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

www.bea.aero

REPORT
Serious Incident

Deviation below manoeuvring airspeed on final, go-around, triggering of Alpha Floor protection

Aircraft	Airbus A320-214 registered F-HEPE
Date and time	3 April 2012 at 12 h 56(1)
Operator	Air France
Place	Tel Aviv Ben Gurion Airport (Israel)
Type of flight	Scheduled public passenger transport
Persons on board	captain (PNF), copilot (PF), 4 cabin crew and 149 passengers
Consequences and damage	None

(1)The times given in this report are expressed in universal coordinated time (UTC).

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.

1- HISTORY OF FLIGHT

Note: the following elements are taken from data extracted from the Quick Access Recorder (QAR), radio communication recordings and crew interviews. The cockpit voice recording (CVR) of the event was no longer available at the time the BEA was notified of the event.

The crew was performing a flight between Paris Charles de Gaulle and Tel Aviv Ben Gurion airports. The meteorological conditions on arrival were CAVOK.

At 12 h 49, the Tel Aviv controller cleared the crew to make an approach to runway 26 via KEREN point (see chart below), according to the RNAV VISUAL procedure.

At about 10 NM from DOVER point, the controller requested that the crew reduce speed to minimum manoeuvring speed in clean configuration. The aeroplane was stable at 4,000 ft. The autopilot, auto-thrust and flight directors (AP, A/THR and FD) were engaged. The speed selected was 210 kt. ATC asked the crew to reduce speed to below 180 kt from DOVER point.

Shortly before this point, the crew displayed an altitude of 3 000 ft on its flight control unit (FCU). The descent was then carried out in DES/NAV mode.

At 12 h 53 min 56, the aeroplane passed KEREN point at a speed of 180 kt, and at an altitude of 3,280 ft(2). The PF indicated having the feeling of being "too high, too fast": she did not share her doubts with the PNF who did not notice any particular difficulty. The aeroplane captured the 3,000 ft altitude.

(2)The KEREN point passing altitude mentioned on the approach chart is 3,000 ft.

At 12 h 54 min 30, from the middle of the downwind leg, the crew selected an altitude of 1,000 ft(3) and changed from vertical mode DES to OPEN DESCENT. Engine thrust decreased to idle. Ten seconds later, the crew engaged "managed speed" and then extended the landing gear and changed to configuration 3. Several seconds later, they changed to FULL configuration which led to a decrease in speed towards the Vapp approach speed, which is 138 kt.

(3)The DALIT point passing altitude mentioned on the approach chart is 1,250 ft.

At 12 h 56 min 05, before the last turn, at 1,540 ft, the autopilot was disconnected manually; the A/THR and FD remained engaged. The PNF stated that he was focused on capturing the approach path and with external monitoring of an aeroplane preceding them on final.

At 12 h 56 min 10, during the last turn with a bank of about 20°, the PF made a pitch-up input for about ten seconds[4]. The recorded parameters indicated that during this phase the FD command bars gave a pitch-down order to maintain the target speed with the engines on idle. Pitch attitude increased from 0.7° to 10°, the angle of attack from 5.5° to 10.9° and the speed decreased from 135 kt to 122 kt, that is Vapp-16 kt.

[4]The investigation could not determine the reason why the PF made a pitch-up input.

The crew indicated having heard the "SPEED, SPEED, SPEED" aural warning during the turn. The PF then carried out a go-around without calling it out to the PNF and placed the thrust levers into the TOGA detent. For two seconds, the PNF gave a pitch down order contradicting the PF's inputs[5], without pressing the takeover pushbutton on the sidestick. He indicated that he still had in mind to continue the approach.

[5]The PNF's input had no effect on the flight path.

Two seconds later, the ALPHA FLOOR mode engaged, followed by the TOGA LOCK mode.

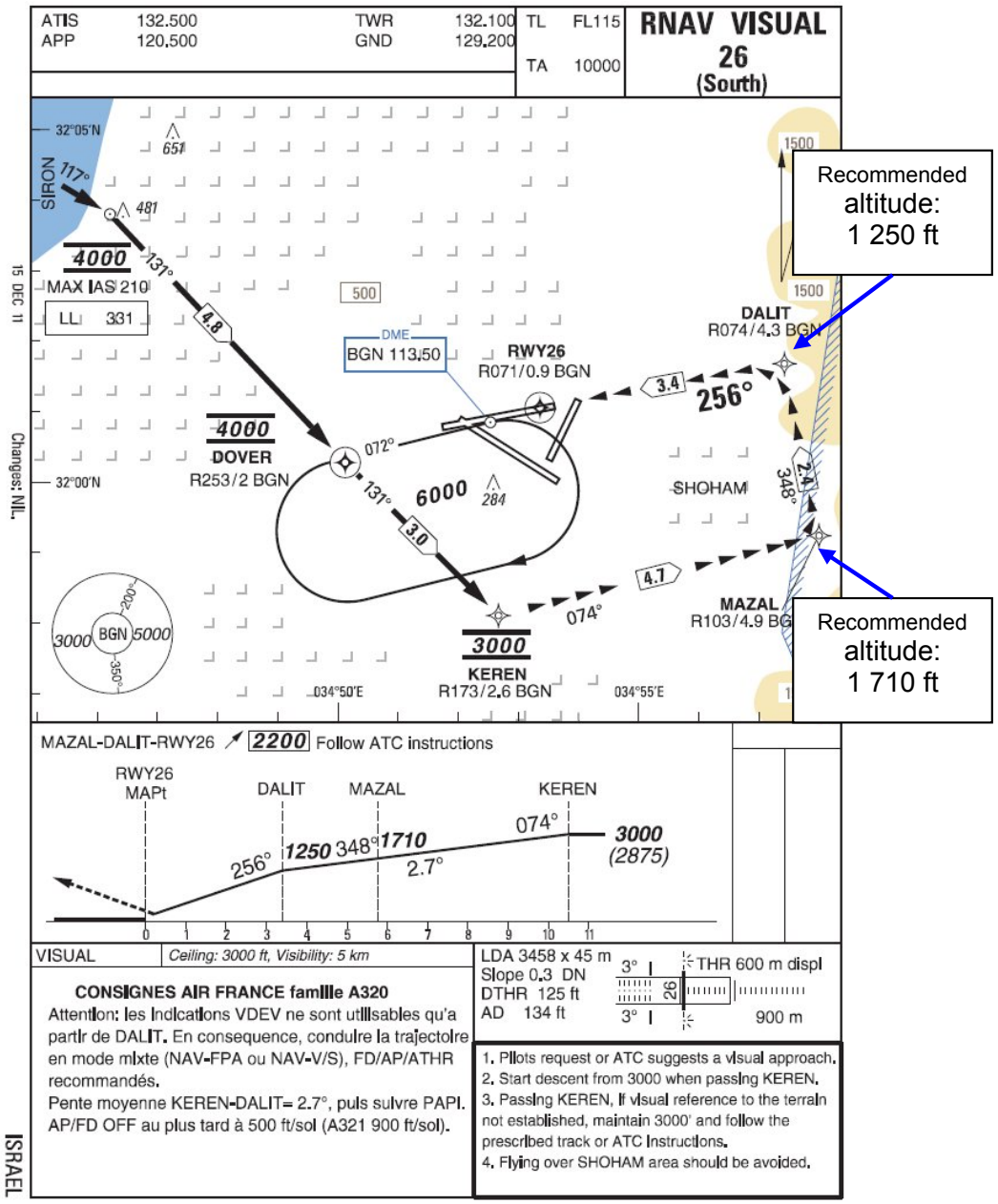
The crew selected configuration 3 and an altitude of 3,000 ft[6]. The speed was increasing. The PF pulled back the thrust levers to CLIMB, without any effect on thrust: TOGA LOCK mode was still engaged but the crew had not identified it. The PNF mentioned that the PF had experienced difficulties in reducing thrust.

[6]The go-around altitude mentioned on the approach chart is 2,200 ft.

Approaching 2,000 ft, the crew selected an altitude of 2,000 ft, re-engaged the autopilot, retracted the landing gear and selected configuration 1. The crew then selected a speed of 188 kt. The speed was then 208 kt and continued to increase. As a result of its inertia, the aeroplane reached a maximum altitude of 2,500 ft.

The speed reached 223 kt. The VFE in configuration 1 was 215 kt. The crew heard the overspeed warning. The PF moved the thrust levers to IDLE, which disengaged the A/THR and the TOGA LOCK mode.

The crew reengaged the A/THR, carried out a second approach and landed without difficulty.



Air France approach chart for the RNAV VISUAL procedure on runway 26 from the south valid on the date of the event

2 - ADDITIONAL INFORMATION

2.1 Personnel Information

At the time of the event, the 58-year-old Captain had a total of about 20,000 flying hours. He had started his career as a flight engineer and then performed 8,000 flying hours as copilot on A320 and A330/A340 aeroplanes and 1,800 hours as captain on A320s.

The copilot was 27 and had a total of 500 flying hours including 200 as copilot on A320s.

2.2 Systems Description

2.2.1 A/THR

The A320 is equipped with A/THR to automatically manage engine thrust when this system is engaged by the crew.

The A/THR can operate as follows:

- In THRUST mode, the A/THR maintains the thrust level;
- In SPEED mode, the A/THR adjusts the thrust to maintain speed;
- In ALPHA FLOOR mode, the A/THR applies maximum TOGA thrust.

The A/THR can operate with or without the AP and/or the FD. When the A/THR operates alone, it is in SPEED mode. However, when the A/THR operates with the FD, it is coupled with the FD vertical control mode:

- When the FD indicates a vertical trajectory to follow, the A/THR controls the speed;
- When the FD is linked to a target speed, the A/THR controls the thrust.

2.2.2 Vertical AP/FD OPEN DESCENT mode

In OPEN DESCENT mode, the AP/FD maintains a target speed by controlling the longitudinal mode. When engaged, the A/THR maintains IDLE thrust. The flight director indicates the pitch attitude required to maintain speed.

Analysis of the flight data showed that during the last turn, when the PF made a prolonged pitch-up input, flight director displayed a pitch-down order.

2.2.3 SPEED, SPEED, SPEED low energy warning

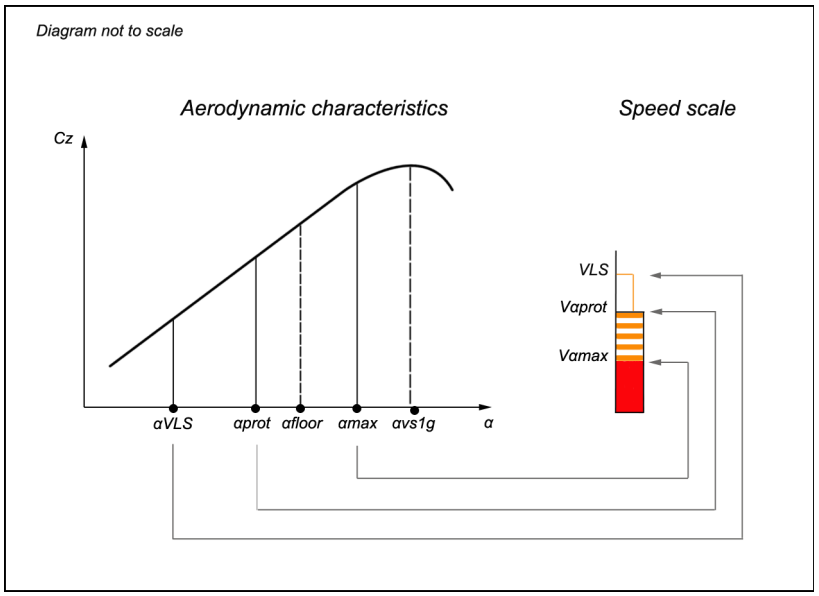
An aural warning indicates to the pilot that the speed is too low and that the aeroplane's energy is lower than the threshold below which thrust must be increased and the pitch attitude adjusted.

This warning is activated during deceleration, before triggering of the ALPHA FLOOR mode.

A procedure associated with the SPEED, SPEED, SPEED warning appears in the QRH. It specifies that thrust should be increased until the warning stops and to adjust the pitch attitude if required.

2.2.4 High angle of attack protection

The normal flight law offers protection, particularly in relation to high angles of attack.



When the aeroplane angle of attack increases and becomes greater than the αprot angle of attack threshold, the pitch control system changes to protection mode. The automatic pitch-up compensation stops and the angle of attack varies in proportion to sidestick deflection.

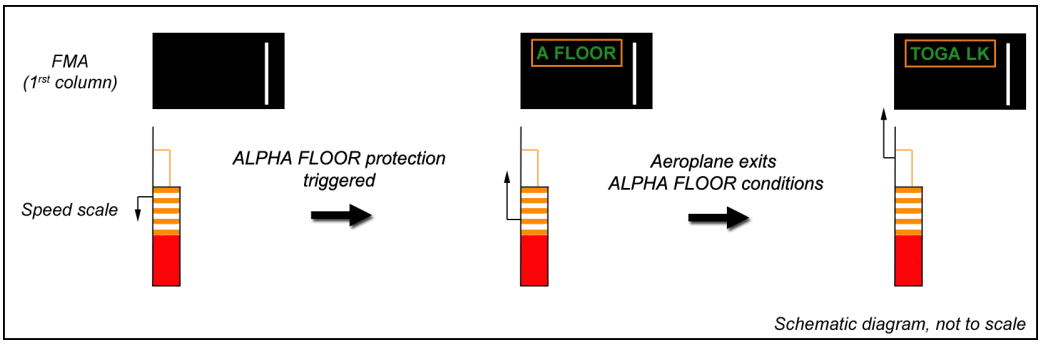
If the angle of attack increases and reaches an αfloor threshold value, the A/THR changes to ALPHA FLOOR mode and automatically commands the maximum TOGA thrust and then maintains it whatever the position of the thrust levers. The locking of this maximum thrust is called TOGA LOCK. Pilot inputs on the thrust levers no longer control thrust. This mode can only be disengaged by manual disconnection of the A/THR.

In this mode, various indications are displayed:

- On the FCU, the A/THR push-button lights up, if the A/THR was not already engaged;
- On the FMA:
  - A FLOOR appears in green, surrounded by an amber flashing rectangle, as long as the ALPHA FLOOR conditions are present;

  - TOGA.LK appears in green, surrounded by an amber flashing rectangle, instead of A.FLOOR when the angle of attack becomes 3 degrees less than the angle of attack triggering the ALPHA FLOOR mode;

  - Maximum TOGA thrust is locked;
  - A/THR is displayed in white;



- On the E/WD, A.FLOOR is displayed in amber and the word TOGA appears in blue with the percentage value.

No aural warning is associated with triggering of the ALPHA FLOOR mode.

2.3 RNAV VISUAL approach procedure

The RNAV VISUAL concept was developed in the USA in the 2000's to overcome destabilisation problems during visual approaches. An FAA audit showed that aircraft RNAV capability was little or badly used. The US Order 8260.55[7] was made official in 2008 in order to better use these capabilities.

[7] consultable at http://www.faa.gcv/documentLibrary/media/order/8260.55.pdf

In RNAV VISUAL approach, guidance is ensured laterally by the FMS. The approach is carried out visually: the crew ensures separation with other aircraft and the terrain.

This approach concept is quite commonly applied in the USA. Each airline wishing to use the RNAV VISUAL procedures must make a request to the FAA to obtain approval. The airlines must then justify specifically that aeroplanes, procedures and crew training are appropriate.

For airlines having received approval, it is on the basis of a crew request that a RNAV VISUAL approach may be granted or not by ATC.

The concept of RNAV VISUAL approach does not appear in the EU-OPS regulation, this type of approach not being used yet in Europe. At the time of the incident, the procedure was not clarified in the Air France Technical Use manual (TU).

Tel Aviv is the only destination in the Air France short/medium haul network with this type of approach. The RNAV VISUAL approach may be proposed at air traffic control's initiative to all crews.

2.4 Tel Aviv approach chart published by Air France

The RNAV VISUAL 26 approach chart box (from the south or north) supplied by Air France to its crews specifies:

> *Attention : les indications VDEV[(8)] ne sont utilisables qu'à partir de DALIT. En conséquence, conduire la trajectoire en mode mixte (NAV-FPA ou NAV-V/S), FD/AP/ATHR recommandés.*
> *Pente moyenne KEREN-DALIT=2,7°, puis suivre PAPI. AP/FD OFF au plus tard à 500 ft/sol.*

[(8)] Indication of the vertical position of the aeroplane in relation to the descent profile calculated by the FMS.

On A320 family aeroplanes, it is technically impossible to code several descent paths in the FMS. Air France did not wish to code a continuous descent path from KEREN to avoid possible GPWS warnings. The airline chose to code the profile only from DALIT, which explains why the VDEV was not usable before this point.

Air France therefore recommends descending on the KEREN – DALIT segment in NAV-FPA mode with a slope of -2.7° or in V/S mode. These modes combine in fact with the A/THR SPEED mode which maintains a target speed.

During the incident flight, the PF specified that the ILS 26 approach had been prepared but that the RNAV VISUAL 26 approach had been subject to a briefer preparation. She had already carried out the ILS 26 approach on three occasions but had never carried out the RNAV VISUAL 26 approach. She stated that the announcement of this approach by the controller was made late and was not the subject of a fresh briefing. The PNF also stated that he was not very familiar with this destination.

2.5 Repetitive nature of the incident

Five days later, a similar event occurred on the same approach with the Airbus A320 registered F-GKXO and a different crew from the same airline. During this second event, the crew reacted as soon as the SPEED, SPEED, SPEED alarm sounded: the crew adjusted the thrust and continued the approach without the ALPHA FLOOR protection mode engaging.

3 - LESSONS LEARNED AND CONCLUSIONS

3.1 RNAV VISUAL approach by Air France crews

Tel Aviv is the only destination in the operator's short/medium haul network offering an RNAV VISUAL approach: making this type of approach is therefore quite rare for the airline's crews.

At the time of the event, the RNAV VISUAL approach concept was not described in the Air France TU and crews were not trained for it on simulator.

3.2 Application of the RNAV VISUAL concept in Tel Aviv

Implementation of the Tel Aviv RNAV VISUAL approach departs from the principle which oversaw its development by the FAA in the USA. It is proposed by ATC whereas normally the onus is only on crews of approved airlines to request it.

3.3 CRM[9] evaluation

[9]In the absence of cockpit voice recording (CVR), the CRM evaluation was based solely on crew interviews.

During the pre-flight briefing, the crew had briefly prepared the RNAV VISUAL 26 approach: the specific features of this approach had not been identified. The PF had little experience and had never carried out this approach.

The PNF had not anticipated the PF's difficulties. He did not offer to detail the key points of this unusual approach during the briefing.

From KEREN point onwards, the PF had a feeling of discomfort in the conduct of the flight: she did not share her doubts with the PNF and did not call out her actions. During the last turn, the crew explained that they focused their attention on the flight path and were no longer monitoring the flight parameters.

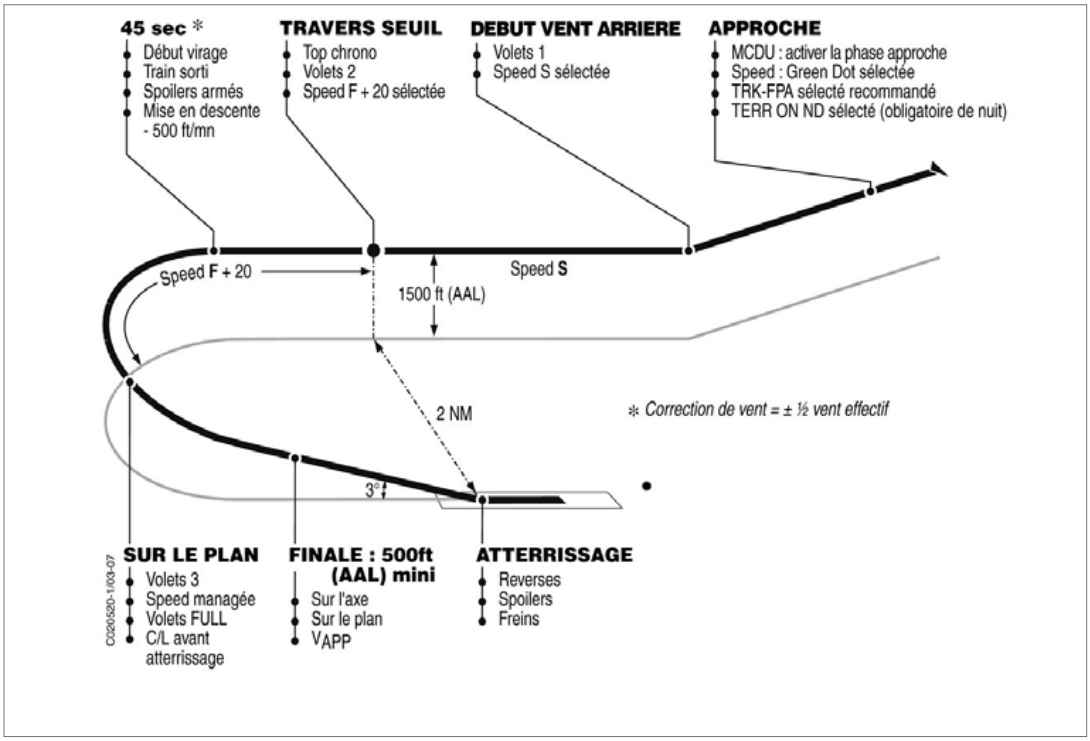
3.4 Management of the descent

The operator's procedures given on the Tel Aviv RNAV VISUAL 26 approach chart recommend carrying out the approach in vertical NAV-FPA or NAV-V/S mode. In these modes, the A/THR adjusts the thrust in order to maintain the target speed.

The crew chose to use the OPEN DESCENT mode. In this mode, the engines are maintained on idle and speed monitoring must be ensured by following FD indications.

Feeling "too high, too fast", the PF configured the aeroplane very early at the end of the downwind leg in FULL configuration with landing gear extended.

The standard visual approach procedure recommended by Air France and the manufacturer provides for changing to configuration 3 then FULL once established on the glide path, just before lining up on final.



Standard visual approach procedure recommended by Air France on the day of the event

As the speed was managed, the target speed became approach speed Vapp during the change to FULL configuration. In this configuration the stall margin is lower than at target speed "F" in configuration 3. The aeroplane therefore had a lower energy level to carry out the last turn.

During this last turn, the PF made a pitch-up input for ten seconds in contradiction with the FD orders. The load factor increased, as did the threshold speed of the ALPHA FLOOR protection. The speed dropped to below VLS until triggering of the ALPHA FLOOR protection.

Both pilots indicated that they thought that the A/THR would adjust the thrust to maintain speed. The PF's pitch-up input without intervention from the PNF showed that the crew had not identified the risk associated with not following the FD in OPEN DESCENT mode.

3.5 Management of the go-around: difficulty in disengaging the TOGA LOCK, overspeed

During the triggering of the SPEED, SPEED, SPEED warning, the PNF noticed the low speed. In reaction, for a few moments he gave a pitch down order in contradiction with the PF's pitch-up inputs.

When the PF performed the go-around, she did not call it out. The PNF did not have the same awareness of the situation: he thought they were continuing the approach. Neither of the pilots communicated their plan of action.

Triggering of the ALPHA FLOOR mode was almost simultaneous with the PF's decision to go around. As a result she did not identify the locking of the TOGA LOCK maximum thrust which impaired her awareness of the situation. This may explain the difficulty she encountered in dealing with the thrust. The PNF did not identify the ALPHA FLOOR mode.

The crew selected the slats and flaps to configuration 3 whereas the speed increased and they selected an altitude higher than the published go-around altitude. The PF pulled back the thrust levers to CLIMB position, which had no impact on the thrust because of the locking of the TOGA LOCK maximum thrust.

While approaching the published go-around altitude, the crew selected it on the FCU. They also re-engaged the autopilot, retracted the landing gear and brought the slats and flaps to position 1. Under the effect of maximum thrust, the aeroplane went into overspeed and the associated warning was triggered. As a reflex action, the PF then selected the thrust levers to IDLE which disengaged the A/THR and, as a result, TOGA LOCK.

3.6 Incident on 8 April to F-GKXO

The investigation conducted on the incident that occurred to F-HEPE brought to light a number of elements that were found during an incident that occurred five days later to the F-GKXO. In both cases:

- The approach was conducted in OPEN DESCENT mode;
- The conduct of flight was carried out AP OFF, A/THR ON and FD ON;
- The indications on the approach chart concerning the NAV-FPA or NAV-V/S modes were not applied;
- The PNF, in the left seat for a left turn, was not monitoring the speed;
- The PF did not follow FD orders;
- The aeroplane had been configured very early at the end of the downwind leg (in configuration 3 in the case of F-GKXO).

3.7 Causes

The proposal of an RNAV VISUAL approach by Tel Aviv ATC to all airlines indiscriminately, departing from the initial concept, the absence of training in RNAV VISUAL approaches at Air France at the time of the event and the short preparation for the approach made by the crew did not allow the Captain to anticipate the PF's difficulties in performing this unusual approach.

In addition poor understanding of A/THR operation and of the importance of following the FD in OPEN DESCENT mode, which led the crew to believe that A/THR would ensure that speed was maintained. Failure to identify the risks associated with the selection of FULL configuration at the end of the downwind leg in OPEN DESCENT mode and inadequate monitoring of the flight parameters led to deviating below the manoeuvring airspeed before the last turn.

During the last turn, while the aeroplane had an insufficient energy level, given its configuration, a prolonged pitch up order led to the triggering of the low energy SPEED, SPEED, SPEED warning and then of the ALPHA FLOOR protection.

4 - RECOMMENDATIONS AND SAFETY ACTIONS

Note: In accordance with Article 17.3 of European Regulation (EU) 996/2010 of the European Parliament and Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation shall in no case create a presumption of blame or liability for an accident, a serious incident or an incident. The addressee of a safety recommendation shall inform the safety investigation authority which issued the recommendation of the actions taken or under consideration, under the conditions described in Article 18 of the aforementioned Regulation.

4.1 Measures taken by the airline

Some weeks before the incident, on 27 February 2012, Air France's Flight Safety Directorate published a Flight Safety Flash. This document dealt with the issue of deviation below manoeuvring airspeed on visual approach and presented five events that led to an ASR. It underlined among other things the need for the PF to closely follow the indications given by the FD as well as the importance of the PNF monitoring the primary flight parameters.

After the incident, simulator training on the Tel-Aviv RNAV VISUAL 26 approach began in March 2013. This exercise is intended to raise awareness among all crews of the specific features of this approach.

In addition, an information leaflet, "Info BIT A320", on the specific features of the Tel-Aviv RNAV VISUAL approach was issued in October 2012 to all pilots of the airline's A320 family. A video presenting the specifics of this approach was also made and made available to pilots.

The establishment of a specific procedure for RNAV VISUAL approaches in the airline's documentation is currently under consideration and should be published shortly.

4.2 Safety Recommendations

4.2.1 Comprehension of automatic systems

The investigation revealed a lack of knowledge of A/THR operation and the importance of following the FD in OPEN DESCENT mode. The same lack of comprehension of automatic systems was found in the event that occurred five days later to F-GKXO.

Consequently and in addition to the awareness-raising campaign for the use of automatic systems that was initiated in 2012 by Air France, the BEA recommends that:

- **EASA, in partnership with national civil aviation authorities, ensure that training and recurrent training programmes include instruction on the risks associated with the use of OPEN DESCENT mode on approach. [Recommendation FRAN-2013-86]**

4.2.2 Application of the RNAV-VISUAL approach concept

The RNAV VISUAL approach concept is based on approval from the civil aviation authority requested by each airline. It is up to the crew of an airline that has obtained this approval to request an RNAV VISUAL approach and up to ATC to grant it or not, depending on the conditions on the day. The investigation showed that at Tel-Aviv it was ATC that proposed this type of approach to all crews, indiscriminately.

Consequently, the BEA recommends that:

- **ICAO define in its standards and recommended practices a framework for RNAV VISUAL approaches; [Recommendation FRAN-2013-87]**

- **Pending the implementation of provisions by ICAO, the civil aviation authority of Israel ensure that the Tel-Aviv ATC only authorises RNAV VISUAL approaches for crews of airlines that have received approval and who have made a prior request for it. [Recommendation FRAN-2013-88]**