THE REPUBLIC OF CROATIA

Air, Maritime and Railway Traffic Accident Investigation Agency

Air Traffic Accident Investigation Department

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F I N A L R E P O R T

ON SERIOUS INCIDENT OF THE AIRCRAFT AIRBUS 320 NEO, REGISTRATION SE-ROJ

4 SEPTEMBER 2021, AT SPLIT AIRPORT

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Investigations are independent and separate from court or administrative proceedings and should not prejudice determination of guilt or liability of individuals.

The final report cannot be used as evidence in court proceedings whose aim is determining civil or criminal liability of individuals.

CONTENT

OCCURENCE INFORMATION

Type of the occurrence:	Serious incident
Date:	4 September 2021
Local time:	12:35
Place:	Split airport (LDSP)
Type of the aircraft:	Aeroplane
Manufacturer / model:	Airbus/A320-251N NEO
Registration:	SE-ROJ
Serial number:	9312
Owner:	SAS
Operator:	SAS
Number of persons on board:	174
Injuries:	No injuries
Damage to the aircraft:	Minor material damage

INVESTIGATION

The Air, Maritime and Railway Traffic Accident Investigation Agency received information about a serious incident, day after the event, from the aircraft operator. AIA investigators performed an inspection of the aircraft and opened a safety investigation.

Upon completion of the investigation, the Air, Maritime and Railway Traffic Accident Investigation Agency issued this Final Report.

SUMMARY

On 4 September 2021, around 10:34 UTC, a serious incident of the aircraft Airbus 320 NEO occurred during landing at Split Airport, in form of tail strike resulting in minor material damage, but there were no physical injuries of the passengers and crew.

During safety investigation it was determined that this serious incident was caused by a combination of flight technique in the final phase of landing and significant change in the wind gradient.

AIA did not issue a safety recommendation in the subject safety investigation.

1. FACTS AND INFORMATION

1.1. FLIGHT INFORMATION

Flight SK7347 started on 4 September 2021 at 07:46 UTC at Bergen Airport and took place without any difficulties. The approach in use at that moment was ILS Z for the runway 05 at Split airport. The approach to the airport was completely stabilized, and the crew was informed about the possible tailwind and the characteristics of the runway in the touchdown zone, which has slight uphill characteristics. Around 10:34 UTC, during landing, ~~aircraft slightly bounced during which~~ a tail strike occurred. The crew parked the aircraft without further difficulties.

1.2. INJURIES

None of the passengers or crew sustained injuries.

Injuries	Crew	Passengers	Others
fatal	0	0	0
serious	0	0	0
minor / none	6	168	0

1.3. DAMAGE TO THE AIRCRAFT

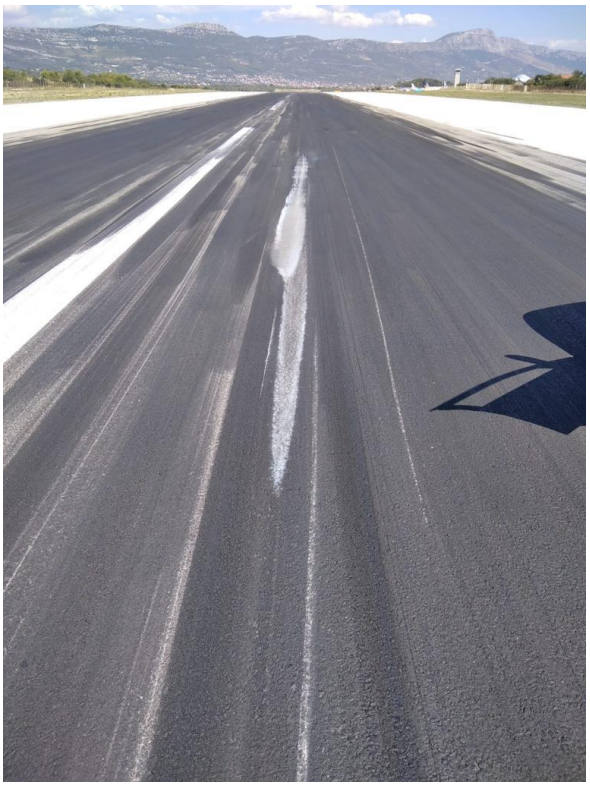
During the landing, damage to the plating and other structural parts typical for such event occurred on the aircraft which are shown in Picture 1 and 2. The damage occurred between frame 68 and 72, and between stringers 32LH and 32RH. There was also damage to the drainage pipe and door of the APU (Auxiliary power unit) and the drainage pipe of the rear galley (Picture 1 and 2).

Picture 1 – Damage to fuselage skin

Picture 2 – Skin damage and APU door damage

1.4. OTHER DAMAGE

During the serious incident, there was no significant damage other than the stated damage to the aircraft. The point of contact of the tail of the aircraft with the runway is visible on the runway (Picture 3).



Picture 3 – The point of contact of the aircraft with the runway

1.5. PERSONAL INFORMATION

1.5.1. Captain

Male person, Norwegian citizen born in 1962. In the serious incident in question, the person was the PIC - Pilot in command and the PF - Pilot Flying, and holds a valid ATPL(A) pilot's license with SEP (land), A320, Boeing 737 300-900 ratings issued by the Norwegian Aviation Authority in 2020. Until the serious incident in question, he accumulated a total of 14,027 flight hours, of which 227 hours were on the A320 type. In the last 90 days he had 102 flight hours with 33 landings on the A320.

He holds a valid Certificate of Medical Competence with limitations: “VNL Correction for defective near vision”, “OML Valid only as, or with, a qualified co-pilot” and “SIC Specific medical examination(s) - contact licensing authority”.

1.5.2. First Officer

Male person, Norwegian citizen born in 1963. In the serious incident in question, the person was the first officer of the aircraft and the PNF - Pilot not flying and possesses a valid ATPL(A) pilot's license with A320, A330/350 ratings (co-pilot only), issued by the Norwegian aviation authorities in 2021. Until the subject serious incident, he accumulated a total of 9,544 flight hours, of which 286 hours were on the A320 type. In the last 90 days, he had 128 flight hours with 95 landings on the A320. The most part of flight hours, i.e. 7,526 hours he had on the Boeing 737 aircraft. The rest of his flying experience was on A330/340 aircraft.

He possesses a valid Certificate of Medical Competence with limitations "*VNL Valid only with correction for defective distant, intermediate and near vision*".

1.6. AIRCRAFT INFORMATION

Airbus 320

Manufacturer / model:	Airbus / 320-251N
Operator:	SAS, Scandinavian Airlines
Aircraft series:	A320-251N
Engine series:	LEAP-1A
Engine manufacturer:	CFMI

The Airbus 320 is a low-wing twin-engine turbofan aircraft of metal construction. The fuselage is pressurized. The landing gear is retractable, tricycle type. On the fuselage there are passenger and service doors and doors for the cargo area.

At the time of the serious incident, the Certificate of Airworthiness of the aircraft was valid until 14 November 2021. The other received technical documentation is in order.

The aircraft is equipped with a tail strikes prevention system. The system consists of a visual indication (pitch limit indicator on the PFD, Primary flight display) and an audible indication (synthetic voice "PITCH PITCH").

1.7. METEOROLOGICAL DATA

At the time of the serious incident on 4 November 2021, meteorological conditions were favourable for flying the aircraft in question.

METAR reports for Split Airport in the period from 10:00 UTC to 11:00 are as follows:

SA 04/09/2021 11:00->
METAR LDSP 041100Z 19003KT 120V250 9999 FEW060 27/12 Q1015 BECMG 23008KT=
SA 04/09/2021 10:30->
METAR LDSP 041030Z VRB04KT 9999 FEW060 26/13 Q1015 NOSIG=
SA 04/09/2021 10:00->
METAR LDSP 041000Z 09004KT 040V150 CAVOK 26/12 Q1015 NOSIG=

The last METAR report was issued 4 minutes before the event in question.

For the purposes of more precise calculation of wind speed and direction, data obtained from the aircraft flight data recorder were also used. The recorded information about the wind on the aircraft is calculated by the ADIRU computer (Air data inertial reference unit). Wind was variable blowing on average from the direction of 204^0, with a strength of 4 kt. However, in the last 70 ft before the landing there was a significant tailwind gradient change of 10 kt.

1.8. COMMUNICATION

During the subject flight, and after entering Croatian airspace, the pilot communicated with the competent controller via radio, on the corresponding frequencies, without difficulties, clearly and comprehensibly.

1.9. AIRPORT INFORMATION

Split Airport is registered for public domestic and international air traffic and is located about 20 km west of the city of Split (Picture 4). The airport operator is the company Zračna luka Split d.o.o. The airport has a runway 2550 m long, 45 m wide, direction 05-23, and several taxi ways and parking positions, at an elevation of 70ft. The airport is characterized by denser air traffic during the summer months.

Picture 4 - Split Airport, marked with red line

1.10. FLIGHT DATA RECORDERS

The aircraft was equipped with a Digital Flight Data Recorder and a Cockpit Voice Recorder, both functional and undamaged. Data was taken from both devices for further analysis of the event.

The data obtained from the flight data recorders were analysed by the aircraft manufacturer (Airbus report 80963322), and the obtained data was used in this report. Investigative bodies from Sweden, Norway and France participated in the creation of the transcript of the audio communication of the flight crew (CVR Transcription Prlim V01, BEA).

DFDR - Digital Flight Data Recorder

Flight data was downloaded and analysed. Results were described in manufacturer report Airbus 80963322. Some parts of the manufacturer report are presented in this Final report.

Cockpit Voice Recorder

For the purposes of a clearer understanding of the course of the subject event, a recording of the voice communication of the flight crew was listened to, and a transcript of the same was made. Listening to the recording of the communication and reviewing the transcript established the following:

- The controller approved the approach ILS Z RWY 05
- The crew made preparation and briefing for the approach to ILS Z RWY 05
- The communication between the captain and the first officer is clear without ambiguities
- During the approach, the crew communicates about the presence of a tailwind and the uphill tendency of the runway at its start
- The captain of the aircraft mentions that he will go a little below the PAPI system (Precision Approach Path Indicators) towards the very end of the landing
- Just before the first contact with the runway, a synthetic warning "50, 40, 20, RETARD, PITCH PITCH, RETARD" is heard, followed by a sound corresponding to the aircraft's hard touchdown
- During taxiing, the crew communicates about the possible contact of the tail of the aircraft with the runway, and possible damage to the aircraft

1.11. INFORMATION ABOUT SERIOUS INCIDENT SITE

After landing on runway direction 05, the aircraft parked without additional difficulties.

During the subject serious incident, the aircraft damage occurred to the underside of the fuselage in the tail area, while the runway has visible traces of the aircraft touching the asphalt surface.

1.12. SEARCH AND RESCUE

Considering that the subject aircraft landed on the runway, and that the pilots and passengers were not injured during the serious incident, there was no need for search and rescue operation.

1.13. ADDITIONAL INFORMATION

1.13.1. Pilot statement

After the serious incident, in his statement the pilot stated the following: *"After a fully stabilized approach, which included informing about possible tailwind and the runway rise at the touchdown zone, we landed quite hard, which resulted in bouncing. To correct the bouncing, I added power to control the descent. I believe that too high nose of the aircraft during the second touchdown caused the tail strike..."*

1.13.2. Audio recording of radio communication on the approach frequency of LDSP

The inspection of audio recordings of radio communication established the following:

- During the approval for landing of the subject aircraft, the controller informs the crew that the wind is blowing from the direction 150^0 with strength of 4 kt
- Communication between the controller and the flight crew is clear without difficulties
- Eight minutes after the landing of the subject aircraft, two other aircraft reported tailwinds of 7 kt during landing

1.13.3. FOBN – Flight operations briefing notes

In 2007, the aircraft manufacturer issued FOBN FLT_OPS-LAND-SEQ08-REV01-SEP, 2007, entitled "Preventing tail strike at landing". In the introduction of this document, the manufacturer states that the tail strike itself can occur during landing or take-off, more often with longer than shorter aircraft. These events are directly related to the pitch and geometry of the aircraft and the extension status of the landing gear. It is further stated that such event can cause significant structural damage to the aircraft, since the pressure bulkhead is located in the rear part of the aircraft.

Statistically, about 25% of reported tail strikes occur during take-off and 65% during landing (Source: Airbus 2004). Other 10% occur during touch and go or the flight phase is unknown. Tail strike occurs more often during the second touchdown after bouncing during the first touchdown and is often associated with a hard landing.

Although most tail strikes occur due to deviations from normal flight techniques, some are related to external conditions such as turbulence and wind gradient.

Factors that increase the probability of tail strike:

- Speed reduction (significantly below approach speed) before the flare phase
- Sink rate too high just before the aircraft enters the flare phase
- Flare is too high
- Prolonged hold-off for a smooth touchdown
- Crosswinds not handled correctly
- Bounce at touchdown

1.13.4. AIRBUS Flight crew techniques manual

The manufacturer in its FCTM includes chapter "Tail strike avoidance". In that chapter it is stated: "Although most of tail strikes are due to deviations from normal landing techniques, some are associated with external conditions such as turbulence and wind gradient".

As one of the deviations of flying techniques it is stated: *"Too high flare – A high flare can result in combined decrease in airspeed and a long float. Since both lead to an increase in pitch attitude, the result is reduced tail clearance".*

1.13.5. Manufacturer report Airbus 80963322

In its report, aircraft manufacturer analysed DFDR flight data. Part of this report is presented below in its original form:

…beginning of report…

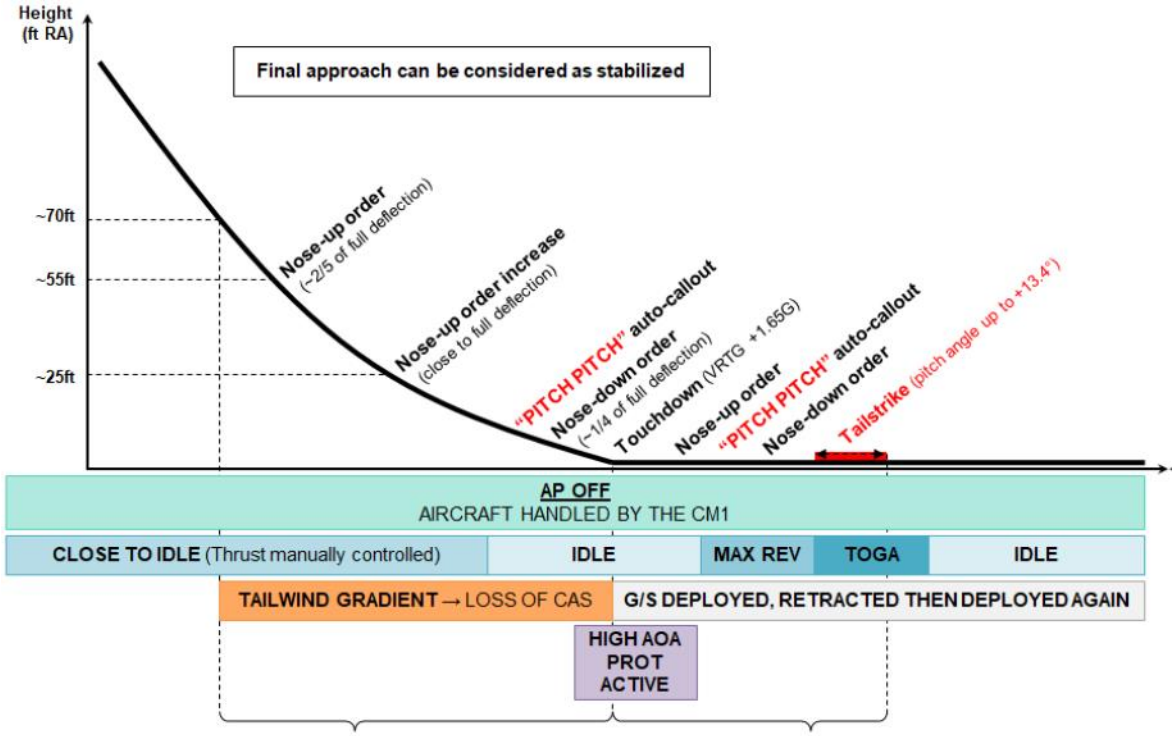
On September 4th 2021, A320-251N MSN 9312 (SE-ROJ) operated by SCANDINAVIAN AIRLINES experienced a tail strike at landing after an ILS approach to runway 05 at Split airport (LDSP).

Weather Condition

During final approach, the aircraft experienced no adverse wind conditions. In the last 70ft, a significant tailwind gradient was encountered by the aircraft.

Key points

The FDR analysis indicates the following key points:



In the last 70ft, the aircraft encountered a tailwind gradient leading the CAS to decrease to speed tgt-9kt and thus leading to a loss of lift at low height.

At ~55ft RA, a nose-up order was applied leading the pitch angle to start to increase. In spite of this order, due to the loss of lift, the rate of descent increased up to ~650ft/min.

In the last 25ft, the nose-up flare input was increased and led the pitch angle to continue to increase.

Due to these flare actions, the predictive pitch (Pitch + Pitch rate x 1s) reached a value of +13°, therefore the "PITCH PITCH" automatic callout triggered.

Then a nose-down order was applied leading the pitch angle to stop to increase, but the tail clearance was significantly reduced at touchdown with a pitch angle of +10.6°.

Note: With main landing gear compressed, the value of pitch angle to have contact with rear fuselage is +11.7°: ***the tail clearance margin was thus only 1.1° at touchdown.***

Prior to touchdown, the AOA increased above αProt value: the high angle of attack protection thus activated.

Due to the nose-down order applied just before touchdown, the AOA decreased. As the current AOA was decreasing below αPROT value, a nose-up demand was commanded by the FCT/L: the high AOA protection tried to maintain an AOA close to αPROT value.

The high AOA protection led the elevators to significantly deflect upward from -5° to -23° and led the pitch angle to start to increase again.

Note: The high angle of attack protection deactivated less than 1s after its activation.

Due to the nose-up demand mainly commanded by the Flight Control Laws, the pitch angle reached a maximum of +13.4°.

A second "PITCH PITCH" automatic callout triggered and a nose-down order was applied but did not sufficiently change the aircraft pitch-up dynamics to avoid a **tailstrike**.

The Airbus Handling Quality analysis highlighted the following contributing factors of the event:

- ***Tail strike:***

A significantly reduced tail clearance at touchdown:

- *The tailwind gradient encountered in last 70ft participated to a loss of CAS and thus to a loss of lift at low height. The nose-up order applied by CM1 at ~55ft RA led the pitch angle to start to increase without effect on the rate of descent.*
- *At ~25ft RA, while the CAS continued to decrease towards speed target-9kt, the increase of the nose-up order led the pitch angle to continue to increase up to +10.6° before touchdown.*

A nose-up dynamics just after touchdown:

- *Due to the flare actions, the angle of attack increased up to +13.2°: the high angle of attack protection thus activated just before touchdown and led to a nose-up demand commanded by the Flight Control Laws.*
- *This nose-up demand mainly commanded by the Flight Control Laws just after touchdown (with the high AOA protection active) led the pitch angle to reach a maximum of +13.4°.*

Operational considerations concerning this event:

FCTM PR-NP-SOP-250 TAIL STRIKE AVOIDANCE (cf. extract p.15):

The combination of the loss of speed due to the tailwind gradient and of the flare actions from 55ft RA led the pitch angle to increase significantly prior to touchdown.

- *Most of tail strikes are due to deviations from normal techniques and some are associated with external conditions such as wind gradient.*
- *Combine a high flare and a low speed led to increase the pitch angle and to reduce the tail clearance.*

FCTM PR-NP-SOP-250 TAIL STRIKE AVOIDANCE (cf. extract p.15):

MSN9312 is fitted with the tail strike prevention system.

The following aircraft systems help to prevent tail strike occurrence:

- *A "PITCH PITCH" auto-callout sounded twice during this event.*

A tail strike pitch limit indicator appeared on the PFD and indicated the maximum pitch attitude (+11.7°) to avoid a tail strike.

…end of report…

In this summary manufacturer graphically and textually describes course of events and key points which contributed to the occurrence outcome. As contributing factors manufacturer is listing a significantly reduced tail clearance at touchdown and nose-up dynamics just after touchdown, following high AOA protection activation just before touchdown.

Among other provided information, manufacturer states it is working on "Flight Control Law" improvement during flare phase. Aim of this improvement is to find new setting preventing the high angle of attack protection activation in similar situations, while continuing to insure the aircraft against stall in case of go around close to the ground.

1.13.6. SAS flight crew training

The company SAS conducts flight crew training related to avoiding tail strikes through the program "Correct take-off and landing techniques".

2. ANALYSIS

2.1. ANALYSIS OF THE EVENT IN QUESTION

For the purposes of analysing the course of the subject event, all data available from the aircraft operator, the aircraft manufacturer, and the investigative bodies of France, Sweden and Norway were used.

It can be determined that the aircraft operator and aircraft manufacturer actively participate in the education of the flight crew regarding the tail strikes during take-off and landing. The flight crew was qualified to perform the flight in question, and the aircraft was technically serviceable.

By analysing the available data about the flight from the aircraft systems, as well as other available information sources, it can be concluded that in the final phase of landing there was a significant change in the wind gradient, which significantly affected on the outcome of the event itself. Due to the changes in the pitch and angle of attack of the aircraft during landing and touchdown, the high angle of attack protection system was activated for less than one second. The flight crew of the aircraft was aware of possible changes in the direction and strength of the wind in the final phase of the approach.

In the documentation available from the manufacturer, some of the stated possible causes and contributing factors of such events correspond to the established conditions under which the subject serious incident occurred, such as changes in the wind gradient and/or landing bounce.

3. CONCLUSION

3.1. FINDINGS

- The flight crew holds a valid Pilot's licence issued by the Norwegian Civil Aviation Authority, and valid Certificate of Medical Competence with limitations for vision (VNL).
- A valid Certificate of Airworthiness has been issued for the aircraft
- Post Flight Report (PFR) did not indicate failure of any system on the aircraft
- The controller approved the approach to ILS Z RWY 05
- The crew prepared for the approach to ILS Z RWY 05

- During the landing, there was a variable tailwind wind component, direction 170^0-245^0, strength 04 kt
- Significant tailwind gradient at last 70 ft
- "PITCH PITCH" activation twice during landing
- Flight control law activation at angle of attack protection
- High pitch angle at touch down
- Tail strike after touchdown

3.2. IMMEDIATE CAUSE

Immediate cause of the subject serious incident was high pitch at touchdown.

3.3. CONTRIBUTING FACTORS

Contributing factors that preceded the serious incident are:

- Significant tailwind gradient in the last 70 ft
- Flight technique during landing
- Activation of angle of attack protection just before touchdown

4. SAFETY RECOMMENDATIONS

Considering that after the serious incident in question, the aircraft manufacturer noticed the possibility of improving Flight Control Law, during the activation of high angle of attack protection system, and that manufacturer is currently working on the system improvements in accordance with the observed behavior, AIN did not issue a safety recommendation.

Investigator in Charge

Danko Petrin