Contribution of Resilience to the Analysis of Flight Crew Decision-Making: Example of a Near-CFIT in Public Transport

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Abstract. It is noticeable that in some incidents crews deviate from standard procedures and continue the flight in deteriorating conditions until a triggering factor makes them return towards normal flight conditions. To be more precise, the procedures that frame the conduct of a flight refer to standards and are within a safety envelope that calls on training and reduced capacity for adaptation. The course of the flight and the reality of operational constraints may lead the flight crew to fly at the limits of the envelope. The situation can then deteriorate in a more or less prolonged or serious manner. When the crew reacts, if they do, their capacity for adaptation will either allow them to return to a normal situation or not. An investigation often makes it possible to explore the reasons for deviations from standards, though it is more difficult to explore the crew's determination to continue the flight in deteriorated conditions: the factors that lead a pilot to perceive danger and to decide to take corrective action remain little known, as do the resilient processes that are mobilized. Based on an example of a near-CFIT, we will demonstrate the need to better characterize the evolution over time of a crew's capacity to react when faced with a dangerous situation in order to limit the consequences.

1 INTRODUCTION

On Sunday 23 November 1997, on final ILS approach to Orly airport (Paris), the Captain of the MD83 registered F-GRMC, performed a go-around in Instrument Meteorological Conditions as the aircraft was passing the Outer Marker. The minimum radio height during the go-around was sixty-seven feet.

This document initially describes the specific context of the flight and the aircraft's manoeuvres during approach as analyzed on the basis of flight documents, recorded data and witness statements.

Causes clearly identified by the investigation are then presented along with the safety recommendations made by the BEA. The standard investigation process was particularly useful to highlight the reasons why the crew deviated from the approach path.

It seems it is more complex to analyse how the sequence then continued for so long into a deteriorated situation, far more challenging to highlight what the criteria were – if any – that triggered the Captain's decision to perform a go-around. The final part considers the possibilities presented by the principles of resilience engineering in undertaking investigations and safety studies in the future.

2 DESCRIPTION OF THE OCCURRENCE

2.1 Specific Context

Flight crew details

The crew consisted of a Captain instructor and two FO's on LOFT. The two FO's on LOFT occupied the co-pilot and observer seats alternately.

The airline

At the end of 1996, the airline had changed ownership and important management changes had been put in place. The arrival of an extra aircraft in April 1997 allowed significant growth in the MD83 sector. Since, in the winter of 1996-1997, it had been decided that there would be no recruitment, there was a shortage of flight crews for the winter of 1997-1998. There were 10 pilot instructors in the MD83 sector for forty-four captains and forty-two first officers. Around six months before the incident, the airline had thus decided to train twenty-two FO's and six Captains and undertake two first JAR 25 qualifications. The first wave of training, which included the two co-pilots on LOFT, had begun in October 1997.

Meteorological conditions

In the afternoon, low clouds, mist and fog, thick in parts, persisted to the north of the Seine. At Orly, at 12 h 30, the RVR at the threshold of 07 was 375 meters. With such visibility, the crew was not qualified to perform the planned landing since the Flight Officer was only qualified to perform restricted category 1 approaches. The Category 1 approach to runway 07 at Orly required an RVR of 600 meters.

2.2 History of Flight

Preparation, takeoff and en-route

On the previous day, the crew had flown the Orly-Nice-Orly-Toulon route legs and earlier that morning, they had flown the Toulon-Orly-Marseille route legs.

The aircraft landed at Marseille at 10 h 35. During the preparation of the Marseille-Orly flight, the crew received a meteorological dossier. The alternate airport was Paris-Charles de Gaulle. The flight dossier indicated that the aircraft was carrying 20,000 pounds of fuel. The Captain stated that he had loaded sufficient fuel in reserve to return to the South of France in case the meteorological conditions made a landing at Orly impossible.

At 11 h 25, the aircraft took off from Marseille with 131 passengers and 7 crew. The co-pilot was pilot flying. The flight took place without any notable events until the preparation of the approach to Orly. The auto-throttle and AP 2 were engaged throughout the flight.

The crew prepared category I, II and III precision approaches to runways 07 and 26 at Orly. At 11 h 53, Paris ATC announced RVR of 400 meters on runway 07. At 12 h 07 the Captain took over as pilot flying. At 12 h 14 min 43 s, the crew contacted Orly Approach which announced RVR of 500 meters.

Approach

During approach, the modes displayed on the FMA (figure 1) changed 30 times. The following description does not show all these modifications. Numbers 1 to 9 refer to the main steps of the approach as shown in figure 2.

***12 h 26 min 23 s* – Error in track selection**
The Captain selected track 258° on the VHF NAV 1 (left) instead of 065°.

Track 258° corresponded to runway 26, which had been used for the previous landing in Orly.
The co-pilot did not check the display.

(1) ***12 h 29 min 34 s* – End of radar vectoring and transfer to Tower**
Until this point, the aircraft was vectored by Orly approach to intercept the localizer.

At that moment, the aircraft was at an altitude of 3,000 feet, at a speed of 160 kt, on heading 020° for interception of the runway 07 ILS.

(2) **Crossing track 065°**
The co-pilot had selected track 065° on the OL VOR. He announced that the aircraft was crossing this track.

Intercepting the runway 07 ILS, the runway line-up deviation indicator began to move on the Captain's HSI as well.

(3) ***12 h 29 min 53 s* – RVR announcement**
Orly Tower announced RVR of 400 meters.

Such an RVR corresponded to a category 2 approach.

Subsequently the Captain did not call out the actions he took in relation to the automatic systems.

(4) ***12 h 30 min 20 s* – Crossing glide path**
The aircraft went above the approach path.

(5) ***12 h 30 min 40 s* – Descent**
The Captain armed the "autoland" mode, displayed an altitude of 2,000

The selected altitude of 2,000 feet corresponded to the preparatory go-around altitude.

	feet, selected a descent speed of around 2,300 feet per minute and a heading of 090.	*The aircraft began to descend in clear skies.*
(6)	**Error detection and Orly Tower indication** The Captain then realized that he had selected an ILS heading of 258° instead of 065° and corrected it. Orly Tower indicated that the aircraft was 1.5 NM north of the track.	*While the Captain was correcting the error and extending the flaps, the aircraft passed below the glideslope*
(7)	***12 h 31 min 26 s* – GPWS and AP off** At a radio-height of 916 feet, the GPWS "Glideslope" warning was recorded by the Quick Access Recorder (QAR) for 45 seconds.	*The aircraft entered the fog at that moment or a few seconds later. During the descent, the FO saw that the bar of the glideslope was up against its stop and said "glide" twice.*
	The Captain disconnected the AP but did not initiate any manoeuvres.	*It was not possible to identify the reason why he did so.*
(8)	***12 h 31 min 49 s* –AP on** The Captain connected the AP and then armed the "autoland" mode.	*The Captain probably connected the AP because he saw "LOC CAP" displayed on the FMA and thought he could still carry out the approach.*
(9)	***12 h 31 min 56 s* – AP off and go-around** The Captain disconnected the AP and initiated a go-around.	*At that moment, the radio-height was about 200 feet. At 12 h 32 min 09 s, the minimum radio-height of 67 feet and the Outer Marker signal were recorded. The co-pilot later stated that he saw the ground and read a radio-height of about 50 feet.*

Fig. 1

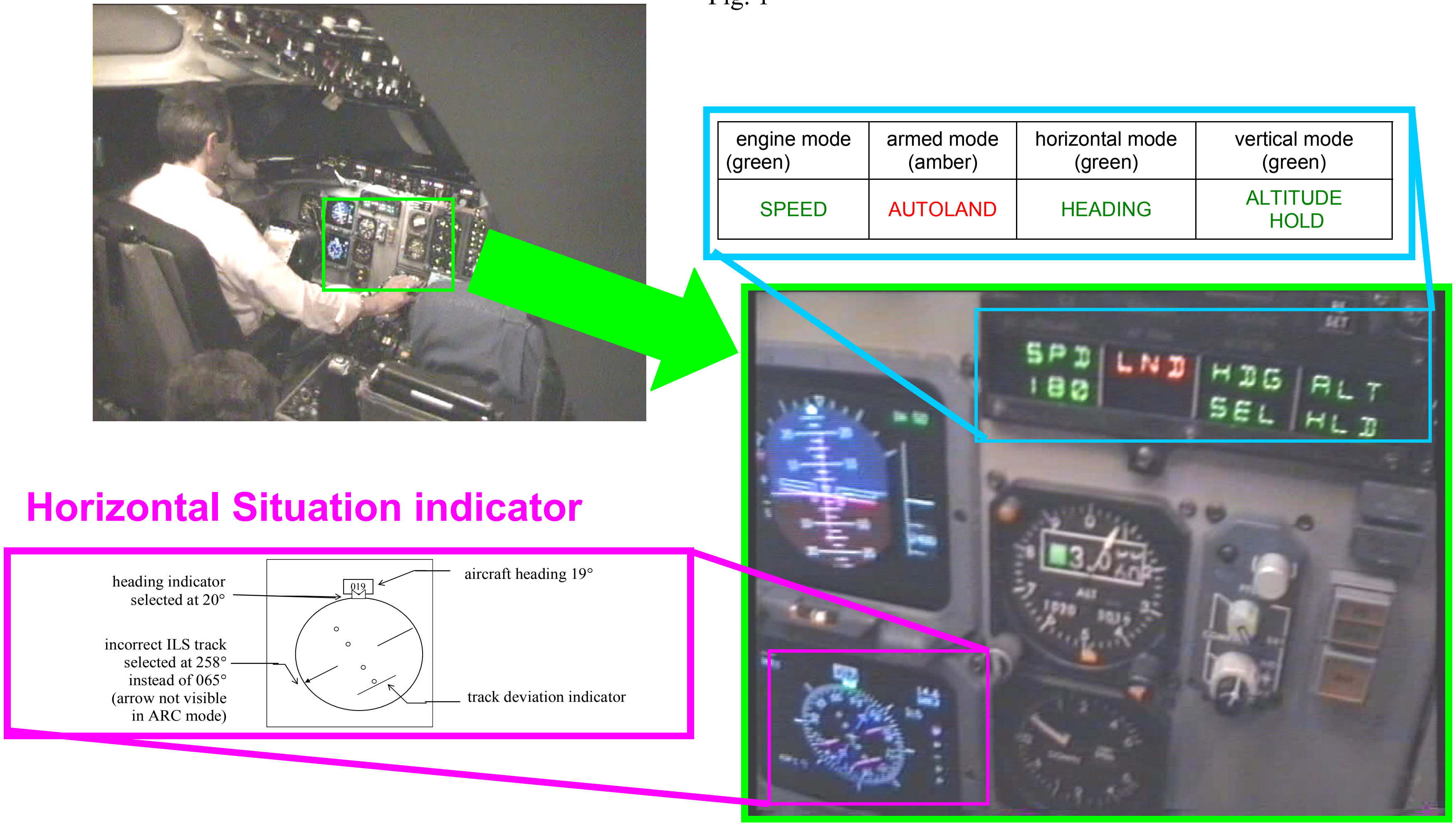
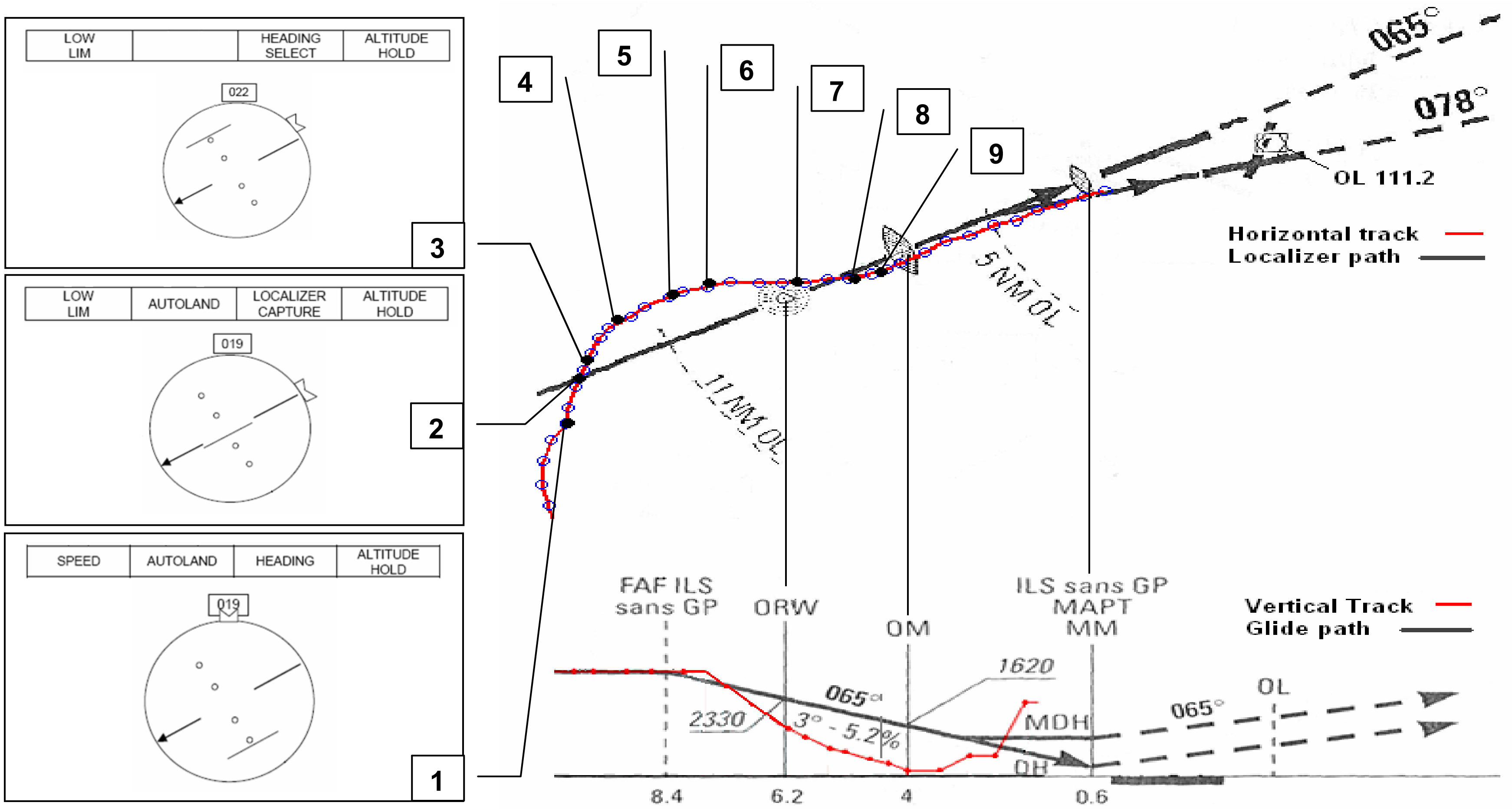

engine mode (green)
armed mode (amber)
horizontal mode (green)
vertical mode (green)
SPEED
AUTOLAND
HEADING
ALTITUDE HOLD
SPD 180
LND
HDG SEL
ALT HLD
Horizontal Situation indicator
heading indicator selected at 20°
aircraft heading 19°
019
incorrect ILS track selected at 258° instead of 065° (arrow not visible in ARC mode)
track deviation indicator

Fig. 2



This is an illustration and should not be considered as the real trajectory.

3 RESULTS OF THE INVESTIGATION: PROBABLE CAUSES AND ASSOCIATED SAFETY RECOMMENDATIONS

The report concluded that the incident resulted from the decision to put the aircraft into descent when, as a result of a display error, it was neither on the localizer track nor on the glide path, and with no context defined for this improvised manoeuvre. Consequently, the BEA made three recommendations concerning the presentation of horizontal and vertical position data on new generation aircraft and the difference between the active modes displayed on the FMA and those in which the aircraft is effectively engaged at any given moment

The operator's company culture directly contributed to the incident through the importance it attached to accelerated training given to new copilots and to undertaking commercial flights. As a result, the BEA issued recommendations about training, regarding the calculation of flights really performed as members of the crew by pilots in training and the number of in-flight inspections, particularly in case of a major increase in an airline's activity.

Other contributory factors were:

- the pilot's fatigue;

The BEA proposed that information should be provided to airlines in order to allow the modification of flight planning so as to avoid pilots exceeding the statutory work time. It was also suggested that regulations on flight crew work time take into account all aspects that cause fatigue.

- the imbalance in the flight crew, made up of a very experienced instructor and an under-trained FO, which led to the abrupt disappearance of teamwork and procedures the moment the workload increased. The Captain did not state his intended actions to the inexperienced FO, who he considered to be a student and who thus became a simple spectator. Finally, rather than aborting the approach, he continued with it while trying to understand what was going wrong.

Concerning this question, the BEA recommended the presence of an additional pilot trained in supervision during flights in the context of LOFT.

- aircraft warning system ergonomics and a fault in the automatic pilot system.

It was recommended that the certification requirements take into account the overall management of alarms in the cockpit. As regards the automatic pilot, the BEA recommended that clear specifications concerning ILS capture be ensured.

Some other safety recommendations were made by the BEA that mainly concerned aerodrome documentation, ground systems and meteorological and administrative procedures.

4 CONSIDERATION OF NEW ANALYSIS MODEL INTEGRATION

To explain the inappropriate decision by the crew, the BEA focused on systemic factors that may, for instance, have contributed to the pilot's high level of fatigue and the high workload during the approach. Ten years later, it may be useful to try to analyze the crew's behaviour through different perspectives, taking this opportunity to define new models.

Indeed, new models would better account for the complex interaction between the parameters that determine our system and its safety margins. We can suppose that the Captain's situational awareness depended on factors such as his state of mind – fatigue and increasing workload – and on his interpretation of the instrument displays. Since the workload evolved erratically and the instrument displays reflected the motion of the aircraft as decided by the Captain, in response to his situational awareness, these parameters interact non-linearly. Moreover, parameters such as the Captain's situational awareness and the spatial position of the aircraft evolved in different time frames.

The crew was forced into the position of managing a crisis while they were handling the airplane's flight track alone, after the end of radar vectoring by the controller. We can consider that the triggering conditions for such a crisis resulted from the progressive lowering of barriers throughout the flight up until ILS interception: at departure, the composition of the flight crew would only have allowed them to continue the approach as far as the OM, bearing in mind the meteorological conditions at the destination; the Captain's take-over of the controls led him to being cut off; the error in selecting the track on the HSI constituted an additional disturbing factor. It would, however, be reasonable to question the validity of this interpretation. In fact, in the course of the investigation, simulations were performed in a flight simulator with a view to confirm the modes triggered by the crew. They revealed that in a similar situation – wrong track selection – it was possible for a pilot to put the aircraft into a descent that would lead the flight into a deteriorated situation.

In the case of this event, the crisis became apparent as soon as the automatic system was unable to intercept the ILS and the regulatory mechanisms did not make it possible to counter the previous failings. From this moment on, the Captain tried to manage the crisis alone by calling on techniques and means that he knew and to which he usually had recourse.

The disconnection of the AP at 12 h 31 min 26 s by the Captain might be regarded as a marker point in an ongoing process, which in this case led him to the decision to go around. Finally, according to the Captain's statement, the key factor in initiating a missed approach was non-stabilization; neither the altitude nor alarms were taken into account in his assessment. Therefore, it seems that his decision was out of phase in relation to the actual flight sequence.

Thus, it appears that the evolution of this event places it into the category of a resilient process, something that the models traditionally employed in accident investigation make it impossible to develop.

GLOSSARY

LOFT	Line Oriented Flight Training
FMA	Flight Mode Annunciator
GPWS	Ground Proximity Warning System
HSI	Horizontal Situation Indicator
ILS	Instrument Landing System
FO	First Officer
AP	Automatic Pilot
QAR	Quick Access Recorder
OM	Outer Marker
RVR	Runway Visual Range
VOR	VHF Omnidirectional Radio Range

FINAL REPORT

The Final report (French and English versions) is available on the BEA website: www.bea-fr.org