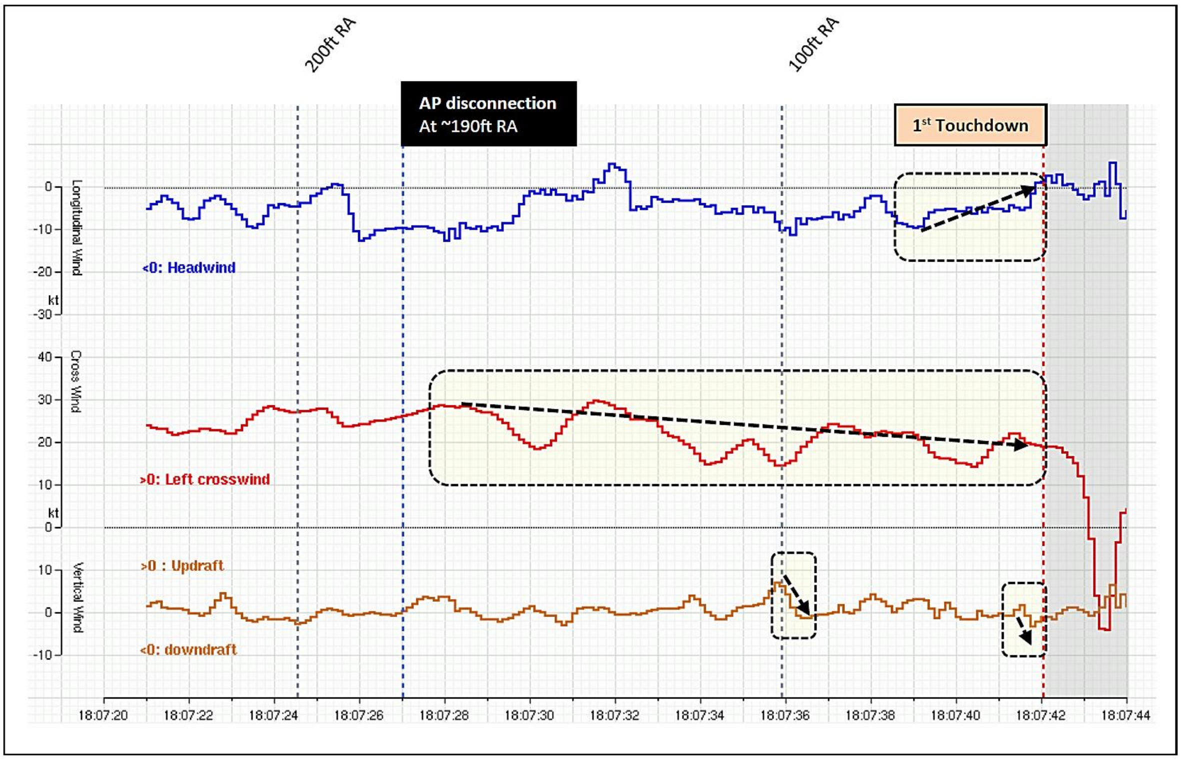
On the lateral axis:
- *A mean left crosswind component decreasing from 32 kts to 25 kts with gusts up to 32 kts.*

Wind reconstruction during the occurrence

In order to determine the influence of the wind on the aircraft behavior during the last 200 ft, the aircraft manufacturer computed a specific wind reconstruction.

The wind reconstruction was computed in 3 axes, based on:

- Anemometric and Inertial data from FDR.
- Anemometric correction: estimation of sideslip and ground effects.
- Inertial bias reconstruction.



Note.
On ground - wind information not reliable.
The reconstructed longitudinal and lateral wind evolutions highlight:

On the longitudinal axis:

- *In the last 30 ft, a gust of 12 kts was encountered by the aircraft leading the headwind to vanish prior to touchdown.*

On the lateral axis:

- *Between ~190 ft RA and touchdown, the left crosswind component decreased by ~10 kts.*

On the vertical axis:

- *Several downdrafts were encountered by the aircraft in the last 100 ft.*

<u>Thrust lever movement upon initial touchdown</u>

On request by the AIB, the aircraft manufacturer computed the necessary force to move the engine thrust levers forward of the climb detent.

The computation revealed that a significant breakout force was necessary to move the engine thrust levers forward of the climb detent.

ANALYSIS

General

The following revealed findings had, in the AIB’s opinion, no influence on the sequence of events:

- Licenses, qualifications, and total/recent Airbus A321 flying experience held by the flight crew.
- Flight and duty times.
- The technical status of the aircraft.
- The aircraft mass and balance.
- NOTAM.
- The aids to navigation.
- Lighting system to runway 27 at EKBI.

The forecasted weather conditions at EKBI were generally consistent with the actual weather reports, the weather observations perceived by the flight crew, and the wind data recorded by the aircraft.

Appropriate risk controls like aircraft tailstrike prevention systems, guidance material by the aircraft manufacturer, standard operating procedures, flight crew briefings, and flight crew training were in place.

The AIB considers these risk controls to have been effective in reducing and keeping the Airbus A321 tailstrike rate low.

Final approach

Based on the available weather information sources, the aircraft encountered moderate turbulence during the final approach, which in combination with strong crosswinds and dark night operations most likely affected the flight crew handling on short final and landing.

Minor and short-term speed variations outside the stabilized approach concept (target speed +10 kts) below 500 RH were recorded.

Despite strong crosswinds and gusts, *Ground Speed Mini* and autothrust in *SPEED mode* ensured an efficient thrust management and corrected minor short-term speed variations outside the stabilized approach parameters.

After disconnection of the autopilot, a headwind gust led the CAS to increase and thereby increasing lift.

Consequently, the rate of descent decreased. The pilot flying counteracted the decrease of the rate of descent with two consecutive nose-down control sidestick inputs leading the pitch angle to decrease.

Nose-down dynamics combined with a downdraft led the rate of descent to increase within approximately 4 seconds up to approximately 1100 ft/min reached at 35 ft RH. In general, on a constant minus 3° glide path and at a GS of approximately 146 kts, the rate of descent would be approximately 770 ft/min.

Though the approach was performed in rainy and dark night conditions, the flight crew, below decision height, kept visual contact with the runway and appropriate visual cues for the landing.

The destabilization before the flare did not trigger flight crew calls and/or a decision on going around.

In stabilized conditions, the flare height was about 30 ft, and the engine thrust levers should be retarded to flight idle between 30 ft RH and touchdown.

Though a synthetic voice call on *RETARD* sounded at 20 RH, the sequence of events apparently took the pilot flying by surprise.

Due to the unannounced and uncorrected rate of descent within approximately 4 seconds prior to the flare, the actual flare initiation did not take place in time to change the vertical aircraft flight path and trajectory sufficiently prior to the touchdown, which led to a hard landing (2.59 g).

A headwind drop and a downdraft just before the initial touchdown aggravated the situation.

Bounced landing

Following revealed findings caused a high bounce:

- The energy of the hard landing partially restored by the main landing gear shock absorbers.
- A nose up sidestick order progressively released after touchdown.
- The thrust lever movement forward of the climb detent to maximum continuous thrust detent.
- The inhibition of ground spoiler partial extension.
- After touchdown and because of thrust lever movement forward of climb detent, the autothrust reverted from active to armed and consequently led the thrust to largely increase.

The AIB finds it probable that the pilot flying - in order to reduce the effect of a coming hard landing, though too late, - instinctively moved the thrust levers forward of the climb detent.

As pitch sidestick order by the pilot flying was released but still in nose-up position and associated with the pitch-up effect of the thrust increase, the pitch angle increased and activated the synthetic voice call *PITCH* for an excessive pitch angle.

The pilot flying applied a pitch-down order leading the pitch angle to decrease.

During the bounce, the thrust levers were retarded to the flight idle detent (within three seconds of the initial touchdown) leading to autothrust disconnection and consequently led the thrust to decrease.

The thrust lever movement to the flight idle detent enabled ground spoiler extension.

The ground spoiler extension and the nose-down order by the pilot flying led to a partial loss of lift with an increase of the rate of descent.

To counteract this partial loss of lift, the pilot flying applied a pitch-up order to an approximately full aft sidestick deflection, which together with a residual pitch-up effect of ground spoiler extension led to activation of the second synthetic voice call *PITCH* for an excessive pitch angle.

The approximately full aft sidestick deflection was too lately applied to have a significant effect on the vertical speed, which continued increasing up to a rate of decent of approximately 600 ft/min at the second touchdown.

At an excessive pitch angle, the aircraft was exposed to a second hard landing (2.56 g), and the aircraft tail section struck the runway.

Even though, the actual recorded pitch angle was less than the geometric limits published by the aircraft manufacturer, runway downslope and the flexibility effect experienced by the aircraft structure and the landing gear resulted in the tailstrike.

The range of aft sidestick inputs on a comparable and “standard” landing varied considerably compared with the control inputs in this tailstrike event. The QAR data of this event indicated a significant change of pitch angle, mainly consistent with the sidestick inputs applied during the dynamic phase of the flare and the touchdown

According to standard operating procedures, a high bounce required a flight crew decision on going around.

However, in practice it is not necessarily easily perceivable to a flight crew, if an aircraft has made a high or a light bounce.

In this tailstrike event, landing performance was not a limiting factor (runway length was sufficient to stop the aircraft in time), which might have had a negative influence on the flight crew decision making.

CONCLUSIONS

The technical and training measures put in place by the aircraft manufacturer have been effective in reducing and keeping the Airbus A321 tailstrike rate low on the global fleet.

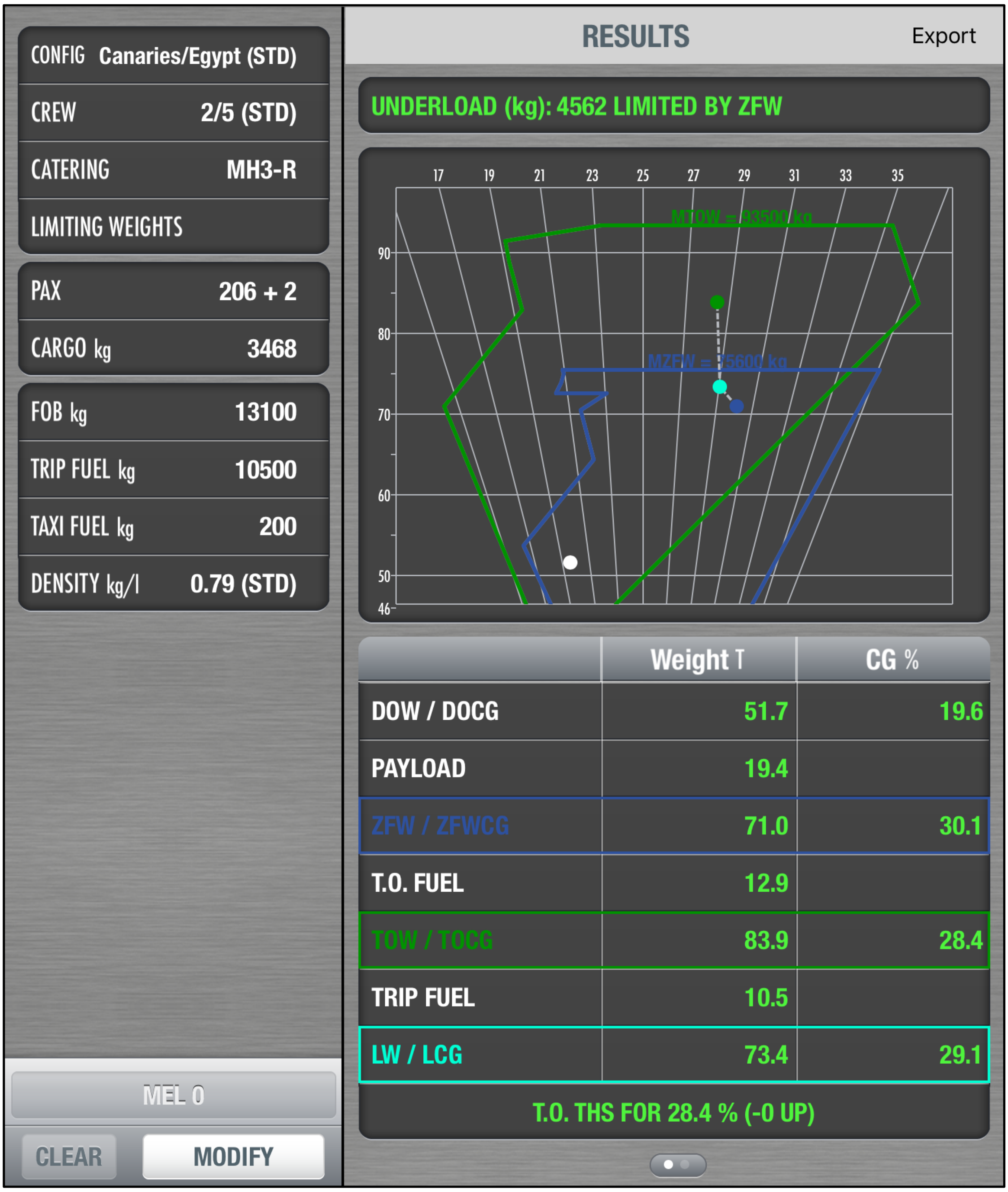
As described in the operator’s FCTM, it is likely that a tailstrike is the result of a combination of factors.

The AIB considers the contributing factors to this specific tailstrike to be:

- Gusting and strong crosswinds in dark night.
- Moderate turbulence and downdrafts on short final to runway 27 at EKBI.
- Too high sink rate, just prior reaching the flare height (destabilization).
- No flight crew calls and/or decision on going around on short final or during the bounce.
- Two hard landings.
- Inappropriate thrust lever management.
- Inappropriate pitch control during the bounce resulting in a pitch angle increasing beyond the critical angle.

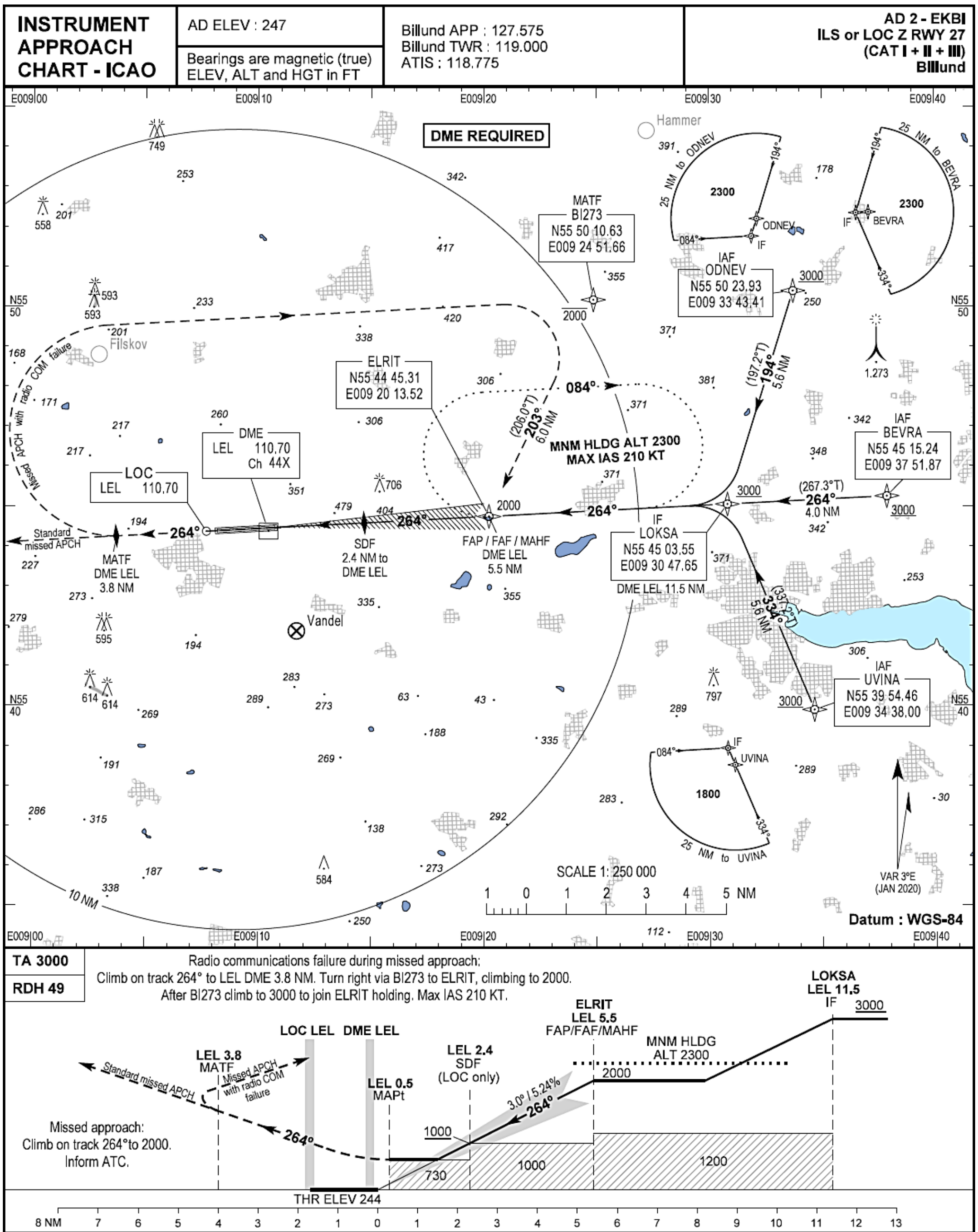
APPENDIX 1

[Return to mass and balance](#)



APPENDIX 2

Return to instrument approach chart



OCA (H)	A	B	C	D	SPECIAL CONDITIONS
ILS CAT I	385 (141)	392 (148)	401 (157)	409 (165)	
ILS CAT II	301 (57)	311 (67)	323 (79)	334 (90)	
LOC*	730 (480)	730 (480)	730 (480)	730 (480)	*Cross LEL DME 2.4 NM not below 1000.
Circling**	800 (550)	800 (550)	1140 (890)	1140 (890)	**N of AD only.
DME LEL NM	1.0	2.0	3.0	4.0	5.0
DIST to THR NM	0.82	1.82	2.82	3.82	4.82
Nominal altitude	554	872	1191	1509	1828

CAT III operations may take place without restrictions as the basic ILS surfaces are not penetrated

APPENDIX 3

[Return to flight recorders](#)