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A320 Family/ Evolution of ground spoiler logic

1. Introduction

Ground spoilers reduce the lift produced by the wings and hence transfer the weight of the aircraft to the landing gear, allowing a more effective wheel braking action.

Their non or untimely extension has been a factor in the following types of A320 Family events:

► The absence of spoiler extension contributed to increase the stopping distance during landing.

► The untimely spoiler extension contributed to a number of hard landings.

In both cases, the cause could be traced back to non arming of the ground spoilers and/or inappropriate thrust levers positions during the flare.

To reduce the frequency of these events, Airbus has modified the spoiler extension logic.

The new logic is now tolerant to inappropriate speed brake and/or thrust levers positions.

This modification applies to the complete as well as to the partial ground spoiler extension.

It was achieved by creating a new standard of Spoiler Elevator Computer (SEC), which is in charge of spoiler control, the SEC standard 120.

This article will describe:

► The current ground spoiler extension conditions.

► The identified causes of runway excursion and hard landings.

► How the new SEC standard will reduce the number of these occurrences.

2. Current ground spoiler extension conditions

2.1. Full extension

Depending on whether the ground spoilers have been armed or not, the following conditions must be met for their full automatic extension (as outlined in FCOM 1.27.10 p12):

► Ground spoilers armed (fig. 1)
- Both main landing gears seen on ground.
- Both thrust levers at or below Idle notch (fig. 2).

Figure 1

Figure 2

► Ground spoilers not armed (fig. 3)
  • Both main landing gears seen on ground.
  • Reverse is selected on at least one engine (the other thrust lever must be at or below Idle notch, fig. 4).

2.2 Partial extension

The Phased Lift Dumping function allows the ground spoilers to deploy with a reduced deflection and serves to accelerate the full spoiler extension when landing in crosswind conditions or on contaminated runways.

The necessary conditions to trigger the partial ground spoiler extension, independently of the position of the ground spoiler lever are:
► One main landing gear seen on ground.
► Reverse is selected on at least one engine (the other thrust lever must be at or below Idle notch).

3. In-service events

The genesis of this flight control computer modification is coming from two types of events:

3.1. Longitudinal runway excursion

Runway excursions resulted from the spoilers not extending during the landing.

This was traced to the following two causes:
► The speed brake lever was in a non retracted position (fig. 5).
► One engine throttle was not in the area that authorized ground spoiler extension (fig. 6).

3.2. Hard landings

Among hard landings, one specific category has been identified where by the hard landing occurred after a bounce. They fit to the following scenario (fig. 7):

► ❶ No engine throttle reduction (retard) during the flare → No ground spoiler extension.

► ❷ Bounce induced by a too high energy level and by the lack of lift destruction.

► ❸ Engine throttle reduction performed during the bounce → Ground spoiler extension if the retard is performed within 3 seconds following the first touchdown.

► ❹ Severe hard landing due to sudden loss of lift leading to a fall from a height of about 5ft to 15 ft.

It has been established that most of the hard landings occurring after a bounce are severe.

Figure 3

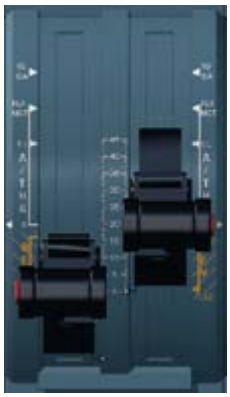


Figure 4

Full ground spoiler extention

Figure 5
The ground spoilers were not armed

Figure 6
The spoilers could not extend

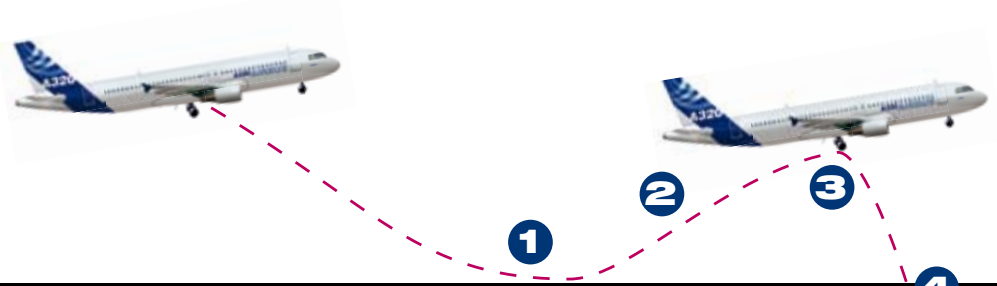


Figure 7

Figure 8
Expanded ground spoiler arming condition based on more tolerant speed brake lever position.

4. Expanded ground spoiler extension conditions

4.1. General philosophy

The Airbus philosophy regarding the ground spoiler activation logic is still based on the achievement of the following three conditions:

- Arming
- Ground detection
- Thrust lever position

The arming and thrust lever position conditions have been expanded to be more tolerant to inappropriate speed brake and thrust lever positions.

The ground detection condition has been expanded as well, albeit only for the partial ground spoiler extension, to address failures of ground detection sensors.

4.2. Changes introduced to limit runway excursions

The changes introduced by the new SEC 120 standard are highlighted in bold.

Complete ground spoiler extension conditions

- Ground spoilers armed or **speed brake lever in non retracted position** (fig. 8).
  - Both main landing gears seen on ground.
  - Both thrust levers at or below Idle notch **or Reverse is selected on at least one engine (the other thrust lever must be below the Maximum Continuous - MCT- notch)**.
- Ground spoilers not armed (fig. 9)
  - Both main landing gears seen on ground.
  - Reverse is selected on at least one engine (**the other thrust lever must be below the Maximum Continuous - MCT - notch,** fig. 10).

Partial ground spoiler extension conditions

The partial ground spoiler extension conditions have been expanded to mirror the full spoiler extension conditions.

- Ground spoilers armed or **speed brake lever in non retracted position**
  - One main landing gear seen on ground.
  - **Both thrust levers at or below Idle notch**.
- Ground spoilers not armed
  - One main landing gear seen on ground.
  - Reverse is selected on at least one engine (**the other thrust lever must be below the Maximum Continuous - MCT - notch**).

note

All combinations that would trigger the full ground spoiler extension hide the partial ground spoiler extension.

4.3. Changes introduced to limit bounces at landing

A new spoiler extension logic is proposed on the SEC 120 to minimize the magnitude of the bounce in the event of an inappropriate thrust lever position during the flare.

Figure 9

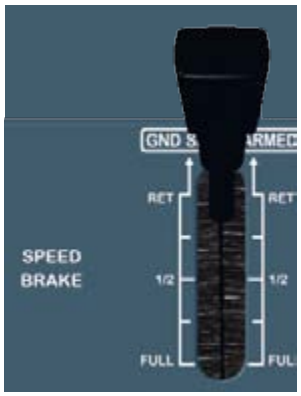
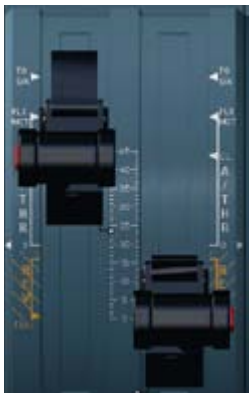


Figure 10
Expanded ground spoiler extension condition based on more tolerant thrust lever position



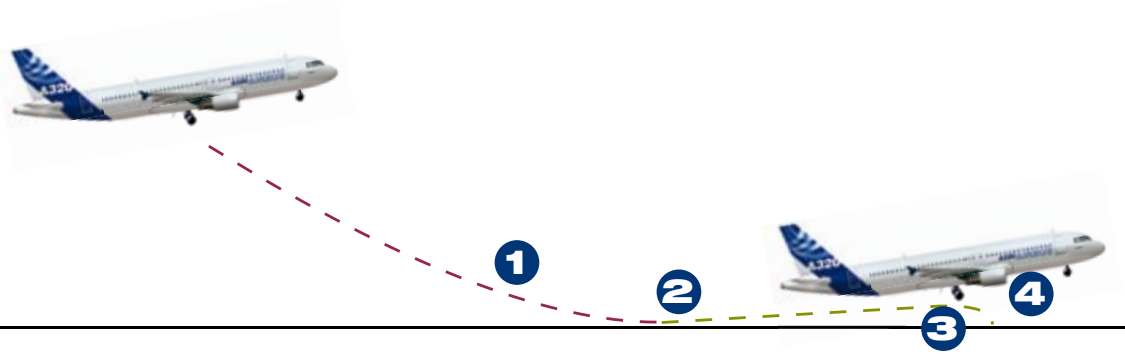


Figure 11

This logic provides some lift destruction through the partial extension of ground spoilers as soon as ground conditions are detected on both landing gears, as long as both thrust levers are at or below the Climb notch (ATHR).

New ground spoiler partial extension conditions:

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

Landing scenario with SEC 120 (fig. 11):

- ❶ No engine throttle reduction (retard) during the flare → No ground spoiler extension.
- ❷ 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.
- ❸ 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).
- ❹ As the height of the bounce is significantly reduced, the vertical speed at the second touchdown is largely reduced as well.

5. Conclusion

Runway excursion and hard landing events have prompted Airbus to develop a new standard of Spoiler Elevator Computer, the SEC 120.

Expansion of the ground spoiler extension conditions means that the spoilers will extend even when the speed brake and/or thrust levers are in inappropriate positions, thereby improving the aircraft's deceleration on ground.

In addition, a new ground spoiler partial extension logic has been developed to limit bounces that may lead to hard landings.

To summarize, the SEC standard 120 provides means to reduce:

- **Runway excursions by enabling:**
  - **Arming of the ground spoilers even when the speed brake lever is not retracted.**
  - **Extension of the ground spoilers even with a thrust lever above the Idle position.**
- **Hard landings by minimizing:**
  - **The number and amplitude of bounces by triggering partial spoiler extension at touchdown even with both thrust levers in the ATHR position.**

Computer hardware	Modification number	Service Bulletin number
B	150471	27-1198
B'	150857	27-1201

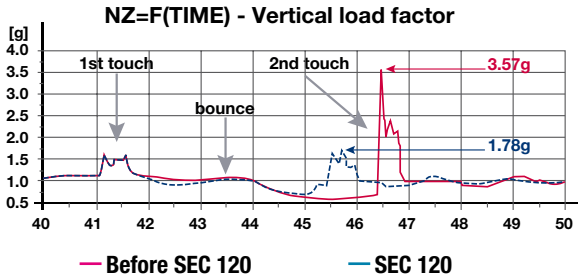
The SEC 120 will become production standard on A320 Family from MSN 4472 on.

Annexe

Hard landing effect following bounce is reduced by 50%.

The modification proposed to reduce bounce occurrences at landing has been validated using a back to back approach.
A dozen of major hard landing occurrences following a bounce have been simulated with Airbus flight dynamics simulations tools with and without the partial ground spoiler extension at touchdown.
Without the partial spoiler extension at the first touchdown, the average vertical load factor at the second touchdown is about 3.2g.
With the SEC 120 modification allowing partial ground spoiler extension on ground even with thrust levers on Climb (ATHR) notch, the average load factor at the second touchdown is reduced to about 1.7g.

Example of typical hard landing event



Hard landings statistical breakdown

A statistical analysis has revealed that a significant bounce (Nz>1.6g) occurs in about 50% of the hard landing events.
In about half of those cases (i.e. 25% of all hard landings), the second impact is harder than the first one.
More globally, the ground spoiler extension during a bounce has been identified as the root cause of the hard landing in 15% to 20% of the cases.
Moreover, those events also represent 40% of the cases with costly issues (aircraft grounded, structural damages, landing gear changes …).

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