BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

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SAFETY INVESTIGATION REPORT

Incident to the Embraer ERJ170 registered F-HBXI operated by HOP! on Saturday 11 May 2024 on Toulouse – Blagnac airport

Time	Around 13:20[1]
Type of flight	Chartered passenger commercial air transport
Persons on board	Captain (PM then PF[2]), co-pilot[3] (PF then PM), 2 cabin crew, 52 passengers
Consequences and damage	Aeroplane slightly damaged
This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.	

Landing with left landing gear not locked indication

1 HISTORY OF THE FLIGHT

Note: the following information is principally based on the CVR and FDR, statements, radio-communication recordings and radar data.

The crew took off from Paris - Charles de Gaulle at 12:15 bound for Toulouse – Blagnac. At 13:11, when the aeroplane was established on the ILS of runway 14R, at around 2,500 ft[4], with the flaps configured to "flaps 3", the PM put the landing gear control lever in the DOWN position (see **Figure 1**, point 1). The LH main landing gear transit light stayed illuminated and would remain illuminated until the end of the flight. The "LANDING GEAR" aural warning was activated (point 2), followed by the EICAS message LG LEVER DISAG. The captain informed the PF that he was going to carry out a landing gear retraction and extension sequence (point 3) and indicated that they would carry out a go-around if this failed. As the LH main landing gear would still not lock, the crew carried out a missed approach (point 4), set the landing gear control to the UP position and retracted the flaps.

At 13:13, climbing through 3,000 ft, the captain allocated the roles: the co-pilot was to remain PF and was also to take charge of communications while the captain took charge of processing the fault.

[1] Except where otherwise indicated, the times in this report are in Coordinated Universal Time (UTC). Two hours should be added to obtain the legal time applicable in Metropolitan France on the day of the event.
[2] The glossary of abbreviations and acronyms frequently used by the BEA can be found on its web site.
[3] At Hop!, a co-pilot is designated by the term First Officer (FO).
[4] The altimetric values are given with the QNH correction.

At around 13:14, after carrying out the after take-off checklist and reaching 4,000 ft, the PM started the **LG LEVER DISAG** emergency procedure (point 5). In the conditions of the incident, complying with the **LG LEVER DISAG** procedure led to the **ABNORMAL LANDING GEAR EXTENSION** procedure being carried out which and this procedure led to the **PARTIAL OR GEAR UP LANDING** procedure.

While following this procedure, the captain informed the cabin crew of the situation. In the meantime, the PF informed the controller and explained that assistance would be necessary on their arrival. The controller offered to observe the landing gear with binoculars. The PM then continued the **PARTIAL OR GEAR UP LANDING** procedure, informing the PF of the actions to be carried out for landing and in the event of a go-round. The crew agreed that the captain would become PF for the final approach.

At 13:18, the controller left the crew the choice of short or long radar vectoring. The co-pilot replied that he preferred long vectoring (point 6) and warned that there was a risk of the runway being blocked after landing.

The crew prepared themselves for a new ILS approach to 14R. At 13:21, the crew were cleared for the ILS approach to 14R (point 7).

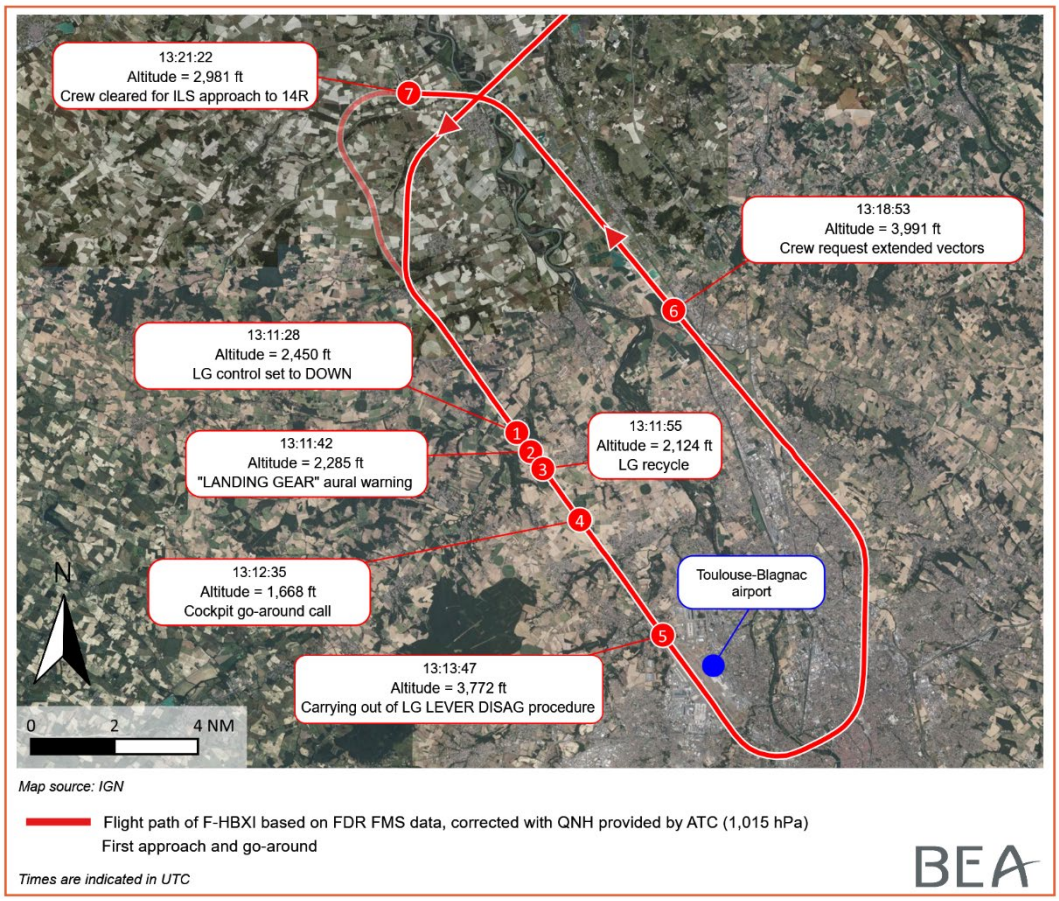


Figure 1: flight path of F-HBXI: first approach and go-around

At 13:22, the captain became PF and the co-pilot, PM. The controller asked the crew if they wanted to carry out a low pass so that he could observe the landing gear from the control tower. The crew decided to continue the approach without carrying out a low pass, asking the controller to observe the position of the landing gear.

At 13:23, in level flight at an altitude of 3,000 ft and a speed of 160 kt, the PM reported that they were established on the LOC for runway 14R. The crew were cleared to land. They progressively extended the slats and flaps to the "FULL" position and selected a speed of 125 kt. The *LANDING GEAR* aural warning was activated on selecting the FLAPS 5 position[5]. It would remain active until after landing.

At 13:25, the PF informed the PM that he was going to aim slightly to the RH side of the runway centreline in case the aeroplane veered to the left after wheel touchdown.

At 13:26:49, at 1,500 ft, the PF deactivated the autopilot. Around ten seconds later, the aeroplane descended through 1,400 ft, the controller reported that he could see the two main landing gear extended.

At 13:28:39, the wheels touched down on the runway. During the deceleration, the PM informed the controller that they were going to continue taxiing so as not to block the runway as everything appeared to be normal from the cockpit. The controller replied that the next inbound was on parallel runway 14L and that the aeroplane could be stopped on the runway. The crew stopped the aeroplane to have it inspected on the runway. Engine 1 was shut down so that the firefighters could approach the left landing gear. They informed the captain that they could not see any anomaly, no fire, no leak. The crew reported to the controller that they could resume taxiing. After starting up engine 1 again, the PF was unable to steer the aeroplane[6]. The crew switched on the APU and shut down both engines.

At 13:48, a mechanic from the flight line team informed the crew of a mechanical rupture on the left main landing gear. Its locking-stay was found out of its position.

All the occupants disembarked via stairs at around 14:40 without any other incident. The aeroplane remained immobilized on the runway until the next day.

2 ADDITIONAL INFORMATION

2.1 Meteorological information

The 13:30 automatic METAR indicated a south-easterly wind of 10 kt, CAVOK, temperature 27°C and QNH 1,015 hPa.

2.2 Airport information

Toulouse– Blagnac airport has two parallel runways oriented 14/32, offset by 1,150 m at threshold 14. Runway 14R/32L measures 3,503 m x 45. Runway 14L/32R measures 3,025 m x 45.

[5] The ERJ170 has seven slat and flap positions, from 0 to 5, and then FULL.

[6] The manual extension of the landing gear carried out while complying with the **ABNORMAL LANDING GEAR EXTENSION** procedure deactivated the nose gear steering function.

2.3 Aircraft information

2.3.1 Examination of left main landing gear

The visual examination found that:

- the torque link actuating the left main landing gear was not aligned (see **Figure 2** and **Figure 3**)
- the locking-stay had separated from the landing gear shock strut (see **Figure 4** and **Figure 5**).

The bolts designed to connect the locking-stay bracket to the landing gear shock strut were found broken or incomplete (see paragraph 2.3.2).

Figure 2: left main landing gear of F-HBXI after landing, view looking aftwards (source: BEA)

Figure 3: left main landing gear in normal position, view looking aftwards (source: BEA)

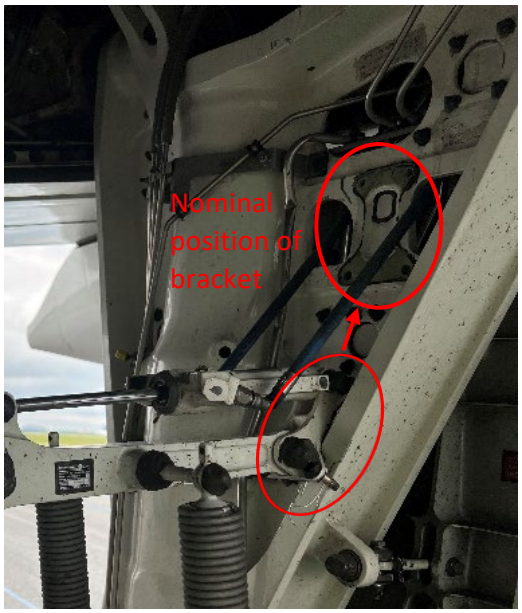


Figure 4: bracket separated from landing gear shock strut (source: BEA)

Figure 5: bracket attaching bolts found damaged (source: BEA)

The bracket of the locking-stay was no longer attached to the landing gear and had moved resulting in the misalignment of the landing gear position sensors (see **Figure 6**). This misalignment explains why the aeroplane did not detect the landing gear locked position.

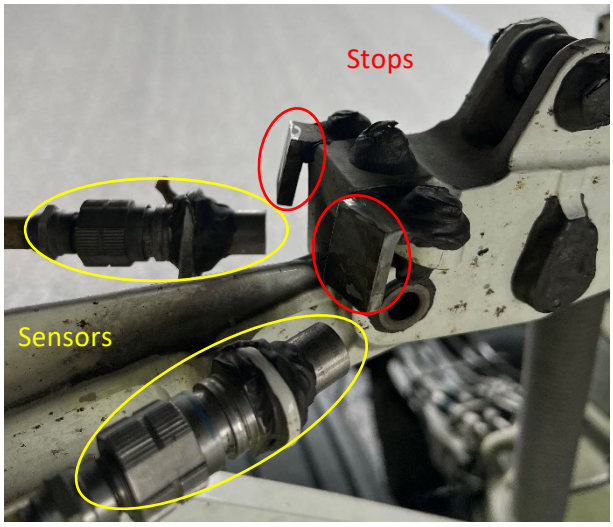


Figure 6: misaligned position sensor (source: BEA)

Some additional minor damage was observed on the left main landing gear. The bracket and attaching bolts were removed for examination.

2.3.2 Examination of bolts of locking-stay bracket

The landing gear system is designed and manufactured by Liebherr. The locking-stay bracket is normally attached to the landing gear shock strut by four bolt assemblies consisting of the screw itself, a nut, a washer and a cotter pin (see **Figure 7**).

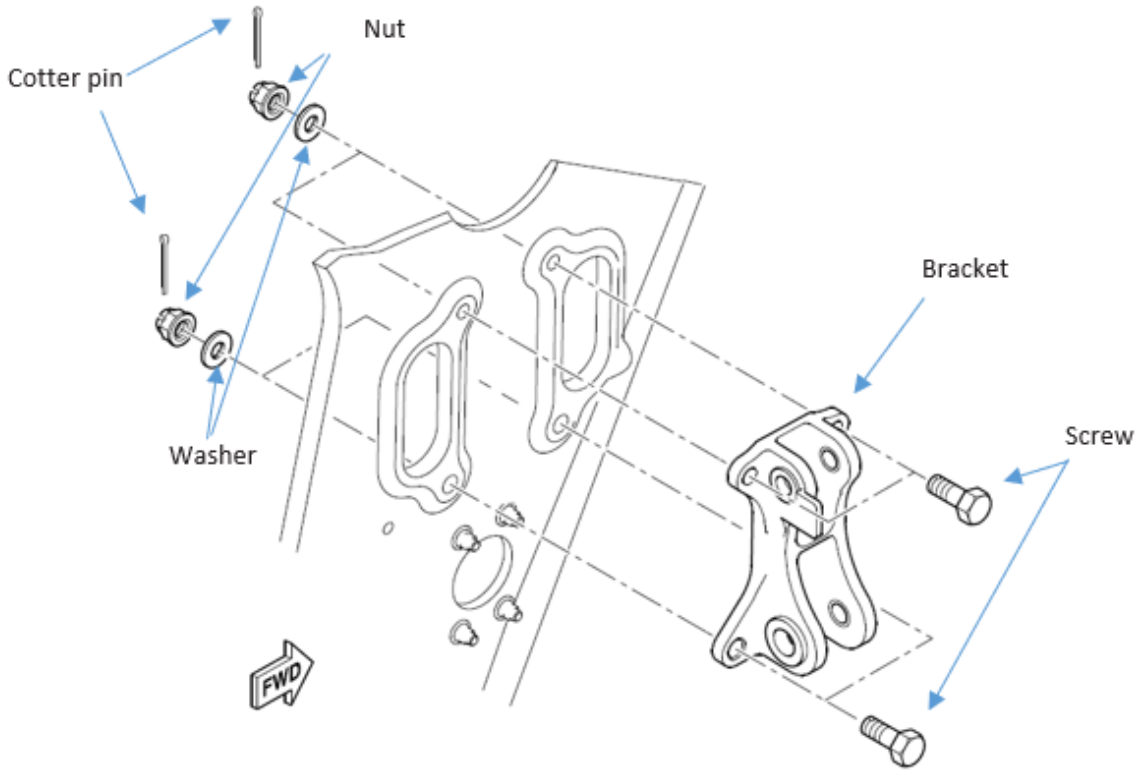


Figure 7: assembly of locking-stay bracket (source: Embraer, annotations BEA)

After the incident, the bracket was found separated from the landing gear shock strut. The four attaching bolts were found in the following condition:

- rear top position (see **Figure 8**): the screw was broken without deformation; all the components were recovered;
- forward top position (see **Figure 9**): the screw was broken and bent, the washer was missing;
- rear bottom position (see **Figure 10** and **Figure 11**): the screw was in good condition, the washer and nut were missing, a fragment of the cotter pin was still in place in the screw. Some metal debris was caught in the screw threads;
- forward bottom position: the screw was in good condition, the washer and nut were missing, a fragment of the cotter pin was still in place in the screw. Some metal debris was caught in the screw threads.

Black sealant was present on all the screw heads and on the remaining nuts. Traces of sealant were visible in the screw threads where the nuts were missing. A green-coloured product was observed in some of the threads of the bottom screws. The fragments of the cotter pins still in place showed signs of shearing.

Figure 8: bolt in rear top position (source: BEA)

Figure 9: bolt in forward top position (source: BEA)

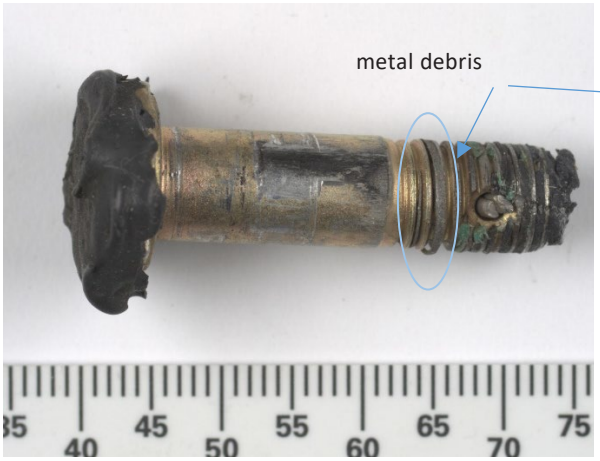


Figure 10: screw in rear bottom position (source: BEA)

Figure 11: screw in rear bottom position - detail view (source: BEA)

A scanning electron microscope (SEM) examination was performed on the fracture surface of the screw in the rear top position. The presence of micro-striations was brought to light, characteristic of a fatigue cracking process under repeated tensile loads. There were multiple incipient cracks on the surface of the screw shank, as evidenced by the presence of radial lines. The material conformed to the expected grade for this type of screw.

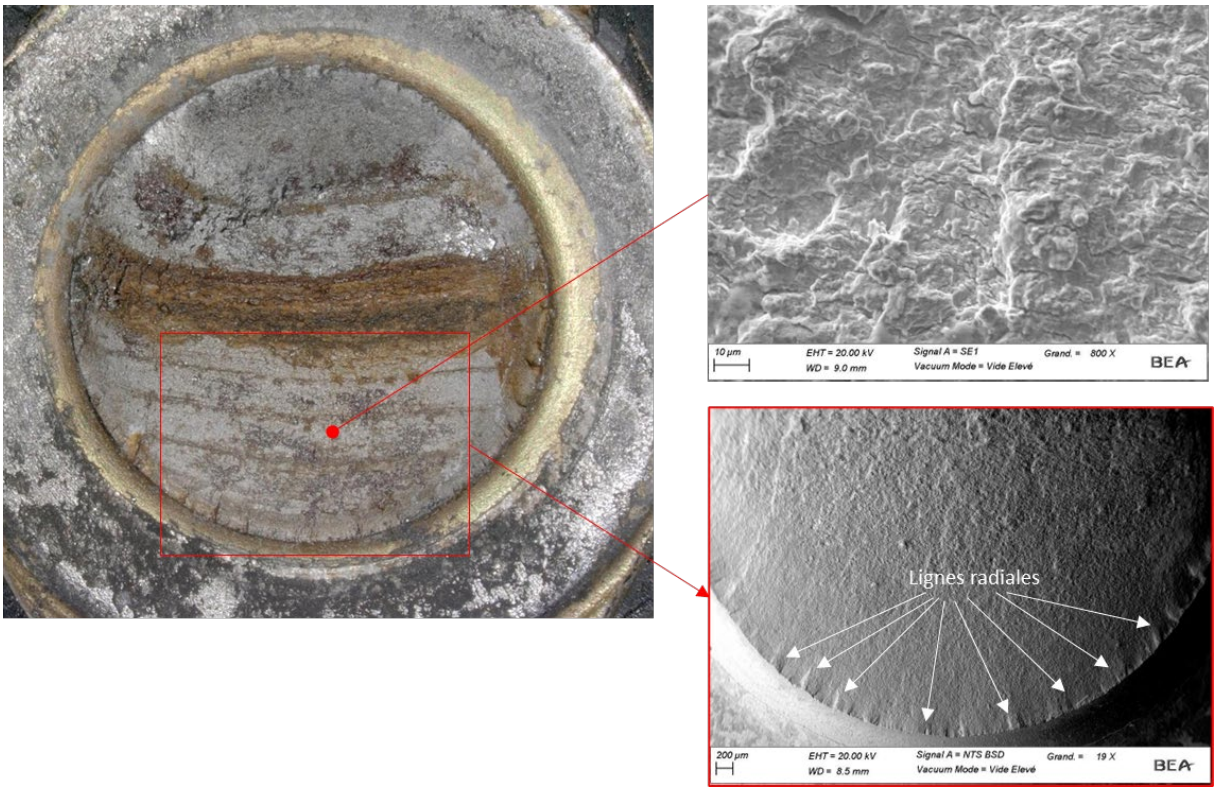


Figure 12: SEM view of fracture surface of screw in rear top position (source: BEA)

The screw in the forward top position exhibited the characteristics of a sudden failure, due to bending overload. The nuts in the top position were type MS14145.

For each of the two screws in the bottom position, the presence of metal debris in one thread, a fragment of a cotter pin in the screw bore, and green product in several threads indicate that MS17826 nuts were installed on these screws.

The maximum tightening torque that can be borne by this type of nut is 8 Nm. The tightening torque indicated in Liebherr's documentation was 22 to 25 Nm.

Figure 13: authorized retaining nuts in Liebherr documentation (pre SB 170-32-0089) (source: BEA)

It is very likely that the nuts of the two bottom bolts, being incorrectly sized, were damaged when torqued during their installation and subsequently tore off[7]. The forward bolt located in the top position then gradually cracked due to fatigue, until eventually breaking. As the bracket was then only held by the rear bolt, the latter suddenly broke due to overloading.

However, it is not possible to precisely date the failure process during the flights preceding the occurrence flight. Furthermore, this damage was difficult to detect during walk-around inspections or daily maintenance checks, as the nuts were not directly visible.

2.3.3 History of nut specification changes

In 2005, nut type MS17826 was introduced into Embraer's technical documentation as an alternative to type MS14145 to facilitate assembly of the bracket in the workshop.

2.3.4 Description of cockpit circuit breaker side panels

The circuit breakers that flight crew members must be able to access are located on the left and right cockpit consoles. The captain has access to the left circuit breaker panel and the co-pilot to the right panel.

It is not possible for each pilot, from their seat, to see the other pilot's actions on the circuit breakers, as they are located on the opposite panel.

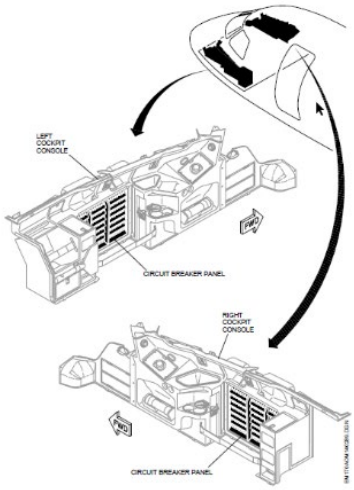


Figure 14: position of circuit breaker panels (source: Embraer)

2.4 Crew information

Captain

The 63-year-old captain held an ATPL(A) obtained in 1990. He held the IR/ME and EMB170 type ratings. On the day of the incident, he had logged 17,892 flight hours, including around 14,000 hours as captain. He had totalled around 6,000 flight hours on the EMB170, all as captain. He had flown around 130 hours in the 3 months prior to the occurrence, including approximately 57 hours in the previous 30 days.

[7] Cotter pins are designed to prevent the nut from loosening. They do not hold the assembly in the event of damage to the nut.

Co-pilot

The 36-year-old co-pilot held an ATPL(A) obtained in 2017. He held the IR/ME along with the A320 and EMB170 type ratings. On the day of the incident, he had flown 2,725 flight hours, including 108 hours on the EMB170. He had flown around 108 hours in the previous 3 months, including approximately 41 hours in the previous 30 days. He had been approved for line operations around a month and a half before the occurrence.

2.5 Processing faults encountered in flight

2.5.1 *Airplane Operations Manual* (AOM)

The LG LEVER DISAG warning light appears when one or more of the landing gear indications differ from the position of the landing gear control lever. The various procedures to be referred to in response to the landing gear extension problem encountered by the crew do not include memory items.

The associated emergency procedure, LG LEVER DISAG requires the crew to recycle the landing gear. If the warning light is still illuminated during gear extension, the **ABNORMAL LANDING GEAR EXTENSION** procedure must be performed.

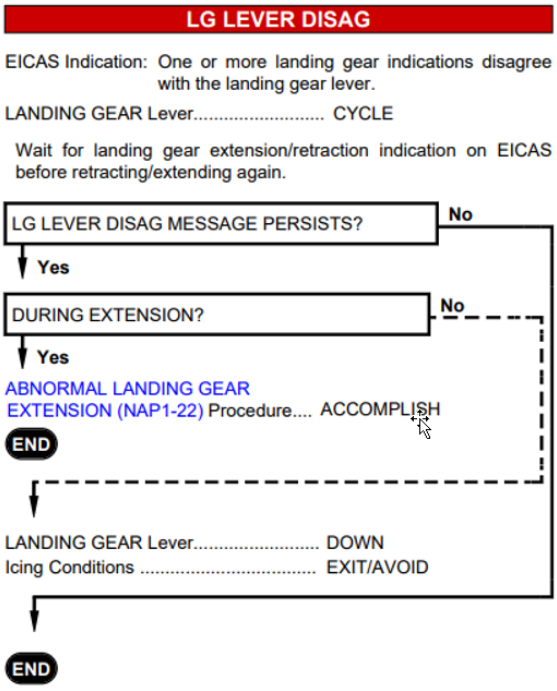


Figure 15: LG LEVER DISAG emergency procedure (source: Embraer)

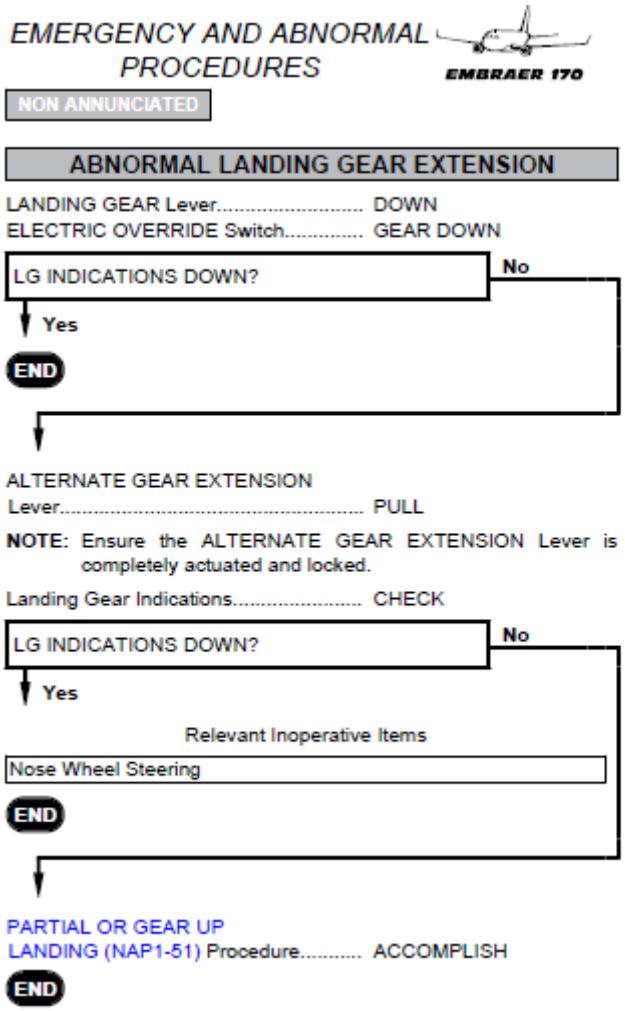


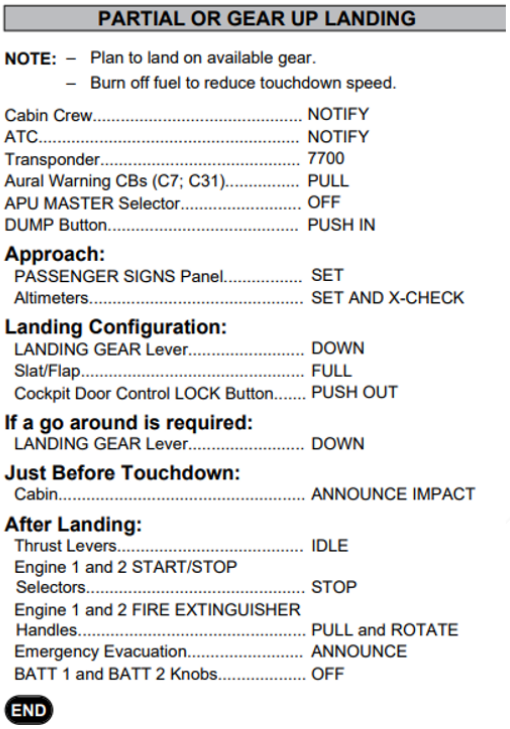
*Figure 16: **ABNORMAL LANDING GEAR EXTENSION** procedure (source: Embraer)*

This procedure requires the crew to use the electric override switch and then the alternate gear extension lever. After using this control, the nose wheel steering system becomes inoperative. If the lights still do not indicate that the gear is extended and locked, the **PARTIAL OR GEAR UP LANDING** procedure must be performed.

The purpose of this third procedure is to prepare for landing with the landing gear retracted or partially extended. It requires the crew to inform the cabin crew and air traffic control. The procedure also requires the crew to pull the two Aural Warning circuit breakers C7 and C31, located on the left and right sides of the cockpit, respectively, to inhibit the aural warnings. These circuit breakers are labelled "AURAL 1" and "AURAL 2" respectively. In this procedure, this action inhibits the "LANDING GEAR" aural warning, which remains activated as long as the following two conditions are met:

- one of the three landing gears is not detected in the "down and locked" position,
- and the system detects an intention to land[8].

[8] The flap control is in position 5 or FULL, or the height of the aeroplane is less than 700 ft above ground level and the thrust lever position is less than 45° for two operational engines.



PARTIAL OR GEAR UP LANDING

NOTE: – Plan to land on available gear.
– Burn off fuel to reduce touchdown speed.

Cabin Crew..... NOTIFY
ATC..... NOTIFY
Transponder..... 7700
Aural Warning CBs (C7; C31)..... PULL
APU MASTER Selector..... OFF
DUMP Button..... PUSH IN

Approach:
PASSENGER SIGNS Panel..... SET
Altimeters..... SET AND X-CHECK

Landing Configuration:
LANDING GEAR Lever..... DOWN
Slat/Flap..... FULL
Cockpit Door Control LOCK Button..... PUSH OUT

If a go around is required:
LANDING GEAR Lever..... DOWN

Just Before Touchdown:
Cabin..... ANNOUNCE IMPACT

After Landing:
Thrust Levers..... IDLE
Engine 1 and 2 START/STOP Selectors..... STOP
Engine 1 and 2 FIRE EXTINGUISHER Handles..... PULL and ROTATE
Emergency Evacuation..... ANNOUNCE
BATT 1 and BATT 2 Knobs..... OFF

END

*Figure 17: **PARTIAL OR GEAR UP LANDING** procedure (source: Embraer)*

Compliance with the procedure implies the crew has to stop the aeroplane on the runway. It does not specify taxiing before the emergency evacuation.

2.5.2 Hop! Operating Manual (OM)

According to part A of the OM, paragraph OPS 8.3.3.1, the various checklists had to be carried out in the following order, according to their category:

1. Emergency
2. Normal
3. Abnormal

The fault analysis method set out in the OM is based on the A.B.C.D.I mnemonic. The first step is to indicate the nature of the fault (analysis), then to conduct a system review using the system pages or system panels, and finally to assess the operational, technical and commercial consequences. At the time of the incident, the OM specified that the captain decided, in agreement with the co-pilot, on the course of action to be taken in terms of diversion. The flight crew must then inform air traffic control, the cabin crew and the airline's operations department.

During the "information" part, the captain must conduct a NITS briefing with the purser. The N.I.T.S is a mnemonic which stands for Nature, Intention, Time, Special instructions. The purpose is to inform the cabin crew about the nature of the problem and its potential consequences, the flight crew's intentions, the time for preparing the cabin, and finally, anything that deviates from a standard procedure.

2.6 Crew activity

2.6.1 Processing landing gear fault

When the landing gear problem was detected during the first approach, the captain retracted and then extended the landing gear (recycle) without first consulting the procedure associated with the fault. This action was performed mechanically.

When the approach was aborted, the crew retracted the landing gear. Once the after take-off checklist was completed, the crew began the **LG LEVER DISAG** procedure, which led them to recycle the landing gear again. Since this was unsuccessful, the procedure required them to proceed to the **ABNORMAL LANDING GEAR EXTENSION** procedure. As part of this procedure, since the landing gear was not locked after the alternate gear extension, the crew proceeded, as indicated in the procedure, to the **PARTIAL OR GEAR UP LANDING** procedure.

They then continued with the action on the warning circuit breakers. The captain pulled circuit breaker C7, located on his side, on the left side panel, and then asked the co-pilot to pull C31, the *aural warning circuit breaker*, located on the right side panel. The co-pilot called out that he was pulling the *master warning caution two alert*. The captain acknowledged this erroneous action. The circuit breaker identified by this name is C32, positioned to the right of C31 (see **Figure 18**). This circuit breaker deactivates the warning and alert light on the co-pilot's side.

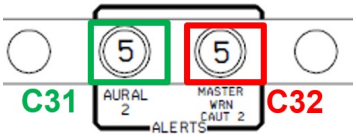


Figure 18: circuit breakers C31 and C32 on the right panel (source: Embraer)

The confusion in circuit breakers (C32 pulled instead of C31) meant that the "*LANDING GEAR*" voice message, emitted every second, was not inhibited.

The voice message emission began when the flaps were set to position 5, although the breaker error was made when the **PARTIAL OR GEAR UP LANDING** procedure was complied with a few minutes earlier. It was therefore difficult to associate this continuous warning with an error committed while complying with this procedure. This warning remained in the background until 13:44, sixteen minutes after landing.

The pilots discussed the discomfort caused by this continuous warning several times. The fault analysis method set out in the OM (A.B.C.D.I) was not followed point by point. The pilots did, however, mention several operational aspects concerning the approach, landing and quantity of fuel.

The three emergency and abnormal procedures associated with the landing gear fault and the after take-off checklist were carried out in six minutes. The confusion concerning one of the circuit breakers which inhibits the aural warnings was probably linked to a high workload. In the situation of this incident, there was no identified element of an emergency nature requiring an immediate landing. There was sufficient fuel for several holding patterns. The use of a decision support tool (such as A.B.C.D.I for HOP!) allows the crew to carry out an objective analysis of the threats associated with the situation.

2.6.2 Actions after landing

After landing, the crew stopped the aeroplane on the runway so that firefighters could inspect the landing gear. Then, when they attempted to taxi, the crew were surprised to find they could not steer the aeroplane. Compliance with the **ABNORMAL LANDING GEAR EXTENSION** procedure (see paragraph 2.5) had rendered the nose gear steering system inoperative. The final procedure, **PARTIAL OR GEAR UP LANDING** (see **Figure 17**) does not specify taxiing, but a full stop of the aeroplane on the runway until evacuation.

This procedure lists several actions to be performed after landing. In particular, the crew must pull the handles to shut down both engines. These actions close the fuel, hydraulic and pressurization system cut-off valves. By rotating these handles, the fire extinguishers are activated. The announcement to evacuate the aeroplane must then be made.

The crew stopped both engines using the selectors on the pedestal. They deliberately did not operate the fire extinguisher handles. The captain considered it unnecessary to operate the fire extinguisher handles because the firefighters were nearby and had not reported a fire or leak.

The captain did not request the evacuation of the aeroplane. However, he decided to adapt the disembarkation procedure, taking into account the risks he had identified. The emergency services, and then a ground engineer, had participated in the assessment of the situation by inspecting the left landing gear. The engineer advised the captain to disembark the passengers through the right door to avoid adding weight to the left side of the aeroplane. The captain followed his advice. The aeroplane was stopped on the runway with the engines off during disembarkation. The manufacturer confirmed after the incident that the landing gear was not at risk of collapsing in this situation.

Emergency evacuations also carry risks, including the risk of passengers being injured in the rush.

3 CONCLUSIONS

The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation.

Scenario

When the landing gears were extended during the first approach to Toulouse-Blagnac airport, the locking-stay bracket was separated from the left main landing gear, causing the misalignment of the gear position sensors. This misalignment led to the "gear locked" position not being detected and the triggering of the corresponding warning in the cockpit.

The captain, who was the PM, retracted and extended the landing gear as a reflex, without referring to the procedure associated with the warning. As the warning was still present after recycling the landing gear, the crew aborted the approach and complied with the procedure. They flew a large left-hand circuit under radar vectors.

Six minutes after the go-around, the procedures associated with the fault had been completed. The captain took the role of PF.

The final approach and landing were uneventful. However, the "*LANDING GEAR*" warning remained active from the selection of the flap 5 configuration during the intermediate approach until after landing. The persistence of this warning is explained by an error during an action on the aural warning circuit breaker (see paragraph 2.5) combined with the near impossibility of performing a visual cross-check of the position of the pulled circuit breakers.

Contributing factor

The following factor may have contributed to the rupture of the locking stay-left main landing gear assembly:

- the use of nuts, recommended by the manufacturer, which were not designed to bear the torque values indicated in the documentation.

Measures taken

Following the incident, Embraer issued a mandatory *Alert Service Bulletin* (Alert SB170-32-A094) to inspect all landing gears in the fleet. By the end of 2024, the entire fleet had been inspected, with the following result: approximately 180 nuts replaced with type MS14145 models.

On 28 April 2025, Embraer issued a Flight Operations Letter (ref. FOL No 170-002/25) applicable to the Embraer 170/175/190/195. This letter indicates that the evacuation part of the **PARTIAL OR GEAR UP LANDING** procedure will be modified in the AOM and QRH. Instead of "Emergency Evacuation… Announce", the procedure will read "Emergency Evacuation… As required". With this modification, it will be for the captain to decide whether to evacuate, based on the crew's assessment of the situation.

Hop! reinforced the fault isolation methods in the 2025 recurrent training. The importance of the crew processing the assessment and decision items together was underlined. Up until then, the operational and commercial assessment was the captain's prerogative. From 2025, the PM (captain or co-pilot) carries out these assessments after carrying out the technical assessment.

It is now specified in the decision item that the captain will ask the co-pilot (PF or PM) to express his opinion, the final decision remaining the captain's prerogative. The co-pilot is thus more involved in the decision-making process. This change has been formalized by modifications to parts A and B of the Operating Manual.

HOP! also used this incident during the 2024 instructor standardization. The various points of the **LG LEVER DISAG** procedure were reviewed during training. The 2025 RTC[9] courses include several aspects of crew handling of a landing gear fault. In particular, it is explained that if the gear must be retracted in the event of a go-around, this retraction should be counted as a cycle in the procedure. The importance of checking the circuit breaker numbers before pulling them is reiterated, as a cross-check is not possible.

The BEA investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.

[9] Recurrent Training and Checking.