Safety first

The Airbus Safety magazine

A Focus on the Landing Flare

There were several cases of aircraft touching down with their nose landing gear first or hard landings reported to Airbus over the last 2 years. This article will present some key points coming from the analysis of two of these incidents and recall the operational recommendations for performing the flare phase that are key to ensuring a safe landing.

This article is also available on safetyfirst.airbus.com and on the Safety first app for iOS and Android devices.

CASE STUDY 1: BOUNCED LANDING, NOSE LANDING GEAR IMPACT, AND A TAIL STRIKE ON GO-AROUND

Event Description

An A320 was on the final approach segment of its ILS approach, configured for landing (CONF FULL).

The Pilot Flying (PF) disconnected the autopilot at 370 ft Radio Altitude (RA) and kept autothrust ON. At 200 ft, tailwind variations caused the airspeed to drop below approach speed (Vapp).

① From 100 ft RA and below, high tailwind gradients maintained the **airspeed below Vapp -5 kt** despite autothrust increase and reached a minimum of 119 kt (Vapp -20 kt) at 5 ft RA.

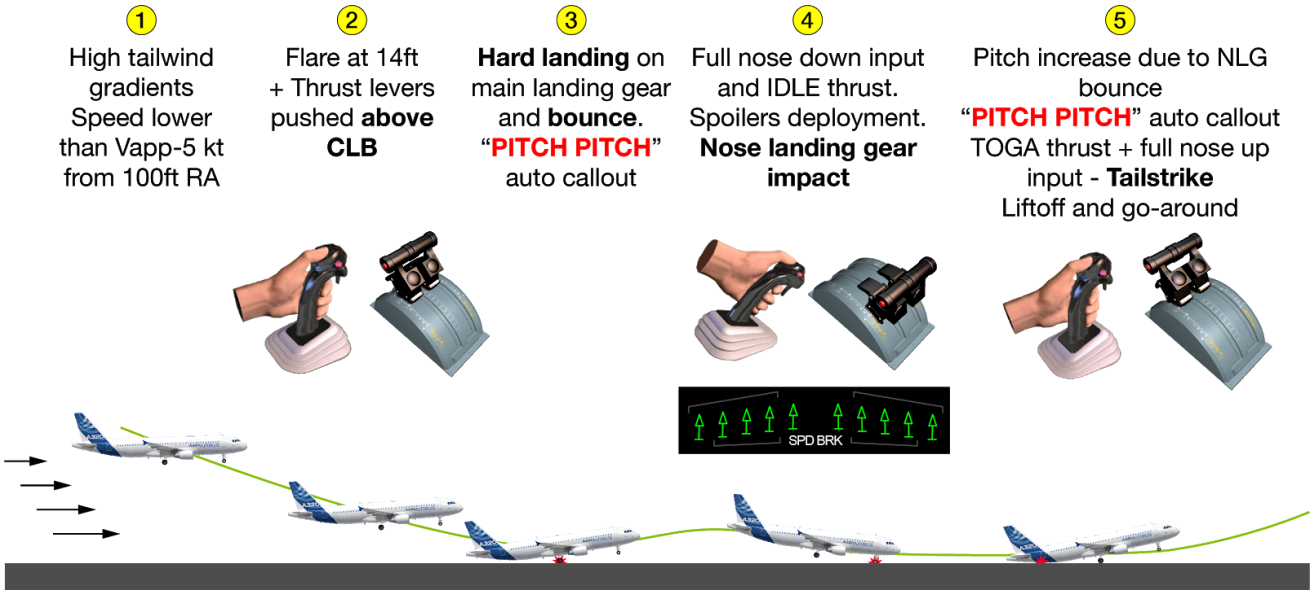
② The PF performed **the flare at 14 ft** and at the same time started to slowly push the **thrust levers above CLB detent**.

③ The aircraft touched down on its main landing gear and **bounced**. During the bounce, a **PITCH PITCH** auto callout triggered.

④ The PF applied **full nose down order** and retarded the thrust levers to **IDLE**. This triggered an extension of ground spoilers leading the aircraft to heavily impact the runway , first with its nose landing gear and then its main landing gear.

⑤ The impact of the nose gear resulted in another sudden increase of the aircraft's pitch and the **PITCH PITCH** auto callout triggered for a second time. The PF initiated a **go-around** by setting TOGA thrust and applying a full nose up command. There was a tail strike as the aircraft lifted off from the runway at 133 kt.

The NLG wheels separated due to the impact of the NLG on the runway and one wheel was sucked into Engine 1, causing this engine to stall. Other system failures occurred due to the impact on the NLG and these caused the aircraft to revert to alternate law. The flight crew diverted to a different airport and eventually landed the aircraft.



(fig.1) Sequence of events from case study 1

Operational Considerations

Role of the Pilot Monitoring (PM)

The FCOM SOP for landing requests a SPEED callout by the PM in the case of speed deviation of 5 kt below the target speed. The PF should initiate a go-around unless they consider that a stabilized condition can be recovered by small corrections to the aircraft and within sufficient time prior to landing.

The FCTM states that the risk of tail strike is increased due to the high angle of attack and high pitch attitude if the speed of the aircraft is allowed to decrease too far below Vapp before the flare.

Looking at step ① in the event described above, it shows the speed went below Vapp -5 kt from 100 ft and below. If the PM had made a "SPEED" callout then the PF may have noticed the speed decay and attempted to correct it or initiate a go-around if it was not likely to stabilize in time.

Flare Height

The FCOM states that in a stabilized approach, the flare should be initiated at 30 ft for A320 family aircraft (the values for other Airbus aircraft are provided later in this article).

The FCTM recommends initiating the flare earlier if there is a tailwind. This is because a tailwind will contribute to a higher ground speed with an associated increase in vertical speed to maintain the approach slope.

Initiating the flare earlier would have reduced the high vertical speed of the aircraft in the event described above.

Thrust Lever Management

The A320 FCTM explains that the flight crew can rapidly retard all thrust levers to IDLE either earlier or later than the 20 ft "RETARD" auto callout reminder depending on the conditions. However, the thrust levers should be at IDLE by touchdown to ensure that the ground spoilers will extend and keep the aircraft on the ground.

In step ② of the event, the PF pushed the thrust levers above the CLB detent during flare. This increased thrust and inhibited the ground spoiler extension during the initial touchdown, which contributed to the aircraft bounce.

Bounce Management

For a high bounce, as was the case in the incident described above, the FCTM recommends maintaining the aircraft's pitch attitude and performing a go-around.

The hard impact of the nose landing gear with the runway described in step ④ of the event was caused by extension of the ground spoilers when the thrust levers were retarded to IDLE during the bounce combined with a full forward stick input after the bounce.

Go-Around Close to the Ground

The FCTM recommends avoiding an excessive rotation rate during a go-around close to the ground and to counteract any pitch-up effect due to the thrust increase.

In step ⑤ of the event, it was the full back stick input combined with the nose landing gear bounce and thrust increase that contributed to the tail strike.

CASE STUDY 2: A321 NOSE LANDING GEAR LANDING

Event Description

The A321 performed an ILS approach in night conditions. The weather was fine and there was a 10 kt headwind.

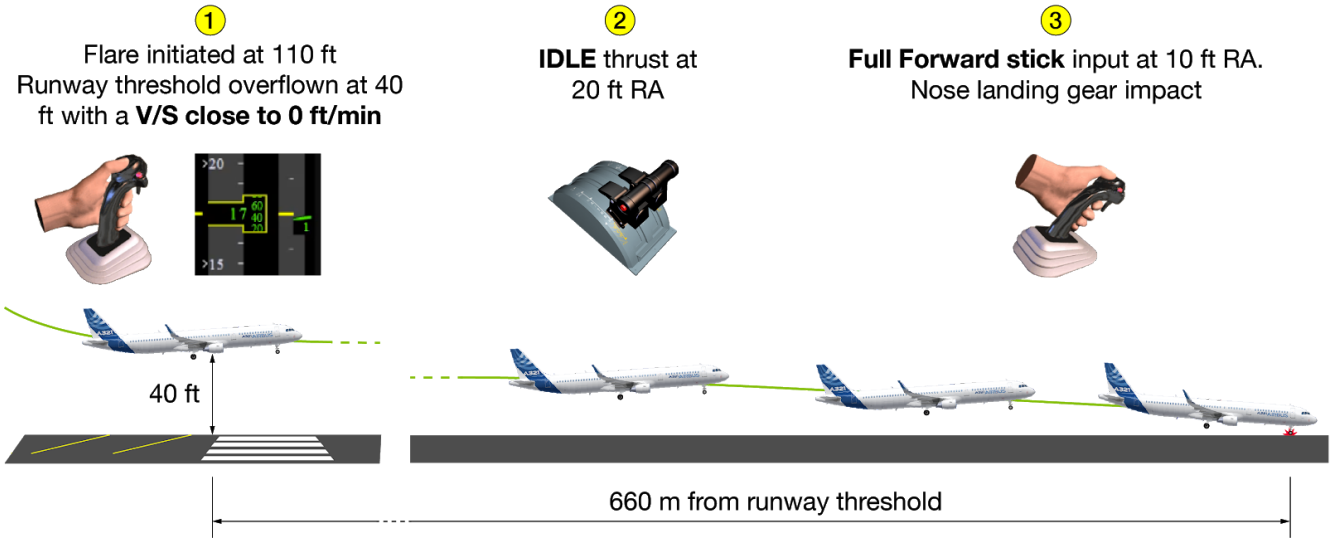
The flight crew switched OFF the autopilot at 940 ft RA and kept the FD ON. The autothrust was ON and the speed was stabilized at approach speed.

① From 110 ft RA to 50 ft RA, the PF applied several nose up inputs that increased the aircraft pitch attitude to 3.8° nose up. The autothrust commanded a thrust increase to maintain Vapp. The aircraft consequently flew over the runway threshold at around 40 ft RA with a vertical speed close to 0 ft/min.

② The PF applied several pitch up inputs that maintained the nose up pitch attitude and the aircraft subsequently floated above the runway for 4 seconds. At around 20 ft RA, the PF retarded the thrust levers progressively to IDLE.

③ 4 seconds later the aircraft was at around 10 ft and the PF applied a **full forward stick input**. The nose landing gear heavily impacted the runway 660 m after the runway threshold, followed by the main landing gear.

Both nose landing gear wheels separated due to the severe impact and the aircraft finally stopped on the runway centerline resting on its nose landing gear axle.



(fig.2) Sequence of events from case study 2

Operational Considerations

Flare Height

The FCOM recommends a flare manoeuvre at around 30ft for an A320 family aircraft in a stabilized condition.

The flare described in the case study 2 was initiated too early at 110 ft RA and autothrust was kept engaged. This Led to the aircraft crossing the runway threshold with a vertical speed close to 0 ft/min.

Thrust Lever Management

The autothrust is active and targets the approach speed or selected speed as long as thrust levers are not retarded to IDLE detent.

In this event, the aircraft descent rate was almost 0 ft/min at the runway threshold. The A/THR was still active (thrust levers remained in CLB detent) and targeting the approach speed. This led the aircraft to float above the runway for several seconds until the PF retarded the thrust levers.

Pitch Control

The FCTM states that the PF must avoid using nose down inputs once flare is initiated. The PF can release the back stick input slightly as required.

In step ③ of this event, the aircraft pitch down effect due to the full forward stick input, combined with the aircraft's descent rate, resulted in a heavy impact of the nose landing gear with the runway surface.

Go-Around Decision

The FCTM states that if a normal touchdown point cannot be reached, a go-around (or rejected landing) should be performed.

In this event, the appropriate action would have been for the PF to initiate a go-around when the aircraft was in a float condition above the runway.

RECIPE FOR A SAFE LANDING

The recommendations below summarize the procedures and techniques provided in the FCOM and FCTM.

Be stabilized

A safe flare can only be achieved when the aircraft is stabilized, meaning that all of the flight parameters areas expected, including:

- the aircraft is on its expected final flight path (lateral and vertical)
- speed is close to Vapp, and
- wings are level.

If the aircraft reaches the flare height at the correct speed and it is on the expected flight path, then a normal flare technique will lead to a safe landing.

PM must call out any flight parameter deviation

Careful monitoring of the flight parameters including speed, pitch, bank and vertical speed, enables the PM to raise the attention of the PF to any deviation during the final approach. This will enable the PF to respond accordingly and initiate a go-around, if required.

Refer to the FCOM SOP for Approach for more information about the PM callout related to the flight parameter deviation threshold.

Flare at the right time

Flare should be initiated at around **30 ft RA (A220/A300/A310/A320) / 40 ft (A330/A340/A350/A380)** in stabilized conditions.

Factors that may require an earlier initiation of the flare:

- Steeper approach slope (more than the nominal 3°)
- Increasing runway slope or rising terrain before the runway threshold
- Tailwind
- High airport elevation.

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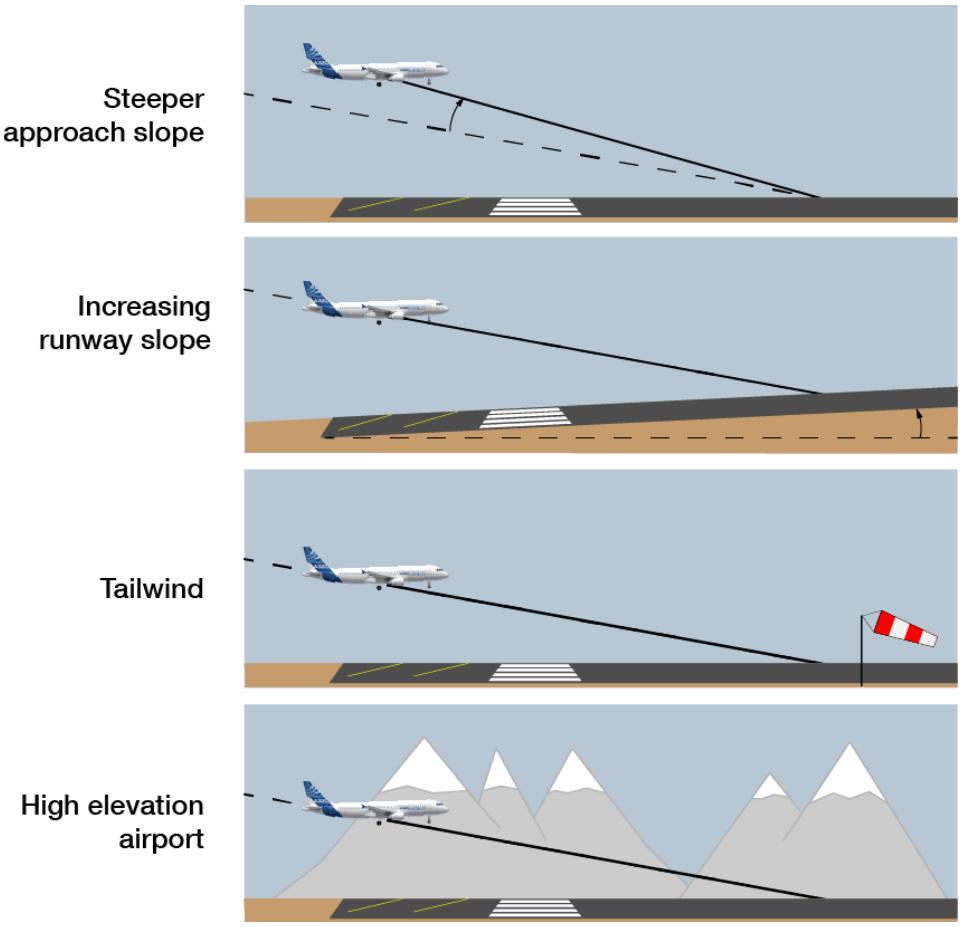


(fig.3) Factors that may require an earlier flare

Flare correctly

On Airbus fly-by-wire aircraft

The PF should apply a progressive and gentle back stick order until touchdown.

The PF must avoid forward stick inputs once flare is initiated. The PF can gradually release the back stick input if needed. The PF must perform a go-around If a normal touchdown point cannot be reached.

Any forward stick input after flare is initiated will increase the risk of landing on NLG with hard impact.

"The PF must avoid forward stick inputs once flare is initiated."

Flare using a **progressive** back stick order

Once flare is initiated:
No forward stick input !
Release back stick pressure if needed

(fig.4) Flare technique on Airbus fly-by-wire aircraft

On A300/A310 aircraft:

The PF must start the flare with a positive and prompt back pressure on the control column to break the descent rate. The PF must then maintain a constant and positive back input on the control column until touchdown.

Retard!

A320/A330/A340/A350/A380 aircraft

The 20 ft "RETARD" auto callout is a reminder, not an order. The PF can retard the thrust levers earlier or later depending on the conditions.

The PF must ensure that the thrust levers are at idle in any case, by touchdown at the latest, to enable automatic extension of the ground spoilers.

Delaying the retard of the thrust levers may increase the landing distance because the autothrust will target Vapp or the selected speed until it is disconnected by moving the levers to the IDLE detent.

A220 aircraft

The A220 is different from the rest of the Airbus family, because when the thrust levers are engaged, they continuously respond to autothrust commands. The A220 does not have any callout for retard. The Flight Mode Annunciator displays the status of the autothrust (when it is armed and active) at the top of the PFD or the HUD. When the autothrust RETARD function is activated, it will automatically reduce the thrust levers to idle. When the autothrust RETARD function is armed, it will be activated at 30 ft AGL(except in the case of an autoland, when it will be activated between 20 and 15 ft AGL depending on the condition).

If the autothrust is not armed or if the autothrust RETARD function is not activated, the flight crew manually retards the thrust levers to idle at 30 ft AGL.

Note that the A220 ground spoiler is activated if the thrust levers are at or near the idle position.

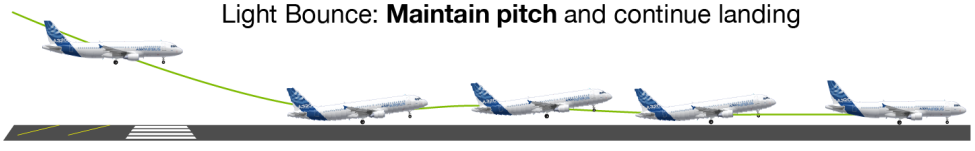
A300/A310 aircraft

If autothrust is engaged, the PF monitors throttle reduction to idle at 30 ft. If the thrust is controlled manually, the PF retards throttles progressively to idle at 20-30 ft. The PF should hold a positive back pressure input on the control column to counter the nose-down pitching moment as the thrust is reduced.

"The PF must ensure that the thrust levers are at idle in any case, by touchdown at the latest, to enable automatic extension of the ground spoilers.

Maintain the aircraft pitch in the case of a bounce

The FCTM recommends to maintain the pitch attitude in the case of a light bounce at landing. The aircraft will make a second lighter touchdown and the landing roll can continue.



(fig.5) Management of a light bounce

The FCTM recommends to maintain the pitch attitude and initiate a go-around in the case of a high bounce . Maintaining the pitch attitude, and counteracting any pitch-up tendency due to the thrust increase, enables the flight crew to avoid a tail strike and ensure a softer secondary touchdown should this occur.

High Bounce: **Maintain pitch**, apply **go-around thrust** and **counteract any pitch-up tendancy** due to thrust increase to avoid tailstrike until safely established in the go-around.

(fig.6) Management of a high bounce

Be go-around minded

The PF must perform a go-around if any parameter deviation becomes excessive, or if the aircraft is destabilized just prior to the flare.

If the aircraft floats above the runway, the flight crew must initiate a go-around instead of attempting to recover the situation.

The PF can abort the landing and go-around at any time until the thrust reversers are selected. However, when the reversers are selected, the landing must be continued.

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Avoid excessive rotation rate in a go-around close to the ground

When the flight crew initiates a go-around close to the ground, they must avoid an excessive rotation rate to limit the risk of tail strike.

The flight crew must wait until the aircraft is safely established in the go-around before retracting the flaps by one step and the landing gear.

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The landing phase is very demanding and it requires good coordination between the flight crew. The FCOM procedure and FCTM provide the recommended techniques that must be carefully followed to ensure a safe landing.

The Pilot Flying must ensure that the aircraft is established on the expected final approach path at the approach speed. They will apply progressive back stick input at the correct height, which has been determined depending on external parameters. Any forward stick inputs must be avoided once flare is initiated. The thrust levers must be retarded to IDLE, by touchdown at the latest, for the ground spoilers to deploy.

In the case of a bounce at touchdown, the PF must maintain the pitch attitude and decide to either continue the landing if the bounce was light, or to go-around if it is a high bounce. In the case of a high bounce, the PF must not attempt to land the aircraft by applying nose down input on the sidestick.

The PM also plays an essential role throughout the entire landing sequence.The PM is expected to call out any deviation of the flight parameter to the PF, which will ensure that the PF can react accordingly or initiate a go-around if the deviation cannot be corrected in a timely manner. Avoiding an excessive rotation rate of the aircraft for a go-around initiated close to the ground will prevent a tail strike.

The PF must be prepared for a go-around, and initiate a go-around in the case of late destabilization or if the aircraft floats above the runway. A go-around can be initiated at any time during flare or landing roll until thrust reversers are selected. However when the reversers are selected, the landing must be continued.

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