Incident to the AIRBUS - A350 - 900 registered F-HREV

on 4 February 2020
at Paris-Orly (Val-de-Marne)

Time	Around 17:00[1]
Operator	French Bee
Type of flight	Passenger commercial air transport
Persons on board	Captain (PM), copilot (PF), relief pilot(2), 10 cabin crew, 206 passengers
Consequences and damage	None
This is a courtesy translation by the BEA of the Final Report on the Safety Investigation published in July 2021. As accurate as the translation may be, the original text in French is the work of reference.	

[1] Except where otherwise indicated, the times in this report are in Coordinated Universal Time (UTC). One hour should be added to obtain the legal time applicable in Metropolitan France on the day of the event.

[2] In the rest of the report, the copilot-PF in the right seat will be called "*copilot*" and the relief pilot on the jump seat will be called "*relief pilot*". French Bee uses the term "*First Officer*" to designate a copilot.

Predictive windshear warning on final, cognitive incapacitation of copilot during go-around, lateral and vertical flight path deviations, low energy alert, conflict with a departing aeroplane

1 - HISTORY OF THE FLIGHT

Note: the following information is principally based on the flight data maintenance recorder, statements, the radio-communication recordings and the radar data. The CVR was not available.

The Airbus A350 registered F-HREV, operated by French Bee, was carrying out flight FBU711 from San Francisco bound for Paris-Orly. This was the last flight of the Paris – San Francisco – Papeete – San Francisco – Paris roster. The crew took off nearly three hours late from San Francisco. On this last leg of around 11 h, the flight crew was augmented by a relief pilot who had joined them the day before at San Francisco, and who was sat on the cockpit jump seat for the arrival at Paris. A cabin crew member was also sat on a cockpit jump seat for the landing.

The aeroplane was stabilized on ILS 25 and configured for landing, the copilot was the PF and the captain was the PM. Visibility at Orly was greater than 10 km and the ceiling was at around 4,500 ft. There was a northwesterly wind of about 25 kt.

At an altitude of 1,400 ft[3], i.e. a radio altimeter height of approximately 1,100 ft, the copilot disconnected the autopilot (AP). The auto-thrust (A/THR) and the flight directors (F/D) remained engaged.

[3] Unless indicated otherwise, the altitude values mentioned in the report are QNH altitudes rounded off to 50 ft.

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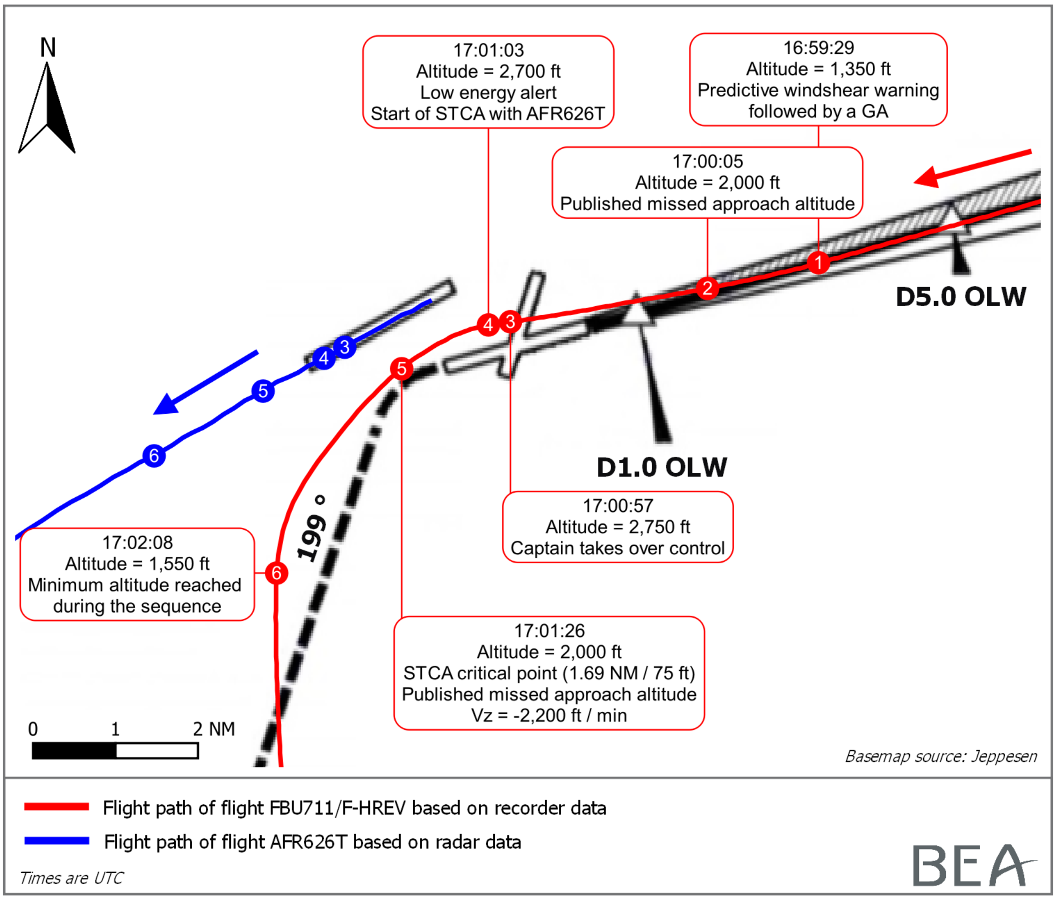
Phase 1: Predictive windshear warning, go-around, copilot cognitive incapacitation, exceedance of published missed approach altitude (points 1 to 3, Figure 1)

[4] Warning which anticipates windshear, see §2.4.1.

At 16:59:29 (i.e. four seconds after the disconnection of the AP) and at an altitude of 1,350 ft, the predictive windshear warning[4] "GO AROUND, WINDSHEAR AHEAD" was triggered in the cockpit (point 1 Figure 1). The crew were surprised by this warning given the day's meteorological conditions. The captain ordered a go-around.



Source: BEA

Figure 1: F-HREV's flight path

The copilot made a slight right input on the sidestick and a nose-up input bringing the pitch to around 8°. He then moved the thrust levers forward to the TOGA detent. After a few seconds the copilot engaged the GA SOFT mode[5] at the captain's request. The FD command bars indicated a reduction in pitch. No sidestick input was recorded and the plane's pitch remained stable at around 8° nose up. The aeroplane continued to climb with a greater pitch than the FD target pitch. The crew retracted the landing gear and set the flaps to CONF3. The LVR CLB message flashed on the Flight Mode Annunciator (FMA) asking the pilot to put the thrust levers in the CL detent[6].

[5] Go Around SOFT is the A/THR mode used to carry out a go-around with a thrust below TOGA. The thrust levers are put in the FLX/MCT detent. The aeroplane climbs with a target vertical speed of 2,000 ft/min.

[6] Putting the thrust levers in the CL detent engages the A/THR, and thus, here, takes the plane out of the GA SOFT mode.

At 16:59:44, at an altitude of 1,450 ft, the captain announced to the air traffic controller that they were carrying out a go-around. The latter cleared him to climb to the published missed approach altitude at 2,000 ft. This altitude had been previously selected by the crew during the approach. The plane's altitude alert[7] was triggered for 1.5 s, indicating that they were approaching the target altitude.

[7] See §2.4.3.

A few seconds later, at an altitude of 1,750 ft, the altitude acquisition vertical mode ALT* was engaged. The captain indicated in his statement that he called out the "SPEED, ALT STAR" modes. Sixteen seconds after the appearance of the LVR CLB message, the copilot put the thrust levers in the CL detent. Seeing that they were going to bust the selected altitude, the captain and the relief pilot asked the copilot (PF) to stabilize the aeroplane at 2,000 ft. The copilot did not react.

At 17:00:05, the plane bust the published missed approach altitude of 2,000 ft (point 2 Figure 1) with an indicated airspeed of 167 kt and a vertical speed of + 1,800 ft/min. Three seconds later, the crew retracted the flaps to CONF1. The FD command bars indicated a higher nose-down input. During this period, the aeroplane's pitch remained stable at around 8° nose-up and no movement was recorded on the sidesticks. Six seconds after flying through 2,000 ft, the altitude alert sounded continuously. The crew put the aeroplane into the clean configuration around 10 s later.

At 17:00:29, at an altitude of around 2,750 ft and with a calibrated airspeed (CAS) of 185 kt, the copilot levelled off using the sidestick. The crew pulled the altitude knob on the flight control unit (FCU) which engaged the OP DES longitudinal mode and the THR IDLE mode. The A/THR reduced the engine power to IDLE but as the AP was not engaged, the aeroplane did not automatically descend to the selected altitude of 2,000 ft and remained stable at an altitude of around 2,800 ft.

At 17:00:37, the plane crossed the threshold of runway 25. The air traffic controller asked the crew to turn left to heading 180°. The captain read back, indicating that they had climbed up to 3,000 ft and that they were now in the process of re-descending to 2,000 ft. The controller also informed them of traffic at 1 o'clock at 4 NM departing from Orly. This traffic took off from runway 24. During the radio exchange, the crew selected heading 180° and engaged the HDG mode. As the two autopilots were still disengaged and the crew did not make an input on the stick, the aeroplane kept the current heading of 267°. The FD command bars indicated an increasingly greater left turn in descent.

Phase 2: Captain takes over control, low energy alert, STCA[8] and altitude undershoot (points 3 to 6, Figure 1)

[8] Short Term Conflict Alert: a safety net to alert the controller of a potential short-term infringement of separation minima.

In his statement, the captain indicated that at an altitude of around 2,800 ft, he was aware that they were too high, that there was a traffic nearby, that they had to turn left and that the copilot was reacting to neither his requests nor those of the ATC. At 17:00:49, the data recordings showed that the captain put his hand on the sidestick. A few seconds later, the extension of the speedbrakes was commanded by one of the members of the crew (probably the copilot, see §2.5) without a callout in the cockpit. The captain then engaged AP1 at 17:00:57 (point 3 Figure 1, i.e. 52 s after climbing through 2,000 ft) and the aeroplane turned left onto heading 180° in descent towards the target altitude of 2,000 ft.

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[9] In the absence of the CVR, no time can be given to this callout. It may have occurred before or after the action on the speedbrake lever.

[10] Velocity Lowest Selectable, minimum speed that the crew can select with the A/THR engaged and below which manoeuvres are rarely performed.

[11] For a VLS of 188 kt, see §2.4.2.

The captain called out to the crew, "*I have control*"[9]. The captain saw the VLS[10] increase and heard the relief pilot's warning about the speed.

At 17:01:03, the plane was at an altitude of around 2,700 ft, speedbrakes extended, a CAS of 175 kt[11] and a vertical speed of - 1 200 ft/min. The low energy alert characterized by the aural message "SPEED, SPEED, SPEED" was triggered for 3 s (point 4 Figure 1). At the same moment, flight FBU711 came into conflict with flight AFR626T taking off from runway 24 and a STCA was triggered on the ATC screen.

In the following seconds, the captain selected a target speed of 260 kt, put the thrust levers in the TOGA detent and started making inputs on the sidestick. The captain wanted to increase the speed and then stabilize the aeroplane at 2,000 ft. The selection of TOGA led to the automatic retraction of the speedbrakes even though the control level remained in the extended position. This triggered a Master Caution for 38 s (see §2.4.2). Returning to manual control disengaged AP1 which also disengaged the FDs at a time where the speed was below the VLS with the OP DES mode engaged.

At 17:01:09, the controller again asked the crew to turn left onto heading 180°. There was no response. The aeroplane had nevertheless started the turn when AP1 was engaged by the captain. The air traffic controllers then saw the plane fly over the control tower. The aeroplane was at an altitude of around 2,500 ft and 650 m to the right of the runway 25 centreline.

Although dynamic inputs of a large amplitude, sometimes up to full deflection on the two axes, were recorded on the captain's sidestick for around 30 s, the plane continued the left turn in a stabilized manner, the speed increased to its target of 260 kt and the altitude continued to decrease to 2,000 ft. The thrust levers were moved from the TOGA detent to FLX/MCT and then CL.

At 17:01:26, the aeroplane flew through the altitude of 2,000 ft with an increasing CAS of 235 kt and a vertical speed of - 2,200 ft/min (point 5 Figure 1). This time also coincided with the point where the distance was at its minimum between the two flights FBU711/AFR626T (critical point of STCA) with a separation of 1.69 NM for 75 ft. However, the flight paths of the two planes were not converging.

The captain indicated in his statement that he heard the relief pilot request the use of the AP and that he saw the copilot touch something on the FCU. He saw that the FMA was in V/S mode and had not understood why it was engaged. In her statement, the relief pilot indicated that she had asked several times for the autopilot to be used to reduce the workload.

At 17:01:34, at an altitude of 1,850 ft, the copilot pressed the AP2 pushbutton. This engaged AP2 in V/S longitudinal mode with the current vertical speed value (– 640 ft/min), and in HDG lateral mode with the current heading value of 228°. The captain then disengaged AP2 and engaged AP1. The aeroplane went from a 10° bank to the left, to wings level. The captain indicated having called out, "*Everybody silent. I'm the only one giving orders.*"

On descending through 1,800 ft, the altitude alert was triggered again and sounded continuously. The captain selected a heading of 198° and reduced the target speed from 258 kt to 220 kt.

At 17:01:42 (i.e. 33 s after the last repeated request from ATC which went without a response from the crew), the captain informed the controller that he was turning towards heading 180. The latter replied, "*Thank you, for your information the traffic is very close, so I suggest you turn very quickly.*" The captain selected the target heading of 180°.

At 17:01:54, the copilot put the speedbrake control lever in the retracted position [note: the speedbrakes had already automatically retracted when the thrust lever was put in the TOGA detent]. The captain pulled the altitude knob which engaged the OP CLB mode. A/THR changed from SPEED mode to THR CLB mode.

At 17:02:00, at an altitude of 1,600 ft, the captain disengaged AP1. The FDs were still engaged and the inputs on the captain's sidestick were consistent with the FD orders.

At 17:02:08, the aeroplane reached the minimum altitude of the sequence of around 1,550 ft (point 6 Figure 1). At the same time, the controller asked the crew to climb to 3,000 ft. There was no response but on board, the target altitude was changed from 2,000 ft to3,000 ft.

Phase 3: Return to flight path, second approach and landing

Ten seconds after his first request, the controller again asked that they climb to 3,000 ft, which the captain read back this time. The aeroplane finished its turn on heading 180° and AP1 was re-engaged for the rest of the flight up to the final approach. During the climb, the vertical speed reached 3,100 ft/min and the IAS 281 kt.

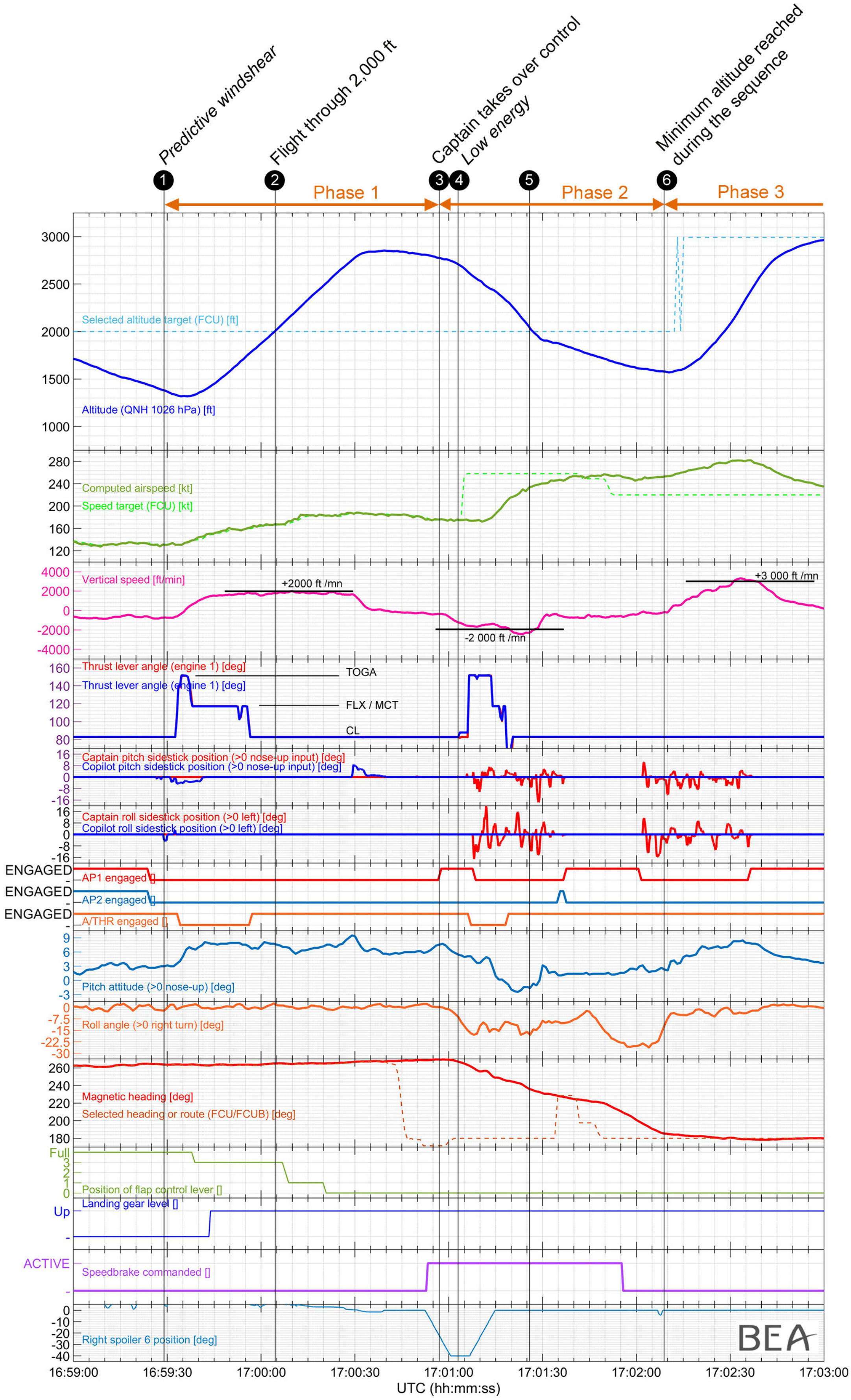
Feeling able to resume an active role, the copilot said he was ready to take over radio-communications. After discussions, the copilot became the PM and the captain remained the PF. The copilot coordinated the frequency change with the controller.

Around four minutes after the triggering of the predictive windshear warning, the aeroplane was stabilized at the target altitude of 3,000 ft at the target speed of 220 kt.

The controller then asked why they had carried out a go-around. The crew replied that it was due to windshear. No other crew reported windshear before or after the occurrence flight.

The crew were vectored for a new approach on ILS 25 and the aeroplane landed without any further incident at 17:16:53 on runway 25 of Orly airport.

Figure 2 describes the main flight parameters during the occurrence sequence.



Source: BEA

Figure 2: Main recorded flight parameters

2 - ADDITIONAL INFORMATION

2.1 Meteorological information

The 17:00 METAR for Orly airport gave the following information:

LFPO 041700Z 31011KT 9999 SCT034 BKN045 08/02 Q1027 TEMPO 29015G30KT SCT020TCU

In light of the available elements, Météo-France indicated that it was unlikely that there had been windshear on 4 February 2020 at around 17:00 on the Orly approach to runway 25, between the ground and 2,000 ft.

Furthermore, the sun had set at 16:52. At around 17:00, at the time of the accident, the sun had already set but there was still some light[12].

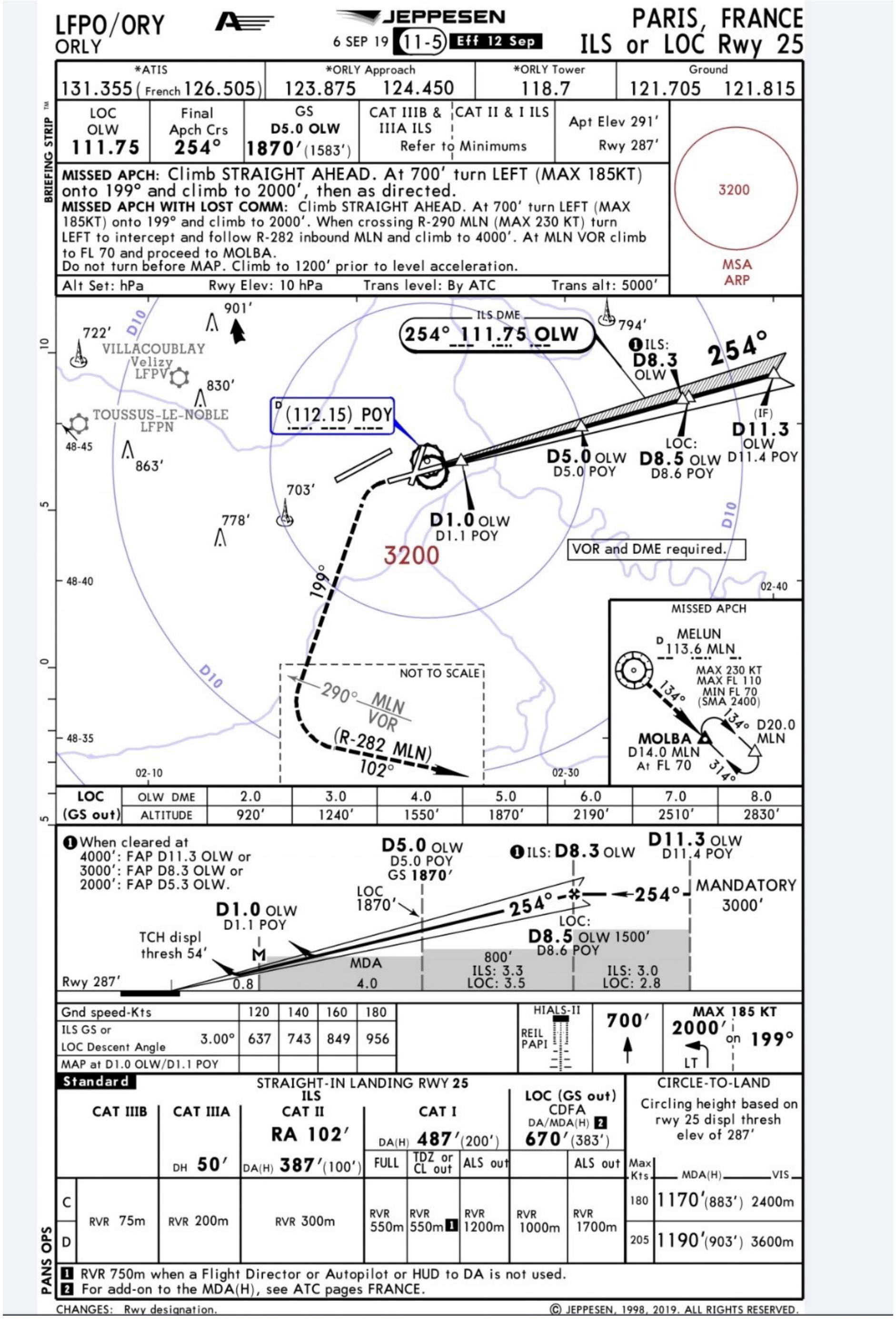
[12] The aeronautical night starts 30 minutes after sunset.

2.2 Missed approach procedure

The missed approach procedure for ILS 25 at Paris-Orly, published in the Aeronautical Information Publication (AIP) requires the crew to climb straight ahead (QFU 254) and to turn left on flying through 700 ft, to follow the magnetic track 199°, to climb to 2,000 ft and then to expect a radar vector. It is also specified that they must not turn before the missed approach point (MAPT) situated at 0.8 NM before the runway threshold and to initially limit the speed to 185 kt.

The French air navigation service provider (DSNA) specifies that this missed approach procedure complies with the regulatory requirements in force for the design of ATM procedures: Procedures order of 4 October 2017 and PROMIN criteria largely based on the ICAO publication, Doc 8168 PANS-OPS.

French Bee uses the information supplied by Jeppesen, including the approach chart for the ILS procedure for runway 25 similar to that of the AIP (see Figure 3).



Source: Jeppesen

Figure 3: ILS approach chart for runway 25

2.3 Crew information and statements

2.3.1 Copilot, PF

The 45-year-old copilot held an Airline Transport Pilot Licence (ATPL). He had been recruited by the operator around 18 months before the incident and had logged more than 8,600 flight hours, including just over 1,200 flight hours on the A330/A350.

In the scope of the 2019 recurrent training and checking programme, he had carried out several go-arounds on simulators as PF, including one due to a predictive windshear warning, in manual, with a light plane and all engines operative.

The following information is based on his statement and is intended to supplement the history of the flight.

He indicated that there had been moments when his mind went blank, although he had not been aware of it at the time and he could only partially remember the sequence of the occurrence.

Phase 1: He added that he had been surprised, given the day's meteorological conditions, by the predictive windshear warning. The go-around was quickly initiated by the captain-PM who called out "*Go-Around*", to which the copilot-PF had replied, "*Go-Around flaps*" and the captain had retracted one notch of flaps. The copilot explained that he had managed the flight path thinking that the AP was engaged. He could no longer remember the modes engaged or the position of the command bars on his FD. He heard neither the calls made by the captain and relief pilot, nor the altitude alerts in the aeroplane nor the ATC's instructions. He specified that at the time he had not felt unwell or lost consciousness.

Phase 2: The copilot explained that once the captain said he had taken over control, he completely "*let go*" and said that his brain was working in slow motion. He could not remember the low energy alert.

Phase 3: He indicated that he gradually recovered, and when scanning the cockpit to get back into the flight, he saw that the speedbrakes were extended and that the indicated airspeed was low. He then called out the retraction of the speedbrakes and moved the lever. The call-out was not heard by the other two pilots.

The copilot indicated that he had not felt particularly tired due to this type of roster. In anticipation of the long flight duty time, he had stayed at the hotel to rest the day of the departure from San Francisco. The in-flight rest had been divided into three periods of three hours and he had taken the middle one which, according to him, was the best one for the PF carrying out the landing. He had been able to sleep around one and a half hours. He had not taken controlled rest as he had not felt that he needed it. Neither had there been any forewarning of intense tiredness, such as yawning, between his return to the cockpit and the occurrence.

After a few days of rest following the incident, during which he declared that for two nights he had slept 14 h, the copilot went to see a doctor who did not diagnose any particular problem.

The analysis of the crew's roster, their statements about the activities between the flights and during the occurrence flight, and the absence of any reported physiological sign did not show that tiredness could have contributed to the occurrence. It cannot be excluded that the copilot's two long nights' sleep may have been an indirect consequence of the incident.

2.3.2 Captain, PM

The 41-year-old captain held an ATPL(A). He had been recruited by the operator in 2017 and had carried out his first flight as captain in June 2019. He had logged around 8,000 flight hours including just over 2,000 hours on the A330/A350 and around 600 hours as captain.

In the scope of the 2019 training and checking programme, he had carried out several go-arounds on simulators as PM and PF, including one following a predictive windshear warning, in manual, with a light plane and one engine operative.

During one of the simulator sessions, the captain had simulated pilot-PM incapacitation on take-off. As it turned out, the copilot-PF of the session was also the copilot-PF in the incident to F-HREV.

The following information is based on his statement and is intended to supplement the history of the flight.

He explained that the flight had proceeded normally up to the approach to Orly when suddenly everything had happened quickly, "*It was like in a simulator session but it was in real life! Predictive windshear, go-around, pilot incapacitation, low energy, traffic conflict.*"

He indicated that he had carried out a standard approach briefing with the crew and that there had been no particular threat identified[13]. During the descent to Orly airport, he had asked the ATC for the latest wind data and had then selected, on the FCU, the AP heading and altitude in case of a go-around. He authorized the PF to carry out the approach without the AP.

(13) The review of the go-around procedure is included in the standard approach briefing.

Phase 1: He immediately reacted to the sudden triggering of the predictive windshear warning by giving the order to go-around. He saw the speed increase, asked for GA SOFT mode to be used and then concentrated on managing the configuration of the aeroplane.

He called to the copilot that they were arriving at the stabilization altitude and then asked him a second time to descend after having exceeded 2,000 ft, without obtaining a response from him. The air traffic controller had also given them traffic information without a reaction from the copilot. The captain indicated that the TCAS[14] was not triggered.

(14) Traffic Collision Avoidance System. The flight data confirmed that there was no TCAS message.

Phase 2: The captain explained that all was normal but at one point he realised that the copilot was no longer reacting, as if he was blocked. The captain then made the associated call and took over control without hesitation but he did not verbalize what he perceived as a copilot incapacitation. He indicated that his priorities at this time were to turn left, return to 2,000 ft and then stabilize the aeroplane's speed.

During the descent to 2,000 ft with the AP engaged, he had not understood why the VLS was increasing, he then heard the low energy alert "SPEED, SPEED, SPEED". He disengaged the AP and moved the stick forward to gain speed before reaching the altitude of 2,000 ft. He remembered having heard the relief pilot request the use of the AP and then unexpectedly found himself with the AP engaged in V/S mode. He had not understood why the V/S mode was engaged. He then firmly asked for silence in the cockpit and reminded everyone that he was the only one giving orders.

In his opinion, the relief pilot had made good calls during the occurrence, in particular, the call out of the missed approach altitude and "*speed*" during the low energy alert. However, after this alert, he found that there was too much noise in the cockpit and he needed silence to concentrate. He specified that the cabin crew member had remained silent throughout the flight and had not interfered.

During the debriefing on the ground between the three pilots, the copilot who was pale, could not remember much about the event apart from having retracted the speedbrakes. Both the captain and relief pilot were surprised to hear this as they had not been aware that they had been extended.

He specified that he had not been particularly tired on this leg and that he had not detected any signs which could have alerted him about the copilot's state. He had taken the last in-flight rest period and had returned to the cockpit around 1 h 20 min before landing.

2.3.3 Relief pilot

The 50-year-old relief pilot held an ATPL(A). She had been recruited by the operator in June 2016 for the launching of the airline company. She had logged around 11,700 flight hours of which more than 3,400 hours on the A330/A350.

The following information is based on her statement and is intended to supplement the history of the flight.

She joined the crew the day before, at San Francisco, to carry out the last leg of the roster and took the first in-flight rest period.

During the approach briefing, they had reviewed the meteorological conditions: the wind was stable and no windshear was envisaged. No other crews had reported windshear.

Phase 1: When the predictive windshear warning was triggered, she indicated that the captain almost immediately called for a go-around. She called out the altitude of 2,000 ft several times without the copilot reacting. She remembered that the altitude alert had sounded several times during the start of the go-around and that the two pilots had had a lot of interactions on the FCU. She had seen the hands of the two pilots cross several times. The PF seemed to be absent, as if he was no longer there. The captain managed the radio-communications and tried to act on the FCU before he understood the copilot's incapacitation. She specified that when the captain took over control, the FD command bars were at the bottom on the left.

Phases 2 & 3: She indicated that she had been concerned about the altitude and that she had asked several times for the AP to be used to reduce the workload. She did not know when the speedbrakes had been extended and was surprised by the low energy alert. She stated that in the manual control phases, the captain was consistent in what he did and that he then stabilized the aeroplane at 3,000 ft in agreement with the air traffic controller.

She thought that this occurrence highlighted that it may be beneficial to keep the AP engaged for as long as possible after a long flight and on arrival at a major airport with notably a demanding missed approach procedure as at Orly.

She also indicated that when she flew for a previous operator, an additional mini-briefing was carried out during the final approach to recall the key points of the go-around.

2.4 Aircraft information

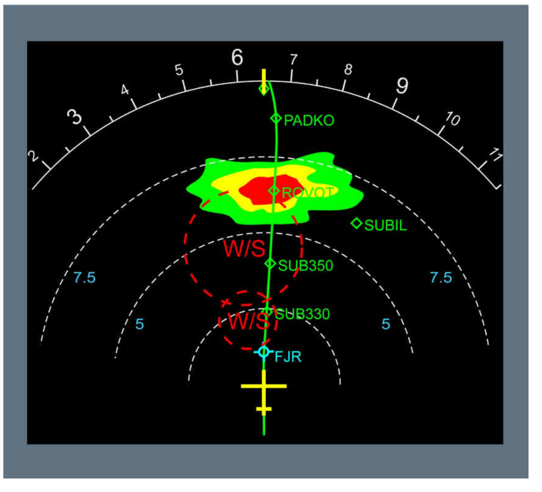
2.4.1 Predictive windshear warning

The aeroplane is equipped with a predictive windshear system which:

- detects windshear at least 10 s before it might be encountered, between 0.5 NM and 5 NM ahead of the plane in a 40° cone left and right of the fuselage centreline.
- emits alerts (*warning, caution or advisory*) if necessary.

On approach, if the predictive windshear (warning) is triggered:

- the aural message, "GO AROUND, WINDSHEAR AHEAD" is called out in the cockpit;
- the message, W/S AHEAD is displayed in red on the PFD;
- the predicted windshear zone is shown on the NDs by a red-dash circle and the indication W/S (see Figure 4).



Source: Airbus FCOM

Figure 4: PWS on ND

In the event of a predictive windshear warning on approach, the Airbus FCOM procedure, adopted in the French Bee operations manual requests:

[MEM] WINDSHEAR WARNING - PREDICTIVE WINDSHEAR (Cont'd)

Ident.: PRO-ABN-SURV-MEM610-00007811.0001001 / 03 JAN 20

L2 Note: *If the flight crew verifies and confirms that there is no risk of windshear, they may disregard the alert, provided that:*
- There are no others signs of possible windshear conditions
- The reactive windshear function is operative.
There are reported cases that specific environments (e.g. obstacles) cause the spurious triggering of predictive windshear alerts, during either takeoff or landing. However, the flight crew must always rely on all reactive windshear (i.e. WINDSHEAR) alerts.

L1 ■ **Before V1:**

RTO....................PERFORM

■ **After V1, or when airborne (initial climb, or during approach and landing):**

THRUST LEVERS....................TOGA
AP (if engaged)....................KEEP ON
SRS ORDERS....................FOLLOW
IF WINDSHEAR IS ENTERED, DO NOT CHANGE CONFIGURATION.
CAREFULLY MONITOR FLIGHT PATH AND SPEED.

Note: *If the FD bars are not displayed, move toward an initial pitch attitude of 15 °. Then, if necessary to prevent a loss of altitude, increase the pitch attitude.*

Source: French Bee FCOM

Figure 5: Excerpt of predictive windshear procedure on A350

Subsequently, Airbus modified its documents and procedures concerning the PWS for all of its fleets. Introduced in January 2021 on the A350, this modification consisted of withdrawing the memory items from the FCOM and replacing them with a description of a "technique" in the Flight Crew Training Manual (FCTM). This change was made, notably, because the actions to be carried out in case of a predictive windshear warning are less urgent than those in connection with a reactive windshear warning written in a memory item.

The introductory note was also rewritten to make it clearer that the crew must assess the windshear threat when the warning is triggered and that if the crew identify the warning as being spurious then they can ignore it[15].

[15] The investigation was not able to determine whether the predictive windshear warning of the occurrence was a spurious warning or not.

"Note: When a predictive windshear alert ("WINDSHEAR AHEAD" or "GO AROUND WINDSHEAR AHEAD") is triggered, the flight crew must carefully check that there is no hazard. If this is the case, the flight crew can disregard the alert, as long as both of the following apply:
- There are no other signs of possible windshear conditions
- The reactive windshear system is operational

Known cases of spurious predictive windshear alerts were reported at some airports, either during takeoff or landing, due to the specific obstacle environment. However, always rely on any reactive windshear ("WINDSHEAR")."

If windshear is effectively encountered, the reactive windshear warning is triggered and the crew must comply with the associated memory item procedure not detailed here.

2.4.2 Low energy alert

According to the Airbus A350 FCTM, adopted by French Bee, the low energy alert is an aural message "SPEED, SPEED, SPEED" which tells the crew that the energy of the aeroplane is below a threshold under which thrust must be increased and/or the pitch adjusted until the alert ceases.

The condition which triggered the low energy alert during the occurrence was a CAS which had been below VLS - 10 kt for at least 0.5 s.

[16] The VLS was not recorded and was recalculated by Airbus.

During the commanded extension of the speedbrakes, the CAS was stable at around 175 kt. The VLS[16], which depends notably on the configuration of the plane, went from 166 kt to 188 kt with the extension of the speedbrakes, which triggered the low energy alert.

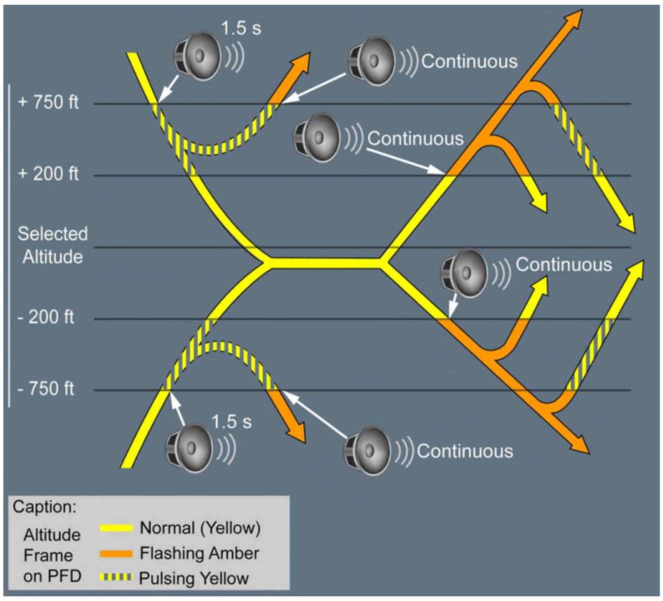
Putting the thrust levers into the TOGA detent automatically retracted the speedbrakes. As the speedbrake lever was still in the extended position, a Master Caution was emitted with the message, F/CTL SPEED BRAKES POS/LEVER DISAGREE displayed on the Electronic Centralized Aircraft Monitor (ECAM).

2.4.3 Altitude alert

According to the Airbus A350 FCOM (see Figure 6), when the aeroplane approaches the selected altitude, the altitude box on the Primary Flight Display (PFD) pulses yellow and an aural alert in the form of a C chord sounds for 1.5 s if the AP is not engaged.

When the aeroplane significantly deviates from the selected altitude (+ or - 200 ft), the PFD altitude box flashes amber and an aural alert in the form of a C chord sounds continuously until a new altitude is selected or until the crew press the Master Warning pushbutton or the aeroplane returns to the selected altitude.

The pressing of the Master Warning pushbutton is not recorded in the flight data. As the CVR was not preserved, it was not possible to determine if the alerts sounded for the duration of their activation or not.



Source: Airbus FCOM

Figure 6: Altitude alert logic

2.4.4 Go-around procedure

The two members of the flight crew can ask for a go-around to be carried out. The task sharing during the go-around published in the French Bee FCOM based on the Airbus procedure is the following:

PF	PM
•Simultaneously apply the following three actions:	
THRUST LEVERS..........TOGA THEN FLX/MCT	
ROTATION..........PERFORM	FLIGHT PARAMETERS..........MONITOR
GO-AROUND..........ANNOUNCE	FLAPS..........RETRACT ONE STEP
FMA..........CHECK/ANNOUNCE	
	POSITIVE CLIMB..........ANNOUNCE
L/G UP..........ORDER	L/G..........UP
NAV or HDG..........AS RQRD	
•At go-around thrust reduction altitude:	
THRUST LEVERS..........CL	
•At go-around acceleration altitude:	
SPEED TARGET..........MONITOR	
FLAPS.......... ORDER RETRACTION ON SCHEDULE	FLAPS..........RETRACT
	GND SPLRS..........DISARM
	EXTERIOR LIGHTS..........SET
AFTER TAKEOFF/CLIMB C/L down to the line. COMPLETE	AFTER TAKEOFF/CLIMB C/L down to the line.. COMPLETE
Fly the published missed approach procedure, or prepare for a second approach, or divert as required.	
•If necessary, at transition altitude:	
BAROMETRIC REFERENCE...... SET STD/CROSSCHECK	BAROMETRIC REFERENCE....... SET STD/CROSSCHECK
AFTER TAKEOFF/CLIMB C/L below the line.... COMPLETE	AFTER TAKEOFF/CLIMB C/L below the line..... COMPLETE

Source: French Bee FCOM

Figure 7: Task sharing during go-around

2.5 Pilot incapacitation

A pilot incapacitation can be defined as being a state affecting the physical or mental faculties of one of the crew members making him/her inapt to carry out his/her flight duties.

The incapacitation can be total, in the case of a cardiac arrest for example. In this case, it is often obvious for the other crew members.

But it can also be partial, with the pilot continuing to act. In particular, when it is the result of a surprise effect or an extra workload, it may be that only the pilot's cognitive functions are affected making the incapacitation difficult to detect and objectify.

The French Bee Operations Manual (OM) describes the obvious and subtle incapacitations and gives certain symptoms of pilot incapacitation: incoherent speech, strange behaviour, irregular breathing, pale face, decreased performance, repeated mistakes, no or unexpected responses to questions. It specifies that:

"*If any of these are present, incapacitation must be suspected and further action taken to check the state of the aircrew member. Similarly an aircrew incapacitation alert condition exists if the Aircrew does NOT:*

- Respond intelligently to two communications, or

- Respond to a verbal communication with a significant deviation from the SOPs."

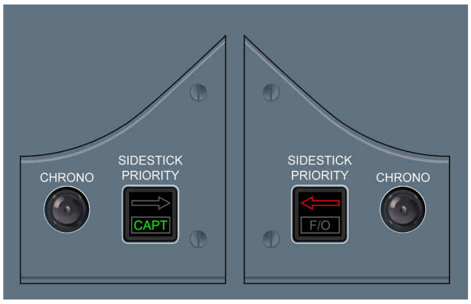
[17] These items are also mentioned in a memory aid for pilots

In case of pilot incapacitation, the OM[17] requires the valid pilot to:

- take over the control immediately and establish a safe flight profile;
- ensure that the AP is engaged (use all possible automation);
- obtain immediate cabin crew assistance;
- declare an emergency situation to the ATC with a MAYDAY message, "*we have a pilot incapacitation*".

Subsequent to this, the procedure also requests that steps are taken to prevent the incapacitated pilot from accessing the controls (either by removing him/her from his/her seat, or by restraining him/her in the seat), that medical assistance is sought in the cabin and when it is possible, that all pertinent factors are considered in order to carry out an emergency landing. The OM also specifies that a partially incapacitated pilot is not allowed to participate in the subsequent operation of the aircraft, as judgement may be impaired.

It should be noted that the Flight Crew Incapacitation procedure in the Airbus A350 FCTM also requires that the valid pilot press the sidestick pushbutton for 40 s in order to deactivate the other sidestick in the event of interference with the management of the flight. When the captain presses his pushbutton, the aural message "PRIORITY LEFT" is repeated for as long as the pushbutton is pressed. As shown in Figure 8, the red arrow of the sidestick priority light lights up opposite the copilot. If the copilot moves the sidestick, the CAPT light lights up opposite the captain.



Source: French Bee FCOM

Figure 8: Priority left lights

In the case of the F-HREV incident, the copilot initially reacted to the captain's call for a go-around by selecting a nose-up pitch and TOGA thrust. Subsequently, it can be seen that there were no inputs on the sidestick despite the off-centre FD bars, that there was no response to the PM's orders to descend to 2,000 ft and no reaction to the altitude alerts. The copilot's reactions are symptomatic of a subtle incapacitation that we have qualified as cognitive incapacitation in this report. The surprise generated by the triggering of the predictive windshear warning, the stress and workload associated with initiating a go-around, and not understanding the aeroplane's reactions to his inputs (the copilot thought that the AP was engaged) may have caused a strong physiological response. The copilot may therefore have been temporarily unable to perceive or analyse new information and to respond to it.

The request for a go-around can be made by the two crew members. Nevertheless, in the case of the F-HREV occurrence, it is possible that the go-around initiative taken by the captain-PM immediately after the predictive windshear warning and without coordination with the copilot-PF may have destabilized the latter. The captain-PM's request to change the thrust mode may have continued to weaken the copilot in his role as PF.

As the copilot carried out some of the expected actions, the PM's decision to take over control was not obvious. It was necessary for the safety of the flight in view of the copilot's post-incident statement.

Subsequently, this cognitive incapacitation was not formalized and remained implicit between the crew members. In addition, the copilot kept the possibility of interfering with the management of the flight and did so several times during the occurrence: it is probable that he extended and then retracted the speedbrakes. Furthermore, he engaged AP2 without making a callout even though the captain was PF.

2.6 Similar events

2.6.1 Aeroplane State Awareness During Go-Around (ASAGA) study

In 2013, the BEA published an Aeroplane State Awareness During Go-Around study (ASAGA study[18]). The BEA estimated the number of go-arounds carried out by a pilot during his career. It emerged that in general:

- between two and four go-arounds for 1,000 flights are recorded;
- a medium-haul pilot carries out one go-around per year;
- a long-haul pilot carries out a go-around every five to ten years.

In the vast majority of the incidents and accidents analysed in the scope of the study, the flight path deviations were the result of the crew's loss of situational awareness leading to wide pitch and speed excursions.

(18) https://www.bea.aero/en/safety-studies/access-to-studies/aeroplane-state-awareness-during-go-around/

These ASAGA type occurrences were often associated with a disruptive element which surprised the crew before or during the application of thrust. The crews found themselves confronted with a situation in which they had to carry out a large number of actions (retraction of landing gear and flaps, management of flight path, interaction with the ATC, etc.) under strong time pressure. The study also showed that the high performance of modern aeroplanes may not be compatible with certain published missed approach procedures.

The F-HREV incident has several characteristic features of the loss of control of flight path scenarios revealed by the ASAGA study:

- the surprise effect for the crew on the unexpected initiation of a GA;
- the sudden increase in workload associated with the GA procedure;
- the difficulty in intercepting the published GA altitude (2,000 ft at Orly), close to the minima, in manual flight control;
- the small amount of time available to reach the stabilization altitude although the crew had used the GA SOFT mode which was one of the actions recommended by the BEA in the ASAGA study;
- the altitude only being stabilized after the management of the aircraft configuration had been completed in full.

In addition, in the questionnaires completed in the scope of the study, there were elements concerning the state of the pilots which were comparable with the state of the copilot during the event. Some indicated omissions in the management of the automatic systems and/or confusion while carrying out the go-around, with the pilots feeling uncertain and vague about the actions carried out. Others mentioned a high workload due to the surprise and difficulties in concentrating or holding to a known pattern.

The study also underlined the disruption that could arise from the ATC modifying the go-around flight path. In the F-HREV occurrence, there was no ATC instruction to modify the flight path. The go-around could therefore have been carried out using the published missed approach procedure and thus by engaging the AP, which would have substantially reduced the workload.

One of the ways identified during the ASAGA study to facilitate compliance with the published go-around procedure when flying manually is to increase the published missed approach altitude. A higher altitude would give the crew more time to carry out all the required actions during a GA, especially when there is a surprise effect.

2.6.2 Go-around at Orly

The BEA incident database was searched for go-arounds at Orly since 2000. The few occurrences that were found showed problems with overspeed warnings while changing the aeroplane's configuration or intercepting the stabilization altitude.

The investigation was not able to identify the study or elements which led to the missed approach altitude on all the QFU's at Orly being fixed at 2,000 ft. In the scope of the investigation and with the help of the air navigation services of Orly airport, statistics relating to go-arounds at Orly, covering the period 1 January to 31 December 2019, were analysed:

- ❒ 339 go-arounds were detected, i.e. around 28 GA per month.
- ❒ For the majority of them (73%), the stabilization altitude observed was 3,000 ft and not 2,000 ft (21%), the operational situation permitting it.
- ❒ Eight go-arounds exceeded the altitude by more than 200 ft: six with a stabilization altitude at 2,000 ft and two at 3,000 ft.

In other words, there are proportionally around ten times fewer go-arounds with an exceedance of 200 ft when the stabilization altitude is higher than 2,000 ft.

It should be noted that the BEA opened another investigation into an ASAGA type incident which occurred at Orly[19] three months previously: when the plane was on short final, the controller ordered the crew to perform a go-around due to a runway incursion. The crew increased power and climbed ahead to 2,000 ft before starting a left turn. During the turn, the aeroplane lost altitude, descended to 1,250 ft and then climbed to 3,000 ft. The crew carried out a new approach and landed without further incident at Orly.

[19] https://www.bea.aero/en/investigation-reports/notified-events/detail/serious-incident-to-the-boeing-737-registered-7t-vjm-operated-by-air-algerie-on-06-12-2019-at-paris-orly/

3 - CONCLUSIONS

The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation. They are not intended to apportion blame or liability.

Scenario

Established on ILS 25 at Paris-Orly, the copilot-PF disconnected the autopilot (AP) at 1,400 ft with a view to landing. Four seconds later, and without any forewarning, the crew were surprised by the predictive windshear warning, "GO AROUND, WINDSHEAR AHEAD" (**Phase 1**). The captain ordered a go-around which was flown in manual flight control by the copilot. This led to an immediate and brutal break in the crew's action plan, substantially increased their workload and considerably changed the rate of work after a flight of more than 11 hours. The flight phase suddenly became very dynamic, all of the occurrence sequence lasting around four minutes and the difference in altitude between the start of the go-around and the stabilization altitude at 2,000 ft being small.

The captain-PM's call for a go-around in immediate response to the predictive windshear warning may have contributed to the destabilization of the copilot-PF. The copilot thought that the AP was engaged whereas this was no longer the case, and made no input on the sidestick after the initiation of the go-around. The plane started to deviate from the missed approach path and the FD command bars progressively moved off-centre on the two axes. The copilot, confronted with the surprise effect in connection with the unexpected triggering of the predictive windshear warning, the change in the rate of work and the increased workload was then "absent" for a few minutes. This cognitive incapacitation was not initially identified by the captain or the relief pilot.

In the vertical profile, the go-around was continued to around 800 ft above the stabilization altitude, and this despite the position of the FD command bars, the altitude alerts and the altitude calls made by the captain-PM and relief pilot. Although the captain had quickly identified this flight path deviation, he took over control of the aircraft and started correcting the flight path more than 50 s after busting 2,000 ft.

In the horizontal profile, it was the slight right input on the copilot's sidestick on increasing the nose-up attitude at the beginning of the go-around and not subsequently corrected, and the FD command bar indications not being followed, which resulted in the plane being around 650 m to the right of the runway centreline, and flying over the control tower.

The copilot then put the aeroplane into level flight at an altitude of around 2,800 ft. The captain had just put his hand on the sidestick when the copilot probably extended the speedbrakes without calling this out. After calling out "*I have control*", the captain engaged the AP (**Phase 2**) to return to the published missed approach path by turning left and descending to 2,000 ft. The case of the PM taking late control of the flight path once the aeroplane configuration changes had been completed, is typical of the occurrences in the study carried out by the BEA into Aeroplane State Awareness During Go-Around (ASAGA).

In the dynamic context of the go-around, the cognitive incapacitation of the copilot was not verbalized by the crew. The captain had to manage a high workload on his own: flight control and navigation as well as handing radio communications and the conflict with a plane taking off from runway 24.

The extension of the speedbrakes, very probably commanded by the copilot, led to an increase in the VLS and the activation of the low energy alert *"SPEED, SPEED, SPEED"*. For the captain, this was the third disruptive element at the end of this flight, coming after the predictive windshear warning and the copilot's incapacitation. The captain then returned to conventional manual flight control with the objective of increasing speed and then stabilizing at 2,000 ft. He temporarily put the thrust levers in the TOGA detent (which automatically caused the speedbrakes to retract) and disengaged the AP by his actions on the sidestick (which also disengaged the FDs due to the effect of a mode reversion). He continued the descent while monitoring the separation with the other aeroplane. In this very emotional situation, the stability of his manual flight control was affected.

During this descent and in reaction to a suggestion made by the relief pilot, the copilot engaged AP2 without coordinating this action with the captain. The latter was surprised and did not understand why the AP was engaged in V/S mode. This led to his firm request for silence in the cockpit, "*Everybody silent, I'm the only one giving orders*" to allow him to concentrate on the management of the flight. He then disengaged AP2 to engage AP1.

After a descent to 1,550 ft, the captain stabilized the plane at 3,000 ft as requested by air traffic control (**Phase 3**). As the copilot felt better, he became PM for the landing which took place without further incident.

Contributing factors

The following factors contributed to the initial path deviations in the go-around (**Phase 1**):

- The cognitive incapacitation of the PF, which by definition was difficult for the crew to identify. It was not possible to fully establish the reasons for this. However, the following factors may have contributed to its appearance:
  - the surprise effect linked to the unexpected triggering of the predictive windshear warning;
  - the initiative taken by the captain-PM, without conferring, with respect to the management of the flight during the go-around phase;
  - the workload associated with the go-around.
- The presence of several elements of a typical scenario of the BEA Aeroplane State Awareness During Go-Around (ASAGA) study:
  - the surprise effect linked to a disruptive element, without any forewarning;
  - carrying out the go-around in manual flight control at an altitude close to the stabilization altitude;
  - a complex missed approach procedure with a low stabilization altitude and a turn.
- The time taken for the PM to take over control.

After the captain had taken over control (**Phase 2**), the following factors may have contributed to the triggering of the low energy alert and to descending below the published missed approach stabilization altitude:

- the cognitive incapacitation of the copilot, which led to his intervening on the flight systems such as the speedbrakes and AP without calling this out;
- the captain's high workload as he had to manage the flight alone in a dynamic phase, which included the interactions with the ATC to manage the conflict with a departing aeroplane.

Safety lessons

Surprise training

The investigation report into the accident to the AF447 Rio-Paris flight[20] recommended introducing in pilot training, scenarios in which pilots are faced with surprises and unexpected situations:

"The startle effect played a major role in the destabilisation of the flight path and in the two pilots understanding the situation. Initial and recurrent training as delivered today do not promote and test the capacity to react to the unexpected. Indeed the exercises are repetitive, well known to crews and do not enable skills in resource management to be tested outside of this context. All of the effort invested in anticipation and predetermination of procedural responses does not exclude the possibility of situations with a "fundamental surprise" for which the current system does not generate the indispensable capacity to react.
The rapid increase in crew workload in an unusual and unexpected situation led to the degradation of the quality of communication and coordination between the pilots.

(20) https://bea.aero/fileadmin/documents/docspa/2009/f-cp090601.en/pdf/f-cp090601.en.pdf

Consequently, the BEA recommends that:

- *EASA review the requirements for initial, recurrent and type rating training for pilots in order to develop and maintain a capacity to manage crew resources when faced with the surprise generated by unexpected situations; [Recommendation FRAN-2012-042]*
- *EASA ensure that operators reinforce CRM training to enable acquisition and maintenance of adequate behavioural automatic responses in unexpected and unusual situations with a highly charged emotional factor. [Recommendation FRAN-2012-043]"*

In this respect, the sequence of events which led to the incident and which can be reproduced in a simulator, can serve as a training scenario in the surprise effect for crews in a rare and unexpected situation. Thus, the BEA invites air operators to take this feedback into account in their safety management system.

Taking over control

The occurrence illustrates the difficulty in identifying a situation of cognitive incapacitation of a crew member, and the difficulty in reacting to it, especially in a context where the workload has suddenly increased.

A totally or partially incapacitated pilot still has the possibility, consciously or unconsciously, of interacting with the aircraft's controls and of causing additional disruptions in an already difficult flight phase. In order to materialize the control take-over, the Airbus procedure specifies that the valid pilot calls out, "*I have control*" and presses the sidestick pushbutton for 40 s in order to:

- deactivate the other sidestick and avoid adverse inputs should the pilot collapse onto the controls in the event of a total incapacitation for example;
- emit the aural "PRIORITY LEFT/RIGHT" message, and illuminate the associated light in order to make the other pilot realise that he must not intervene in the conduct of the flight.

Lastly, when the flight control and navigation are stabilized and permit it, the procedure specifies that an emergency message shall be sent to the air navigation services.

Go-around briefing on final approach and use of automatic systems

The go-around is described during the approach briefing which on long-haul flights, is generally carried out 30 minutes before landing. According to the threats identified at the destination airport, the BEA invites air operators to give thought to:

- the appropriateness of having a "mini-briefing" during the final approach, covering the key points of the go-around (management of automatic systems, initial flight path, expected FMA modes, etc.), notably when it is identified as being complex and/or requiring considerable resources (typically with a low stabilization altitude and/or a turn), even for the airports often used by the operator;
- using the AP which should be the preferred mode for the management of complex flight paths.

4 - RECOMMENDATIONS

Note: in accordance with the provisions of Article 17.3 of Regulation No 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation in no case creates a presumption of fault or liability in an accident, serious incident or incident. The recipients of safety recommendations report to the issuing authority in charge of safety investigations, on the measures taken or being studied for their implementation, as provided for in Article 18 of the aforementioned regulation.

4.1 Study into increasing the published missed approach altitude at Orly airport

The occurrence of a disruptive element (in this case a predictive windshear warning) on approach triggered a crew decision to carry out a go-around. This started at an altitude of 1,400 ft, close to the published missed approach altitude of 2,000 ft. The crew reached the go-around altitude at 2,000 ft within 30 seconds and then exceeded it by more than 800 ft.

In this particular case, contributing factors to the go-around altitude being largely exceeded were the PF's incapacitation and the PM only taking over control of the flight once the aeroplane configuration changes had been completed. However, other operational circumstances may lead to similar occurrences. This incident recalls the conclusions of the BEA study on Aeroplane State Awareness during Go-Around which particularly underlined the fact that a low stabilization altitude with respect to the minima does not give crews sufficient time to carry out a go-around manoeuvre in good conditions and may not be compatible with the high climb performance of modern aircraft in an unexpected situation.

Some of the study proposals for the improvement of safety in similar situations were in place during the incident: notably, training pilots in manual go-arounds with all engines operative and soft go-arounds. However, a go-around procedure with a turn and low stabilization altitude with respect to the minima, is one of the factors which could be improved on. The BEA had recommended at a systemic level and thus not directly in relation to Orly that:

- ICAO indicate, during the design of a missed approach procedure, that a straight-ahead missed approach flight path must be given preference when that is possible [Recommendation FRAN-2013-048];
- ICAO introduce, in SARPS or PANS during the design of a missed approach procedure, that the first vertical constraint be as high as possible, taking into account the high performance of public transport aircraft, to carry out a standard go-around [Recommendation FRAN-2013-049];
- EASA, without waiting, in coordination with Eurocontrol, take the necessary steps to propagate the safety benefits from the above recommendations [Recommendation FRAN-2013-050].

Thus the main stake in carrying out a successful go-around relies on finding a way to give crews time to carry it out and to simplify their actions.

The configuration of the Orly airport runways means that the turn cannot be avoided. All that remains then is the possibility of acting on the altitude, given that the large majority of go-arounds are already carried out with a stabilization altitude above 2,000 ft. Statistics concerning go-arounds at Orly show that there are relatively more altitude deviations with a stabilization altitude at 2,000 ft than with a higher altitude. In addition, this is an old procedure and it was not possible to find the justifications for this stabilization altitude at 2,000 ft.

Consequently, the BEA recommends that:

- **whereas the climb performance of modern aircraft;**
- **whereas a go-around by a long-haul aeroplane at the end of a flight is a procedure which is rarely carried out in actual conditions and mobilizes considerable resources;**
- **whereas a low stabilization altitude requires crews to carry out all the tasks associated with a go-around procedure in a short time interval and induces a high risk of a significant deviation from the path, and even loss of control;**
- **whereas a higher stabilization altitude reduces the exposure to a go-around close to the stabilization altitude;**

the DSNA study the feasibility of increasing the published missed approach altitude at Orly airport.
[Recommendation FRAN 2021-004]