Accident to the BOEING - 737 - 400 registered TF-BBM on 20 November 2022 at Paris-Charles de Gaulle (Val-d'Oise)

Time	21:32[1]
Operator	Bluebird Nordic (Island)
Type of flight	Freight commercial air transport
Persons on board	Captain and co-pilot
Consequences and damage	Aeroplane substantially 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.	

Uncontrolled movement of aeroplane during push-back, strike with infrastructures

1 HISTORY OF THE FLIGHT

Note: the following information is principally based on the CVR[2] and FDR, statements, radio-communication recordings and video-surveillance camera recordings.

The crew were carrying out a freight transport flight from Paris Charles-de-Gaulle airport bound for Lisbon (Portugal).

At 21:24, they obtained the ground controller's clearance to start up and then a few minutes later, to push back from stand I81.

As the aeroplane's APU was inoperative, the first engine was started up using a GPU, which on this aeroplane, is connected on the right-hand side. This connection required the crew to start up engine No 1 (left engine) first, contrary to the normal engine start-up procedure (engine No 2 (right engine) first). The crew thus started up engine No 1 (left engine) first.

The push-back was carried out in compliance with procedures. An operator in contact with the crew (wire connection with headset) walked with the aeroplane while another operator drove the push-back tug. They had installed a steering lockout pin on the aeroplane's nose gear.

After the push-back, the aeroplane, with only engine 1 operating, was on taxiway BM1. The operator with the headset asked the crew to apply the parking brake in order to remove the towbar and release the tug. The crew confirmed the application of the parking brake.

[1] Except where otherwise indicated, the times in this report are in local time.

[2] The glossary of acronyms and abbreviations frequently used by the BEA can be found on its web site.

After unhooking the bar from the tug, the operator with the headset observed that the aeroplane was moving forward with the bar still connected to the nose gear. It was no longer possible for him to reconnect the bar to the tug and he asked the crew several time to apply the parking brake. The crew replied that the parking brake was on and that they could not brake. The tug and the ground operator managed to move out of the way as the aeroplane accelerated (the maximum recorded speed was 12 kt). As the towbar and steering lockout pin were still in place on the nose gear, the crew were unable to steer the aeroplane which struck a lamppost and a jet blast barrier before coming to a halt.

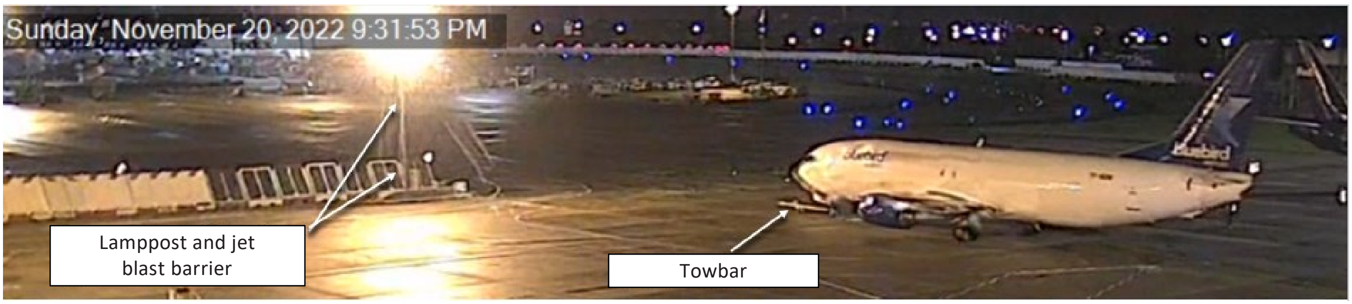

Figure 1: excerpt from video surveillance recording just before collision (source: FEDEX)

2 ADDITIONAL INFORMATION

2.1 Aircraft information

2.1.1 Damage to aeroplane

The damage was confined to the left wing.

Figure 2: damage to aeroplane (source: BEA)

2.1.2 Description of aeroplane's hydraulic systems

The Boeing 737-400 has two main hydraulic systems, A and B which supply the aeroplane's hydraulic equipment (flight controls, flaps and slats, landing gear, braking system, steering of nose wheel, thrust reversers and autopilot, etc.). A standby hydraulic system is used in the event of a pressure loss in systems A and/or B and supplies the thrust reversers, rudder, slats and flaps. The nominal pressure in these systems is at least 2,800 psi.

The hydraulic pressurisation of systems A and B is ensured by EDP[3] and EMP[4].

System A is pressurised by:	System B is pressurised by:
• the EDP (ENG 1) driven by engine 1 • and/or the EMP (ELEC 2) driven by engine 2 or by the APU.	• the EDP (ENG 2) driven by engine 2 • and/or the EMP (ELEC 1) driven by engine 1 or by the APU.

The hydraulic pressurisation of the standby system is ensured by an electric pump powered either by engines 1 or 2 or by the APU.

The operation of the engine driven and electric motor pumps is controlled by means of four toggle switches (ENG 1, ENG 2, ELEC 1, ELEC 2) situated on panel P5 (see **Figure 3**). This panel also has amber indicator lights which come on when there is low pressure in one of the engine driven or electric motor pumps. These lights come on when the pump output pressure is between 1,200 and 1,600 psi. In this case, the "MASTER CAUTION" and "HYD" indicator lights situated on the central panel of the instrument panel also light up.

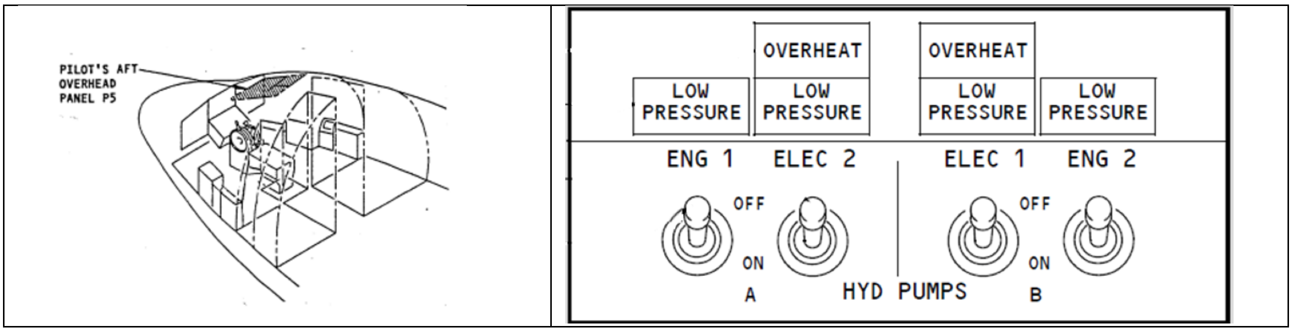

Figure 3: hydraulic system A and B control panel P5 (source: Boeing)

[3] Engine Driven Pump.
[4] Electric Motor Pump.

System A and B pressure and fluid quantity indicators are also available (see **Figure 4**).

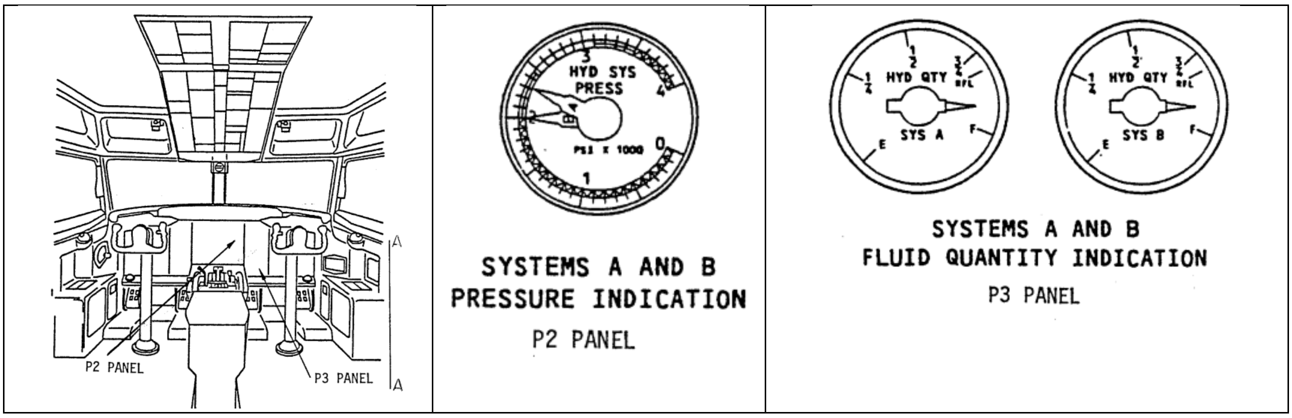

Figure 4: hydraulic system A and B pressure and fluid quantity indicators (source: Boeing)

2.1.3 Description of aeroplane's braking system

The four wheels of the main landing gear are equipped with a hydraulically-controlled braking system. The nose gear wheels have no brakes.

The aeroplane is equipped with three hydraulic braking systems:

- a NORMAL system;
- an accumulator associated with the NORMAL system;
- an ALTERNATE system.

The NORMAL system is supplied by the aircraft's hydraulic system B. It has an accumulator, the volume of which is designed to provide temporary pressure in the NORMAL and ALTERNATE systems in the event of a loss of pressure. This pressure supplied by the accumulator allows the crew to brake but this is limited to a few pedal or parking brake inputs.

This accumulator is only recharged by hydraulic system B, i.e. by engine driven pump ENG 2 when engine 2 is operating, or by electric motor pump ELEC 1. This accumulator is not perfectly leaktight and empties after the aeroplane has been stationary for a certain length of time. A pressure indicator is available in the cockpit on the co-pilot's side (see **Figure 5**).

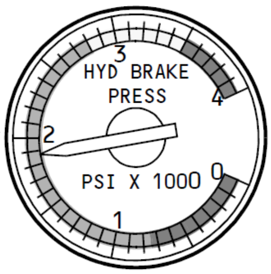

Figure 5: accumulator hydraulic pressure indicator (source: Boeing)

In the event of a loss of pressure in the NORMAL system, the system automatically switches or is manually switched to the ALTERNATE system, which is supplied by hydraulic system A of the aeroplane.

2.1.4 Description of parking brake system

The parking brake is applied by fully pushing the brake pedals and pulling the parking brake lever upwards. When this is done, hydraulic pressure is applied to the brakes on all four wheels of the main landing gear via the NORMAL system, the accumulator or the ALTERNATE system.

When the parking brake lever is pulled, a switch on the control mechanism illuminates a red light next to this lever.

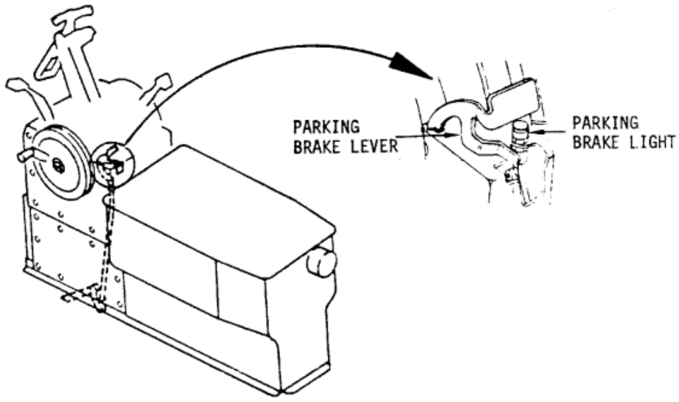

Figure 6: parking brake lever (source: Boeing)

This light is associated with the position of the lever and does not confirm the pressurisation of the parking brake system.

2.1.5 Description of nose wheel steering system

The nose wheel is normally steered by hydraulic system A. In the event of a system A fault, the crew can manually activate pressurisation of the system via system B.

During towing/push-back operations, the nose gear is connected to the towbar. Movements of the towbar can damage the nose wheel steering system if the latter is under hydraulic pressure. If there is no steering lockout pin, hydraulic system A has to be depressurised for towing/push-back operations.

Positioning a steering lockout pin on the aeroplane's nose gear depressurises the nose wheel steering system.

2.1.6 Push-back procedures

2.1.6.1 Amplified normal procedures based on Flight Crew Operations Manual (FCOM)

The Bluebird Nordic FCOM amplified procedures are a copy of those in the Boeing FCOM.

- **Preflight Procedure**

Parking brake .... Set

Verify that the parking brake warning light is illuminated

Note: Do not assume that the parking brake can prevent airplane movement. Accumulator pressure can be insufficient.

- **Before Start Procedure**

  - **Without nose gear steering lockout pin**

If pushback is needed and the nose gear steering lockout pin is not installed:

WARNING: Do not pressurize hydraulic system A. Unwanted tow bar movement can occur.

System A HYDRAULIC PUMP switches .... OFF

Verify that the system A pump LOW PRESSURE lights are illuminated.

System B electric HYDRAULIC PUMP switch ....ON

Verify that the system B electric pump LOW PRESSURE light is extinguished.

Verify that the brake pressure is 2,800 psi minimum.

Verify that the system B pressure is 2,800 psi minimum.

  - **With nose gear steering lockout pin**

If pushback is not needed, or if pushback is needed and the nose gear steering lockout pin is installed:

Electric HYDRAULIC PUMP switches ....ON

Verify that the electric pump LOW PRESSURE lights are extinguished.

Verify that the brake pressure is 2,800 psi minimum.

Verify that the system A and B pressures are 2,800 psi minimum.

Figure 7: excerpt from Boeing FCOM (source: Boeing and Bluebird Nordic)

2.1.6.2 Procedures used by crew

The BlueBird Nordic Standard Operating Procedures (SOP) contained in the electronic flight bag used by the crew at the time of the accident did not have different procedures according to whether the nose gear steering lockout pin was in place or not in place. The crew were asked to:

- systematically depressurise system A by setting the ENG 1 and ELEC 2 switches to OFF;
- pressurise system B by setting the ENG 2 and ELEC 1 switches to ON.

This procedure does not require the crew to check that the system B pressure is effectively 2,800 psi minimum or that the pump LOW PRESSURE lights are off.

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2.15 Start Up Procedures and Callouts

2.15.1 Before Pushback

After hydraulic pressure clearance has been received from ground crew, proceed on BEFORE START PROCEDURE.

Commander	First Officer
	Fuel pumps... .ON
	HYD Pumps.. ON
	System A pumps OFF and system B ON
Trim... SET	
Check each trim for freedom of movement.	
Stabilizer trim... __ UNITS	
Set the trim for takeoff.	
Verify that the trim is in the green band.	
Aileron trim........................ .... 0 UNITS	
Rudder trim.. 0 UNITS	
„BEFORE START CHECKLIST TO THE LINE“	
	Read the Before start checklist down to the line.
	„BEFORE START CHECKLIST COMPLETED TO THE LINE“

Figure 8: excerpt from SOP (source: BlueBird Nordic)

2.1.7 Examinations of braking system

The braking system was tested by the BEA in coordination with Boeing. These tests were carried out on the aeroplane with a GPU connected.

These tests demonstrated:

- the correct operation of electric motor pump ELEC 1, which pressurises system B and the accumulator. A continuous fault on this pump could therefore be ruled out but not a possible intermittent problem not identified during these tests;
- the conformity of the pressure value in the accumulator (2,900 psi) to the manufacturer's specifications (3,000 ± 100 psi) once recharged by the pressurisation of hydraulic system B. Further tests indicated that the leaktightness of this accumulator was also within the manufacturer's specifications;
- the correct operation of the parking brake lever mechanism. The associated light illuminated correctly when the lever was pulled;
- the correct operation of engine driven pump ENG 1, which pressurises system A;
- the correct operation of all the indicator lights and pressure indicators associated with the hydraulic systems.

None of the tests and checks carried out on the braking system of TF-BBM revealed any malfunction likely to explain the accident.

2.1.8 Read-out of Flight Data Recorder (FDR)

The parameters of the occurrence were decoded and analysed in coordination with Boeing. The pressures in hydraulic systems A and B were not recorded. Two BRAKE PRESSURE NORMAL and ALTERNATE parameters recorded the pressures in the NORMAL and ALTERNATE braking systems. The values of these two parameters were below 100 psi, which indicates that systems A and B were not pressurised.

The positions of the brake pedals were not recorded.

Four binary parameters (HYD SYS ENG - 1 / 2 and HYD SYS A/B ELEC) indicated that the LOW PRESSURE indicator lights on the upper panel of the hydraulic system (see **Figure 5**) were all on. This shows that the output pressures of the engine driven and electric motor pumps of systems A and B were below the 1200-1600 psi values.

Given the recorded parameters and the results of the braking system examinations, the positions of the switches in the cockpit were very probably:

- SYS A ENG 1 in OFF position
  - As engine 1 had been started up, the HYD SYS A ENG 1 parameter indicated a low pressure (LOW PRESSURE light lit) and the examination of engine driven pump ENG 1 showed that it was functional, hydraulic system A was not pressurised by engine driven pump ENG 1.
- SYS A ELEC 2 in unknown position
  - The position of the switch, ON or OFF, had no influence on the operation of the braking system. Electric motor pump 2 was not electrically powered because engine 2 had not been started up and the APU was out of service.
- SYS B ENG 2 in unknown position
  - The position of the switch, ON or OFF, had no influence on the operation of the braking system. Engine driven pump ENG 2 was not driven because engine 2 had not been started up.
- SYS B ELEC 1 in OFF position
  - The operation of the parking brake depended on the activation of electric motor pump 1, which pressurises system B.
  - The HYD SYS B ELEC parameter indicated a low pressure (LOW PRESSURE light lit) which showed that the electric motor pump was not electrically powered (the examinations did not find any fault on this pump). An intermittent fault on this pump cannot, however, be excluded.

2.2 Crew information

2.2.1 Licence, rating and experience

The 54-year-old captain held an ATPL(A) licence obtained in May 2013 and the Boeing B737 300-900 type rating.

On the date of the accident, he had logged a total of 7,600 flight hours including 3,600 flight hours on type.

The 33-year-old co-pilot-pilot held an ATPL(A) licence obtained in August 2020 and the B737 300-900 type rating.

On the date of the accident, he had logged a total of 2,800 flight hours including 2,600 flight hours on type.

2.2.2 Crew statements

The crew indicated that the APU was out of service and that a GPU had to be used for the start up. As the GPU was positioned on the right side of the aeroplane, the crew started up the left engine (No 1) first.

At the end of the push-back, the crew applied the parking brake when requested to do so by the operator with the headset in order to disconnect the towbar. The crew specified that they effectively observed that the red light was illuminated and therefore confirmed to the operator with the headset that the parking brake had been applied.

The crew added that they felt the aeroplane moving forward and back slightly. They checked that the brake control was correctly positioned and that the light was indeed illuminated.

The operator with the headset then repeatedly asked for the parking brake to be applied. The crew specified that at each new request, they once again checked the activation of the parking brake by pushing hard on the brake pedals and pulling hard on the parking brake lever.

The aeroplane then slowly began to move forward because of the downward slope of the tarmac. The speed gradually increased and the crew explained that they were unable to steer or brake the aeroplane.

After colliding with the lamppost and the jet blast barrier, the aircraft came to a halt. The crew observed a large fuel leak from the left wing tank, requested assistance from the firefighting services and then shut down all the electrical systems to prevent a fire.

The crew stated that they applied the before push-back start-up procedure. This procedure required the system A switches to be set to "OFF" and the system B switches to be set to "ON". They added that since engine 2 had not been started up, many of the lights were red and that they had not paid attention to the status of the low pressure lights of the system A and B pumps (see **Figure 3**, panel 5). They also specified that they did not check the pressure indicator for systems A and B (see **Figure 4**, panel 2) or the accumulator pressure indicator (see **Figure 5**).

3 CONCLUSIONS

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

Scenario

The conditions the day of the accident were the following:

- push-back operation with the nose gear steering lockout pin installed. Hydraulic system A was not pressurised (in accordance with operator's procedure);
- engine No 1 was operating and engine No 2 was shutdown. This meant that hydraulic system B was not pressurised by engine driven pump 2;
- the standby accumulator was empty as discharged since the previous flight and would not be recharged until pressurisation of system B.

In these conditions, only the activation of electric motor pump 1, powered by engine No 1, could pressurise hydraulic system B and thus ensure the correct operation of the braking system (parking brake and pedal braking).

Hydraulic system B was not pressurised during the occurrence as the crew had very probably not activated electric motor pump 1. However, the investigation was not able to exclude a possible intermittent fault on this pump. Hydraulic system A was not activated by the crew in accordance with the operator's normal procedures.

In the absence of pressurisation in hydraulic systems A and B and with the accumulator discharged since the previous flight, the braking system (parking brake and pedal braking) and the steering control system were not operational.

At the end of the push-back and before disconnecting the towbar, the crew operated the parking brake lever and considered that the latter was operational on observing that the associated red light illuminated. Due to the design of the system, this light only indicates that the parking brake lever is correctly positioned for applying the brake, it does not guarantee that the braking system is pressurised. The crew explained that they did not check that the pressure of hydraulic system B was at a minimum value of 2,800 psi and did not pay attention to the indicator lights indicating low pressure in the various systems and in the accumulator.

When the towbar was disconnected, the aeroplane moved and the crew tried to brake several times without understanding why the braking system was not operating although the red light was on. With the steering lockout pin and towbar still in place, the aeroplane's path was not controllable and it came to a halt after striking obstacles.

Contributing factors

The following factors contributed to the absence of hydraulic pressure in the braking systems when the towbar was disconnected from the tug:

- the crew's erroneous understanding of the meaning of the red light next to the parking brake lever;
- the crew not checking the pressure indicators of the hydraulic systems and the low-pressure indicator lights of the pumps;
- the operator's choice to simplify the manufacturer's procedure by the systematic absence of pressurisation of system A, even when the steering lockout pin was in place, and by not asking the crews to check that system B was actually pressurised.

Safety action taken by operator after accident

Following the accident, the operator updated the "Before push-back" procedure by adding the instruction to check the pressure in the hydraulic systems. This procedure which still does not make a distinction between cases where the steering lockout pin is used or not, systematically requires system A to be left in the OFF position. This deprives the crew of a back-up means in the event of system B failing.

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2.15 Start Up Procedures and Callouts

2.15.1 Before Pushback

After hydraulic pressure clearance has been received from ground crew, proceed on BEFORE START PROCEDURE.

Commander	First Officer
Trim.. SET Check each trim for freedom of movement. Stabilizer trim.................................. __ UNITS Set the trim for takeoff. Verify that the trim is in the green band. Aileron trim....................... .... 0 UNITS Rudder trim....................................... 0 UNITS **„BEFORE START CHECKLIST TO THE LINE“**	Fuel pumps.. .ON HYD Pumps.. ON System A pumps OFF and System B pumps ON **Verify that brake pressure is 2,800 psi minimum** Read the Before start checklist down to the line. **„BEFORE START CHECKLIST COMPLETED TO THE LINE“**

Figure 9: excerpt from updated SOP (source: BlueBird Nordic)

Safety lessons

The push-back can be a tricky operation because it involves moving the aeroplane in a confined environment. There is a high risk of collision and injury to ground staff, particularly when the towbar is disconnected, if the aeroplane's braking system is not operational.

Not positioning a chock against the nose wheel during push-back operations may have contributed to the following occurrences:

- Serious incident to the Airbus A330 registered B-HLT operated by Hong Kong Dragon Airlines on 24 January 2020 at Hong Kong
- Accident to the Boeing 777 registered C-FNNQ operated by Air Canada on 24 July 2019 at Paris - Charles de Gaulle.

The use of a chock positioned in front of the nose wheel, after the push-back, can constitute an additional safety barrier.

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