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INVESTIGATION REPORT

Incident to the Boeing B737-800 registered EI-EMK operated by Ryanair on 29 January 2015 on approach to Bergerac-Roumanière airport (Dordogne)

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

Illustration photo / Balazs Meszaros / Airliners.net

BEA2015-0037.en/September 2020

Safety investigations

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SPECIAL FOREWORD TO ENGLISH EDITION

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation published in June 2020. As accurate as the translation may be, the original text in French is the work of reference.

Contents

Glossary

AAIB	Air Accidents Investigation Branch (UK investigation authority)
AAIU	Air Accident Investigation Unit (Irish investigation authority)
AIP	Aeronautical Information Publication
ALT ACQ	Altitude Acquire
ALT HOLD	Altitude Hold
ANR	Active Noise Reduction
ANSP	Air Navigation Service Provider
ATIS	Automatic Terminal Information Service
ATPL	Airline Transport Pilot Licence
CPL	Commercial Pilot Licence
CVR	Cockpit Voice Recorder
DGAC	*Direction Générale de l'Aviation Civile* (French civil aviation authority)
DME	Distance Measuring Equipment
DSNA	Direction des Services de la Navigation Aérienne (French air navigation service provider)
E-GPWS	Enhanced Ground Proximity Warning System
EASA	European Aviation Safety Agency
EU	European Union
FAF	Final Approach Fix
FCL	Flight Crew Licence
FCOM	Flight Crew Operating Manual
FD	Flight Director
FDR	Flight Data Recorder
FL	Flight Level
FMS	Flight Management System
Ft	Feet
GNSS	Global Navigation Satellite System
HDG	Heading
ICAO	International Civil Aviation Organization

ICAS	International Council of the Aeronautical Sciences
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IR	Instrument Rating
Kt	Knot
LNAV	Lateral Navigation
MAP	Missed Approach Point
MCP	Mode Control Panel
MDA	Minimum Descent Altitude.
MSA	Minimum Safe Altitude
MSAW	Minimum Safe Altitude Warning
NDB	Non Directional Beacon
NM	Nautical Mile
NPA	Non-Precision Approach
NTSB	National Transportation Safety Board (American investigation authority)
PBN	Performance Based Navigation
PF	Pilot Flying
PM	Pilot Monitoring
QFU	Magnetic bearing of runway in use
RCA	*Règlement de la Circulation Aérienne* (Air traffic regulation)
RNAV	Area Navigation
SOP	Standard Operating Procedures
UTC	Coordinated Universal Time
V/S	Vertical Speed
VNAV	Vertical Navigation

Synopsis

Time	13:20[1]
Operator	Ryanair
Type of flight	Commercial air transport (passengers)
Persons onboard	Captain (PM); first officer (PF); 4 cabin crew; 166 passengers
Consequences and damage	None

[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.

Descent below the minimum safe altitude during the approach, activation of ground proximity alerts, missed approach

The crew were carrying out a scheduled commercial flight from London Stansted airport to Bergerac-Roumanière airport. The ILS and DME equipment at destination was not available and the captain deduced from the approaches listed in the Airfield Brief that they were not authorized to carry out RNAV (GNSS) approaches. The crew started an NDB Y timed approach to runway 28. During this procedure, as they approached the inbound turn, the crew established a descent under the minimum safe altitude in V/S mode. A MSAW was activated in the Aquitaine-Approach control room. The turning descent continued for nearly two minutes, in IMC, up to the activation of the E-GPWS "TERRAIN" alert. At this point, the aeroplane was more than 8 NM from the runway threshold, left of the final approach path, at an altitude of 1,054 ft and a radio altimeter height of 842 ft. The crew started to fly a missed approach; at the same moment, the "PULL UP" warning was activated. The factors likely to have contributed to the anticipated descent and continuing this descent for nearly two minutes include:

- An initial preparation of the approach which was insufficiently precise and complete.
- The holding pattern not being performed after a late change and despite the captain having some doubts as to the sequence which they were starting.
- The misunderstanding between the captain and the first officer concerning the modes to be used.
- The progressive diminution of the pilots' situational awareness.
- The first officer's small amount of experience, particularly with respect to this type of approach.
- The controllers' lack of knowledge of the NDB procedures.
- The absence at Bergerac of a MSAW system (or a remote display) and, failing this, the absence of emergency coordination procedures between Aquitaine-Approach and Bergerac.

In particular, due to the rapid expansion in RNAV (GNSS) procedures and the development of FMS, pilots may no longer have sufficient practice in carrying out non-precision approaches relying solely on conventional equipment and instruments. Following the incident, the operator concerned decided to forbid the performance of timed approaches in V/S mode. The operator considered that there was an additional risk associated with this type of approach and thought that its operational objectives could be met without crews having to resort to it.

ORGANISATION OF THE INVESTIGATION

The BEA was notified by the DSNA of the activation of the minimum safe altitude warning in the Aquitaine-Approach control room, at Bordeaux, the day after the incident. In accordance with Annex 13 to the Convention on International Civil Aviation and Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety investigation was opened by the BEA.

In accordance with the provisions of Annex 13, accredited representatives from the Irish investigation authority (AAIU) and the American investigation authority (NTSB) were associated with the investigation, representing respectively the State of the Operator and the State of Manufacture. The United Kingdom investigation authority (AAIB) was contacted to obtain certain information from the training organization which had trained the first officer.

The flight data recorder (FDR) was removed and the data concerning the incident read out by the BEA.

On the BEA's request, the AAIU carried out interviews with the captain and the first officer on 5 February 2015.

The BEA investigation team worked in cooperation with its technical advisers, the accredited representatives of the foreign organizations concerned by the investigation and their technical advisers. These authorities and organizations were provided with the draft final report for consultation.

1 - FACTUAL INFORMATION

1.1 History of the flight

Note: the following information is principally based on flight data recorder (FDR) data, radar data and the radio communication recordings.

The crew took off at 12:02 from London Stansted airport[2] for a scheduled commercial flight bound for Bergerac-Roumanière airport[3]. The first officer was PF.

At 13:03, the crew were authorized to descend to FL70. On the Aquitaine-Approach controller asking the crew about their ability to carry out a RNAV approach, the first officer replied "No...yes" and then asked for the weather conditions at destination.

At 13:05 the approach controller again asked the crew if they were planning a RNAV approach. The captain replied that they were going to carry out an NDB approach. The controller told them that it would be an NDB Y for runway 28 and cleared them to the BGC beacon and to descend to 2,500 ft[4].

At 13:17:48, the aeroplane flew over the BGC beacon at an altitude of 2,723 ft (see Figure 2) in autopilot with the LNAV and V/S modes activated. It was in descent to the selected altitude of 2,500 ft. The heading followed was 213°. The aeroplane's indicated airspeed was 216 kt and decreasing. The landing gear and flaps were retracted.

At 13:18:23, the crew selected flap position 1. The aeroplane, still in LNAV mode, started a left turn (see Figure 1, point ①).

At 13:19:42 (see Figure 1, point ②), the aeroplane came out of the turn on a heading of 097°. It was then in level flight at an altitude of 2,500 ft (in ALT HOLD mode) and its indicated airspeed was 185 kt. Three seconds later, the crew extended the flaps to position 5.

At 13:20:05, as the aeroplane entered a new left turn in LNAV mode, the first officer selected an altitude of 900 ft, engaged the V/S mode and selected a vertical speed of -900 ft/min. The indicated airspeed was 168 kt. At 13:20:38, the first officer selected a vertical speed of -1,200 ft/min.

From 13:21:18, the first officer progressively reduced the selected descent rate to a value of 300 ft/min.

At 13:21:23, when the aeroplane turned past heading 340° at an altitude of 1,447 ft and an indicated airspeed of 175 kt, the crew reported that they were established on "Inbound". The aeroplane was then at 65° from the final approach path. The approach controller released them from the frequency and asked them to contact the Bergerac tower controller.

At 13:21:34, (see Figure 1, point M), when the crew had changed frequency, a MSAW was activated in the Aquitaine-Approach control room.

At 13:21:38, the crew contacted the tower controller. The aeroplane's altitude was 1,240 ft. The crew were authorized to continue the approach.

[2] ICAO code: EGSS.

[3] ICAO code: LFBE. This airport is called Bergerac-Dordogne-Périgord airport since January 2020.

[4] 2,500 ft corresponds to the procedure protection altitude, the racetrack altitude and the minimum safe altitude (MSA).

At 13:22:02 (see Figure 1, point T), the E-GPWS "TERRAIN" alert was activated and perceived by the crew. At this point, the aeroplane was more than 8 NM from the runway threshold, still turning, left of the runway axis, at an altitude of 1,054 ft, i.e. a radio altimeter height of 842 ft. The autopilot lateral and vertical modes engaged at this moment were LNAV and ALT ACQ respectively[5]. The rate of descent was 970 ft/min and the indicated airspeed 166 kt.

Two seconds after the activation of the "TERRAIN" alert, the crew pushed the TOGA button[6] and flew a missed approach. At this point, the aeroplane was at an altitude of 1,018 ft (i.e. a radio altimeter height of 797 ft). The rate of descent was 986 ft/min and the indicated airspeed 164 kt. At the same moment, the activation of the E-GPWS "PULL UP" warning was recorded.

At 13:22:10, a new MSAW was activated in the Aquitaine-Approach control room.

Shortly afterwards, the crew announced the missed approach on the Bergerac tower frequency. The aeroplane climbed back to an altitude of 4,000 ft, the crew contacted the approach controller again and then held at the BGC beacon for around seven minutes. They then performed a second NDB Y approach procedure and landed on runway 28 of Bergerac-Roumanière airport at 13:44.

[5] The ALT ACQ mode was activated on approaching the selected altitude which was still at 900 ft. The activation of this mode led to the rate of descent, which the PF had set to 300 ft/min, increasing again. This way of functioning complies with the design logic of the flight management system.

[6] Take Off/ Go Around

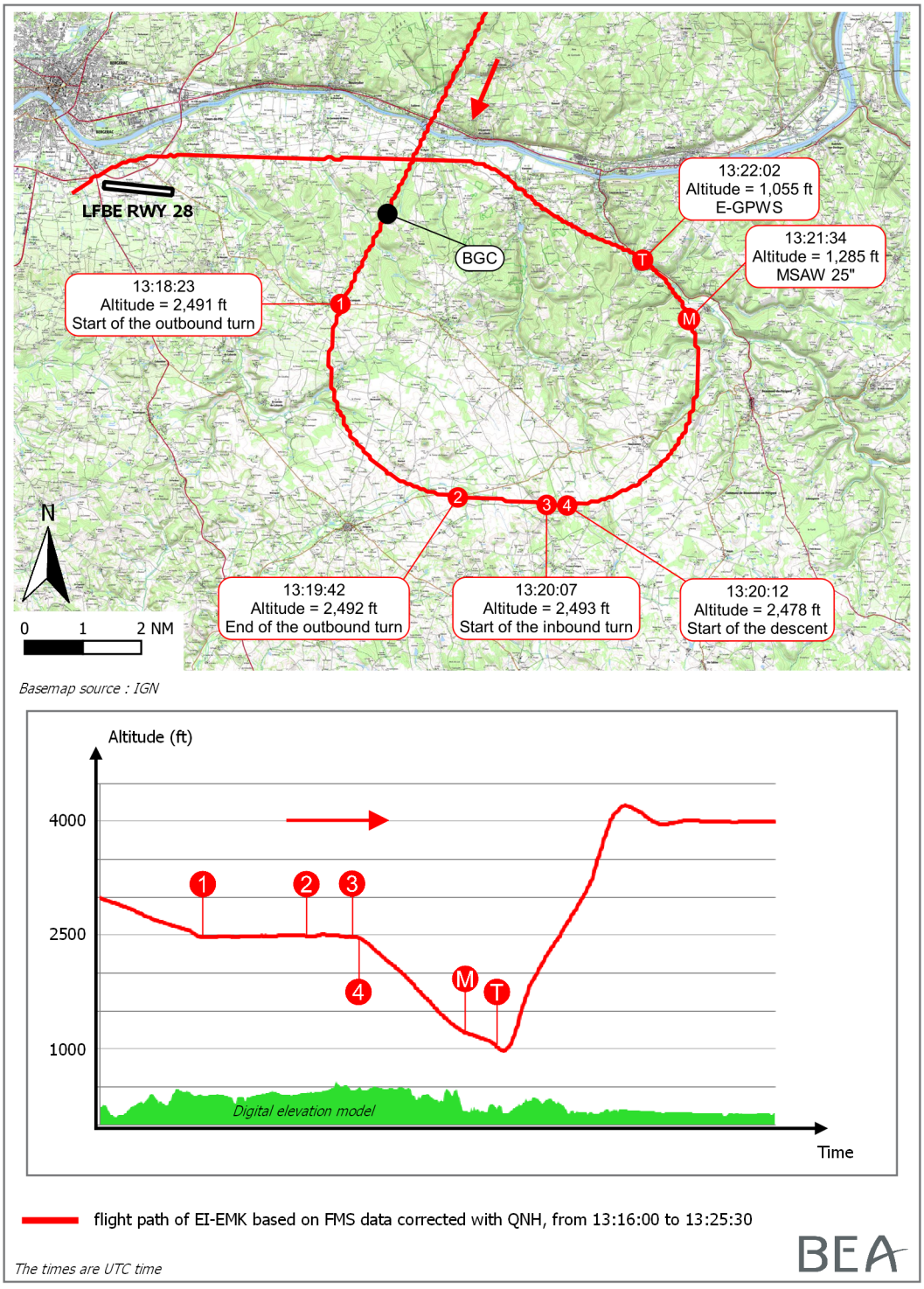


Figure 1: path

1.2 Injuries to persons

	Injuries		
	Fatal	**Serious**	**Minor/None**
Crew	-	-	6
Passengers	-	-	166
Others	-	-	-

1.3 Damage to aircraft

Not applicable.

1.4 Other damage

Not applicable.

1.5 Personnel information

1.5.1 Captain

Male, aged 57, of British nationality.

The captain held an Airline Transport Pilot Licence (ATPL) issued on 7 May 2013 , associated with a B737 300-900 type rating issued on 11 November 2012, valid until 30 November 2015. He had been granted Performance-Based Navigation (PBN[7]) privileges.

[7] Cf. paragraph 1.18.6.

He had logged around 15,000 flight hours of which more than 6,000 hours on the B737.

Recent experience:

- in the previous three months: 84 h
- in the previous 30 days: 49 h
- in the previous 24 hours: 7 h.

1.5.2 First officer

Male, aged 27, of British nationality.

The first officer held a Commercial Pilot License (CPL) issued on 4 July 2014, associated with a B737 300-900 type rating issued on 1 September 2014, and valid until 30 September 2015. He also had PBN privileges.

He had logged 430 flight hours of which 280 hours on the B737.

Recent experience:

- in the previous three months: 164 h
- in the previous 30 days: 107 h
- in the previous 24 hours: 11 h.

He had started an ab initio integrated training course[8] in 2012. The BEA was not able to obtain the detailed programme of this training course or the first officer's pilot training record.

[8] Training for those who have no prior aeronautical experience.

The first officer had started line flying under supervision for the operator at the end of September 2014 and had been released to line operations in December 2014.

1.6 Aircraft information

The B737-800 registered EI-EMK had a valid certificate of airworthiness. It was approved for PBN.

1.7 Meteorological information

1.7.1 General situation

There was light to moderate rain in the region in the time frame of the incident accompanied by a very moist to saturated air mass from a height of 1,000 ft.

1.7.2 Meteorological reports and forecasts

METAR

LFBE 291300Z AUTO 23011KT 9999 -RA BKN011/// BKN016/// OVC021/// ///TCU 09/08 Q1000-
LFBE 291330Z AUTO 23012KT 200V260 4900 RA BR BKN012 BKN020 OVC027 09/08 Q0999

TAF, issued 29 January 2015 at 08:04

LFBE 290800Z 2909/2918 24012KT 9999 BKN012 BKN030 BECMG 2915/2918 27015G30KT TEMPO 2909/2918 24015G30KT 3000 RA BKN005 BKN015 TEMPO 2916/2918 26020G40KT=

Bergerac ATIS message recorded at 13:00 (information Foxtrot)

Approach RNAV 28 or NDB Y. Runway in service 28. Wet runway. Transition level 60. ILS out of service. DME out of service. Bird hazard. Wind 230°, 11 kt. Visibility greater than 10,000 m. Present weather: light rain. Clouds BKN 1,100 ft OVC 2,100 ft. Temperature +9 °C, dew point +8 °C. QNH 1000.

1.8 Aids to navigation

1.8.1 Radio and GNSS equipment

The day of the incident, due to work in progress on the ILS and DME equipment, only the RNAV (GNSS) and NDB Y approaches were usable for runway 28 at Bergerac-Roumanière airport.

LFFA-D5425/14
A) LFBE BERGERAC ROUMANIERE
B) 2014 Dec 15 00:00 C) 2015 Apr 25 23:59
E) LOCALIZER RM RWY28 HORS SERVICE
REF SUP AIP AIRAC 182/14

LFFA-D5426/14
A) LFBE BERGERAC ROUMANIERE
B) 2015 Jan 05 13:00 C) 2015 Apr 25 23:59
E) DME RM RWY28 HORS SERVICE - TRAVAUX GENIE CIVIL ZONE THR28 - REF SUP AIP AIRAC 182/14.

LFFA-D5424/14
A) LFBE BERGERAC ROUMANIERE
B) 2014 Dec 15 00:00 C) 2015 Apr 25 23:59
E) GP RM RWY28 HORS SERVICE CAUSE TRAVAUX GENIE CIVIL ZONE THR28 - REF SUP AIP AIRAC 182/14

Figure 2: NOTAM[9] indicating that the ILS and DME equipment was not available

[9] Notice to Airmen.

1.8.2 Flight Management System (FMS)

According to the information obtained from the operator, at the date of the incident, the Bergerac-Roumanière airport RNAV (GNSS) 28 procedure and NDB Z 28 procedure [10] were encoded in the FMS.

The operator indicated that the procedures which rely on a single radionavigation means (e.g.: NDB without DME) were generally not encoded in the FMS at the date of the incident. The investigation was unable to confirm the situation for NDB Y 28.

[10] The LFBE NDB Z 28 relies on the DME which was not available on the day of the incident.

1.8.3 Bergerac Roumanière NDB Y 28 approach procedure

The NDB Y 28 approach procedure includes a holding pattern and a racetrack procedure. The procedure is published in the AIP France[11] (see Figure 3).

[11] French Aeronautical Information Publication.

Furthermore, paragraph ENR 1.5.2.3 in the AIP France indicates that when the holding pattern and racetrack are shown separately, entries must be made in the holding pattern, the racetrack can only be flown once the aeroplane is stabilised in and at the minimum altitude of the holding pattern; if racetrack entries are nevertheless possible for certain aircraft, this possibility is mentioned.

The Bergerac-Roumanière airport NDB Y 28 chart clearly shows a holding pattern and a racetrack. Thus, in the absence of information specifying the possibility of directly entering the racetrack, the aeroplane should enter the holding pattern according to these AIP instructions. For a direct entry such as the one flown by the crew, the expected sequence would thus be:

- vertical flight over the beacon;
- outbound flight of one minute followed by an inbound turn;
- inbound flight on runway axis, at the minimum holding pattern altitude and maximum published speed;
- vertical flight over the beacon followed by the procedure turn, outbound flight of 1 min 30 s and inbound turn;
- once on the runway axis, start of final descent to the published altitude for flying over the beacon.

The services responsible for the design of the procedures and the publication of the approach charts in the AIP France specified that the possibility of entering a racetrack must be specifically studied during the design phase. This is because the applicable protected areas in this case are generally not the same as those for the entry into a holding pattern. The study of protected areas requires their manual construction which is not done systematically. In the case of the Bergerac-Roumanière airport NDB Y 28 procedure, the possibility of entering the racetrack had not been studied which is why it was not shown on the published chart.

The DGAC specified that these AIP instructions were not of a regulatory nature; their purpose was to remind crews of certain applicable requirements from other sources. The investigation was not able to identify the regulatory requirements which might have been at the origin of these, notably at ICAO level. The Irish AIP[12] (operator's country) does not show such instructions. These instructions have not been included in a regulatory text applicable to aircraft operators. Statements gathered from different private or airline IFR pilots brought to light that these instructions are not always known, that they leave room for various interpretations and that in all cases, the approach procedures are complied with in extremely different ways.

Notwithstanding these AIP instructions, crews can ask to carry out one or more holding patterns if required.

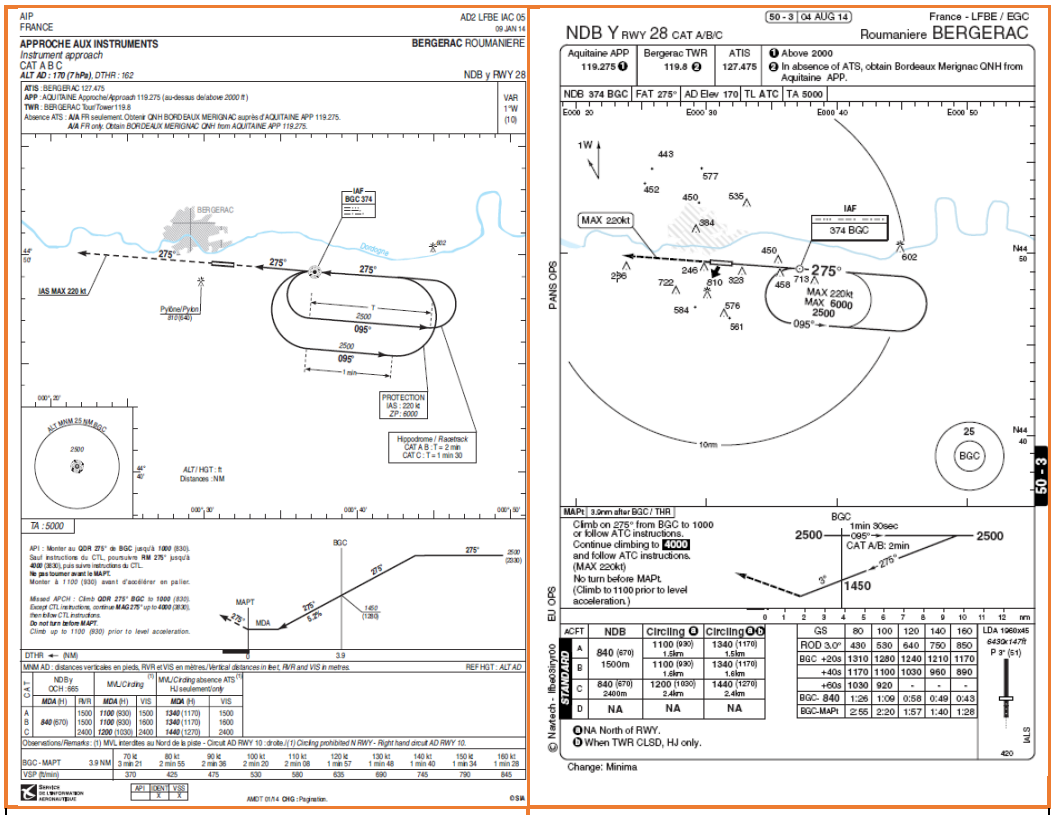
Furthermore, the Bergerac-Roumanière airport NDB Y 28 procedure is solely based on the NDB and thus does not include a FAF[13] . When making an approach without a FAF, the final descent starts at the end of the inbound turn. When this type of approach is carried out in a conventional way, the aeroplane is suitably positioned on coming out of the inbound turn if the racetrack has been fully flown. Thus, if it is permitted and strictly speaking, the racetrack can only be entered if the aeroplane is lined up, stabilized at the racetrack altitude and within the indicated airspeed limits.

At the date of the incident, the operator used the documents provided by a service provider. The comparison between the chart used and the AIP France chart revealed the following points:

- On both charts, it is not indicated that there is the possibility of directly integrating the racetrack procedure.
- On the horizontal profile of the chart used, there is a portion of a circle with a radius of 10 Nm, centred on the airport reference point.
- Under the vertical profile of the chart used, there is a distance scale; the BGC beacon is positioned on it at 3.9 NM from the threshold, as specified in the inset next to it. The starting point of the final descent is positioned between 9 and 10 NM. The point corresponding to the MAP is not shown on the vertical profile. Its position is mentioned in the inset nearby.

[12] Consultation of a version published subsequent to the incident.

[13] Point which materializes the start of the descent in certain standard approaches.



Carte de l'AIP France | Carte utilisée par l'équipage

Figure 3: comparison between Bergerac-Roumanière airport NDB Y 28 approach charts

Paragraph 11.3.3 of ICAO Annex 4 regarding aeronautical charts[14] deals with the chart scale. It specifies that "*except where this is not practicable, a distance circle with a radius of 20 km (10 NM) centred on a DME located on or close to the airport, or on the airport reference point […] shall be shown*" on the chart. Furthermore, it is recommended that "*a distance scale should be shown directly below the profile.*"

France had initially advised of a deviation from ICAO Annex 4 with respect to the 10 NM circle[15]. This difference concerned all the approach charts and not solely those concerning timed approaches. It was explained by the practical difficulties of showing a complete circle given the scale used.

More specifically, concerning the procedures without a means for obtaining distances, as for the Bergerac-Roumanière NDB Y 28, certain experts in charge of the design and publication of the approach charts in the AIP France consider that the representation of a 10 NM circle could cause confusion, as could the representation of a detailed distance scale under the vertical profile.

[14] In France, the provisions of Annex 4 were included in the decree of 23 June 2008 regarding aeronautical charts, subsequently repealed by the decree of 6 July 2018.

[15] ICAO had not been informed that this difference still existed for the past several years.

1.9 Communications

The DSNA, the Air Navigation Service Provider (ANSP), provided the BEA with the communication recordings. The relevant elements from the radio communications have been given in paragraph 1.1 "History of the flight".

Before the incident, there were two discussions by telephone between the Aquitaine-Approach control unit and the Bergerac tower at 13:02 and 13:06 to coordinate the arrival of the aeroplane.

Aquitaine-Approach called Bergerac again at 13:22:54, i.e. 80 s after the first MSAW had been activated and 44 s after the second warning had been activated. The crew had already reported that they were going to fly a missed approach to the Bergerac controller.

1.10 Aerodrome information

This airport is open to public air traffic, including traffic flying under IFR.

The airport has one runway 10/28. QFU 28 was in use on the day of the incident.

The published distances for QFU 28 are 2,205 m (TORA[16]) and 1,960 m (LDA[17]).

[16] Take-Off Run Available.

[17] Landing Distance Available.

1.11 Flight recorders

1.11.1 General parameters

The crew did not preserve the flight recorders after landing at Bergerac. The return flight to London and the subsequent flights before the operator was informed of the nature of the incident meant that the CVR data concerning this incident was deleted.

The FDR data was read out on the BEA's premises. The most relevant parameters are given in the appendix.

1.11.2 Duration of outbound leg

The average ground speed recorded for the outbound leg was 227 kt. This value was used to position the theoretical points for the start of the inbound turn corresponding to the holding pattern and racetrack procedure (i.e. respectively 1 min and 1 min 30 sec outbound after passing abeam BGC beacon).

For information, during the incident flight, the aeroplane (in LNAV mode) started the inbound turn shortly before the theoretical start of turn point for a holding pattern, and before the theoretical start of turn point for a racetrack procedure (see Figure 4).

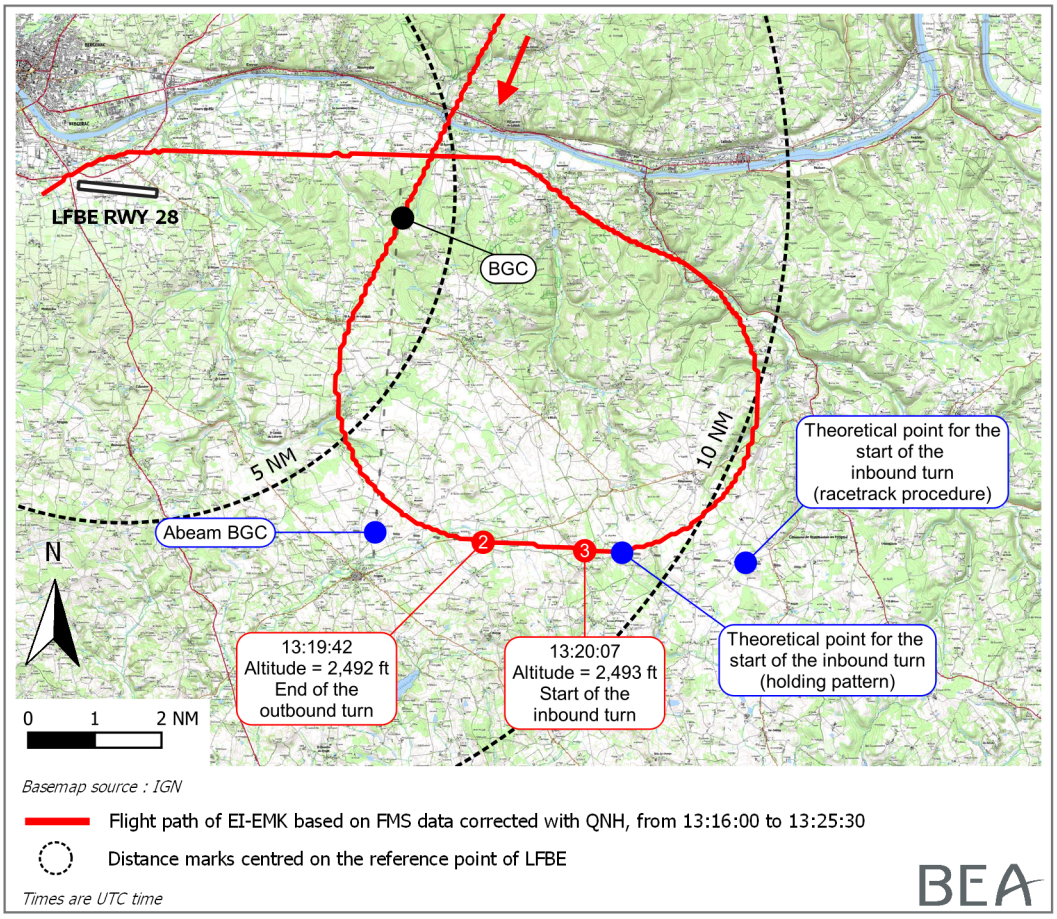


Figure 4: estimated theoretical positions of start of inbound turn in the holding pattern and in the racetrack procedure with respect to the aeroplane's actual path

1.12 Wreckage and impact information

Not applicable.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

Not applicable.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

Not applicable.

1.17 Organizational and management information

1.17.1 Operator documentation concerning types of approach

The operator provides crews with an Airfield Brief which describes the types of approach available as well as the specificities of each airport. The version in force on the day of the occurrence for Bergerac-Roumanière airport did not mention the existence of RNAV (GNSS) approaches for runways 10 and 28.

The approach charts available on the day of the incident in the operator's documents included all the charts regarding approaches for runways 10 and 28 at Bergerac-Roumanière airport, including the RNAV (GNSS) approaches.

In part NP.21.71 "Timed Approaches" of the FCOM, it is stated that:

- "*VNAV may be used subject to: An appropriate path with the MAP at or before the runway threshold, and/or a glidepath is published on the LEGS page. [...] LNAV may be used as the magenta line takes into account the timing limitations of the outbound leg.*"
- When the approach was not encoded in the FMS, the HDG and V/S modes were to be used; the MDA to be used was then to be the greater of the following two values, the published MDA plus 300 ft or 1,000 feet above the airport.
- If the VNAV mode was used, the landing gear was to be extended at 5 NM whereas in V/S mode, it was to be extended once established inbound.

The operator's normal procedures (SOP paragraph 8.20) told the crew to "*Set the MAA at 1000' AAL (White altitude reference bar on altimeter). If the MDA/DA is 900' AAL or higher, then the MAA must be set earlier to avoid ALT ACQ. This point must be agreed by the flight crew prior to the approach. In the unlikely event that the MAA is below 1300' AAL then the MAA must be set 300' below MAA.*"[18]

The operator specified (SOP paragraph 8.16) that all the non-precision approaches must be the subject of a 'Double Brief' where the detail of the approach procedure is reviewed and also the intentions of conducting the approach, including the planned aircraft configuration, autopilot modes and action at MDA. The operator's procedures require these steps to be verified by checklist before commencing any type of Non Precision Approach.

The Monitored Approach procedure was described in the Operations Manual (paragraph 8.3.0.3.3) and reiterated in the FCOM and QRH[19]. It was applicable to non-precision approaches when the visibility was less than 3,000 m or the ceiling was below 1,000 ft AAL[20]. A Monitored Approach was to be flown by the first officer and monitored by the captain. On making the "LAND" call, the captain was to take control of the aircraft. In the case of a non-precision approach, the first officer then had to select F/D to off, select the missed approach altitude, reselect F/D to on, and monitor the remainder of the approach/landing with particular emphasis on vertical situational awareness. In the event of a missed approach before the transfer of the control of the aircraft, it was to be flown by the first officer. A Double Brief was to be carried out when such an approach was envisaged, whether it was a precision approach or not.

Paragraph 8.3.2.2.1.6 of the Operations Manual specified that the operator was approved for RNAV (GNSS) approaches.

[18] The manufacturer's documentation specified that the go-around altitude must be systematically set at 300 ft before arriving at the MDA.

[19] Quick Reference Handbook.

[20] Above Aerodrome Level.

1.17.2 Transfer procedures for IFR arrivals between approach control unit and local control unit

The control, information and alert services in the Aquitaine TMA[21] are provided by the Aquitaine-Approach control unit situated on Bordeaux-Mérignac airport[22]. The Bergerac-Roumanière airport control is provided by the airport's local control service.

The transfer procedures, including the IFR arrival procedure at Bergerac, are governed by an agreement between the Aquitaine-Approach control unit and the Bergerac control unit.

For the NDB Y approach, the agreement in force on the day of the incident indicated that the transfer should be carried out when the aeroplane passes over the BGC beacon, once it is established on the procedure.

1.17.3 Deployment and use of Minimum Safe Altitude Warning (MSAW) ground system

The MSAW system provides the controller with a warning in the event of a potentially dangerous distance between an aircraft and the terrain or an artificial obstacle[23].

It is not a mandatory system and is deployed on the ANSP's initiative[24]. The Aquitaine-approach control unit was equipped with a MSAW system in May 2012 for Bordeaux airport. The system was configured to include inhibition zones, one being centred on Bergerac-Roumanière airport[25].

Within a given area, the MSAW function can be inhibited in certain geographical zones where aircraft are not the responsibility of the ATC unit with the MSAW function. This mainly concerns:

- ❒ military zones;
- ❒ airports which have a local control (CTR);
- ❒ uncontrolled airports.

During the incident, according to the ANSP, the MSAWs activated in the approach room corresponded to a detection outside the Bergerac inhibition zone. The validity of these warnings was confirmed by the ANSP.

The Bergerac control unit was not equipped with a MSAW system and did not benefit from a remote display of the MSAWs in the Aquitaine-Approach control unit.

A MSAW is materialized by:

- ❒ A red MSAW caption at the top of the label on the control screen.
- ❒ A MSAW warning window which gives the call sign, the transponder code, the radial and the aircraft distance on the control screen.
- ❒ A "terrain alert" announced via dedicated loudspeakers in the approach control room and in the control tower.

Following the incident, the ANSP checked the volume level of the MSAW in the approach room. No anomaly was observed.

[21] Terminal Manoeuvring Area.

[22] ICAO code: LFBD.

[23] The system compares the altitudes transmitted by the aircraft transponders with the minimum safety altitudes defined in the area where the aircraft is located. Detection thresholds can be configured locally.

[24] The DSNA said that for the deployment of the MSAW, preference is first given to airports with a reliable radar coverage in low levels.

[25] The Bergerac inhibition zone is in the shape of a cuboid 16 NM x 11 NM x 2,500 ft in height.

The air traffic regulations (RCA) state that on receiving this warning, when the aircraft concerned is not being radar vectored (case of incident), the controller must immediately inform the pilot[26]. In particular, using a specific phraseology, he must instruct him to check his altitude. No mention is made of several control units having to coordinate when this is necessary.

The Aquitaine-Approach control unit operations manual did not include coordination procedures in the case of the activation of the MSAW system for an aircraft likely to be on the frequency with another unit.

1.18 Additional information

1.18.1 Crew statements

Note: *The pilots were interviewed individually by the AAIU on 5 February 2015. The pilots had previously taken part in a debriefing at the operator's, including the reconstruction of the incident in a simulator with the head of training.*

Captain's statement

The captain explained that he had never flown with the first officer before. The first officer told him that he had not been line flying for very long. Earlier in the day, they flew a return flight between London and Turin.

While preparing the flight to Bergerac-Roumanière, the captain decided that the first officer would be the PF for this leg in order to carry out a monitored approach, at the end of which he would take control of the aeroplane to land. The first officer and himself were aware, before taking off, that the Bergerac-Roumanière airport ILS and DME were not usable.

Before the descent, observing that the RNAV (GNSS) approaches for runways 10 and 28 were not mentioned in the operator's Airfield Brief for Bergerac-Roumanière airport, the captain decided to carry out an NDB approach. He thought that the briefings concerning the approach took place just before or at the very beginning of the descent.

When the controller asked them the first time whether they could carry out a RNAV (GNSS) approach, the first officer was monitoring the frequency while he was trying to obtain the ATIS. The first officer was not sure what response to give. At this point, they were already close to the airport and had carried out a briefing for an NDB procedure. On the controller asking a second time, the captain said that they would carry out an NDB approach and the controller cleared them to continue to BGC beacon.

The captain temporarily managed the aeroplane's path while the first officer started programming the FMS for the approach. At this point they were 20 to 30 NM from the airport. According to him, the path given by the FMS had numerous discontinuities. The captain thought that the first officer had made three attempts to enter data into the FMS. The captain was not satisfied with the vertical profile of the path. He explained that he then asked for the approach to be carried out in HDG and V/S modes. He specified that he heard no reply from the first officer. The captain considered that from this moment, he started to be overloaded with work; he had the impression that he was managing all the aspects of the flight on his own. He thought with hindsight, that he should have then entered the holding pattern.

[26] Procedures for units providing air traffic services to aircraft manoeuvring in accordance with general air traffic rules (RCA/3), see paragraph 2.2.1.1.4.

The captain said that he had some doubts when they were flying outbound: he did not know if the aeroplane was flying the holding pattern or the racetrack procedure. He asked the first officer to start the descent in V/S mode as the aircraft commenced the inbound turn. He thought that the turn would take one minute and the inbound phase one minute, so they had less than two minutes to lose 1,000 ft before reaching BGC beacon. He was concerned not to make a high energy approach. He thought that he may have initially requested a rate of descent of 1,200 ft/min.

The captain explained that as the aeroplane approached the runway axis, he regained situational awareness, that he told the first officer that they were too low and that they had to reduce the rate of descent. At this moment, the E-GPWS "TERRAIN" alert was activated. The captain heard this alert once but he said that he did not hear the "PULL UP" warning.

The captain said that during the approach, he experienced a problem with his headset. He had a standard headset, provided in the aeroplane by the operator, whereas the first officer had his personal ANR[27] headset. He explained that he had to considerably raise the volume of his headset to hear the first officer. This also increased the level of static noise. While they were descending, and the noise from the wind drag and rain increased, his discomfort became greater and greater, to the point of having a headache.

[27] Active Noise Reduction.

The captain explained that he considered that the NDB approach was the simplest and he had done hundreds of them. He did not know that the first officer had never flown any raw data NDB approaches. He thought that if the first officer had told him he had never done this type of approach, things would have been different. The captain insisted on the fact that he perceived the communications as being one way, from him to the first officer.

First officer's statement

The first officer explained that during the London Stansted turn around, before the flight to Bergerac, the captain carried out the pre-flight inspection while he remained on board to programme the FMS. He thought that when he entered the route to Bergerac, the FMS proposed an NDB Y approach and that he accepted it. The first officer indicated that they knew, before the flight, that the Bergerac ILS and DME were not usable.

He said that he had never been to Bergerac before.

The first officer explained that en route, they had a discussion concerning the approach. They carried out the specific briefing for a non-precision approach, during which they discussed an NDB approach with a final of 10 NM.

The first officer said that during the descent, they were cleared to BGC beacon for the NDB Y approach. He then reprogrammed the FMS and they had new briefings.

The first officer explained that they were in LNAV mode for all of the procedure; they briefly spent time in the ALT HOLD mode with the intention of changing to VNAV. They noticed that the VNAV profile indicated that they were low. The first officer cannot exactly remember the deviation indicated but they were at an altitude of 2,500 ft in level flight at this point. They discussed this while flying outbound. According to him, the path displayed did not pose a specific problem.

According to the first officer, they planned to turn inbound and extend the landing gear at 5 NM. The first officer explained that when they were about to start the inbound turn, the captain said that they were high and that they should start descending in V/S mode. He said that he contented himself with simply carrying out the captain's request by selecting an altitude of 900 ft. Looking back, he considered that he should not have automatically complied with this request made by the captain.

The first officer said that they had a "TERRAIN" alert. He explained that he was concentrated on the vertical speed and was no longer conscious of the altitude. He did not hear the "PULL UP" warning or see the associated indicator light. He was still the PF and carried out the missed approach.

The first officer explained that after landing, they had a short discussion. Both were aware that they had lost situational awareness.

The first officer indicated that the weather conditions were difficult with gusty wind and rain. There was light turbulence and icing during the descent. They were in IMC conditions throughout up to the activation of the E-GPWS alert. In his opinion, the workload was high.

Communication in the cockpit was good according to him. However, he had observed that the captain had missed a few radio messages earlier in the day and that he had struggled to hear him. He used an ANR headset which he had bought himself.

He said he had never done a timed approach in V/S mode and that he had not been trained to do this in a simulator. He might have done it during his CPL training but never in a B737.

1.18.4 Synthesis of controllers' statements obtained by the Air Navigation Service Provider (ANSP)

The approach controller explained that he had stopped monitoring the radar blip after he had cleared the crew for an NDB Y approach. When the crew re-contacted him, he mechanically transferred them to the Bergerac tower controller. He had observed the aeroplane's descent but did not know if it was normal or not. He said that he was not sufficiently acquainted with the NDB procedure and did not understand the chart published in the AIP that the assistant controller had got out for this occasion. He filled in the strip and then saw the MSAW when he looked at his screen again. He could no longer intervene as the crew was no longer on the frequency. He specified that he did not hear the MSAW aural warning. He said that he hesitated calling the Bergerac control unit. He imagined that it was also equipped with the MSAW system and thought that a phone call could make the tower controllers lose time. It was only after observing the missed approach that he called them.

The approach assistant controller added during a later exchange with the BEA, that it is often difficult for them to know beforehand if the aeroplane will fly a holding pattern before the racetrack procedure, as the crews have different practices in this respect. Furthermore, he mentioned paragraph ENR 1.5.2.3 in the AIP France, indicating that according to him, in the light of these instructions, the crew involved in the incident should have carried out a holding pattern.

The Bergerac tower controller and the assistant controller explained that they had observed the aeroplane on the radar display screen perform a racetrack far off to the south. On coming out of the inbound turn and established on the axis of runway 28, the crew advised that they were going to fly a missed approach. The tower controller said the path at this point did not appear abnormal. The approach controller telephoned him just after the crew's announcement to find out whether they had received the MSAW, but they were not equipped with this system.

1.18.3 Regulations concerning instrument rating (IR)

Commission Regulation (EU) No 1178/2011 laying down the technical requirements and administrative procedures related to civil aviation aircrew defines in its appendix 1 (Part-FCL), the licence requirements. At the date of the incident, the instrument rating (IR) granted a pilot the right to carry out all the instrument approaches except for those relating to PBN privileges, such as the RNAV (GNSS). A pilot had to hold a specific authorization for this, as was the case of the captain and first officer of the incident[(28)].

The Aircrew regulation specifies the content of the IR training and practical examination (appendices 6 and 7 of Part-FCL). Appendix 6 of Part-FCL indicates that there must be training in instrument approaches according to specified minima, without giving more details about the types of approach that must be carried out during the training. Appendix 7 of Part-FCL indicates that the flight test to obtain the IR must include a non-precision approach (section 5) without giving more details about the type of non-precision approach to be carried out.

1.18.4 Regulations concerning recurrent training and checking of commercial air transport crews

Commission Regulation (EU) No 965/2012 laying down the technical requirements and administrative procedures related to air operations (Air Ops) establishes the requirements to be followed by air operators. In particular, there are the following provisions:

- ORO.FC.230 b)1): Each flight crew member shall complete operator proficiency checks as part of the normal crew complement to demonstrate competence in carrying out normal, abnormal and emergency procedures.
- ORO.FC.230 b)3): The validity period of the operator proficiency check shall be six calendar months.
- AMC1 ORO.FC.230 [sub-paragraphs (b)(1)(i)(D)]: when possible, the operator's check must include at least one 2D approach operation to minima as PF.

During the investigation, EASA specified that of the 2D approaches which must be carried out on these occasions, the frequency of the timed approach training is left to the operators' discretion according to their own assessment of the risks.

[(28)] In accordance with Regulation (EU) No 2016/539 which has amended the Aircrew regulation since the incident, all IRs will include PBN privileges from 25 August 2020.

1.18.5 Another incident during an NDB Y 28 approach to Bergerac

Almost one month after this incident, there was another incident involving a different operator on the same type of aeroplane on the approach to Bergerac-Roumanière airport when the ILS and DME equipment was still out of operation. The description of the incident given below is taken from the notification made by the Aquitaine-Approach controllers.

The crew announced that they could not carry out the RNAV (GNSS) approach for runway 28. They were cleared to fly directly to BGC and to descend to 2,500 ft with a view to carrying out the NDB Y 28 procedure. At around 4 NM north of BGC, the controllers saw that the aeroplane was at 2,100 ft. They asked the crew to climb so as to be at 2,500 ft overhead BGC in order to carry out the NDB Y procedure. The pilot replied that he had descend in order to be established at 1,400 ft at BGC on final and that he was now climbing to 2,500 ft. When overhead BGC, the controllers asked the crew to carry out a racetrack but the crew continued their descent to the runway. The crew were transferred to the Bergerac airport controller who asked them to fly a missed approach.

1.18.6 Implementation of performance based navigation (PVN) and rationalization of means

In 2010, ICAO fixed by resolution[29], the worldwide objectives for PBN and asked each member state to draw up an implementation plan including the deployment of GNSS approach procedures, in particular with vertical navigation. The DGAC published its plan in 2012. In the short term, under this plan, all the QFUs of controlled IFR aerodromes were to be the subject of a RNAV (GNSS) procedure. On 1 January 2017, the results of this deployment were the following[30]:

- 202 QFU had non-precision GNSS approach procedures (without vertical navigation);
- 150 QFU, including the 2 QFU at Bergerac, had GNSS approach procedures with lateral and vertical navigation.

At the same time, the DGAC plan provided for the assessment of the usefulness of keeping certain radio equipment and the associated procedures once the RNAV (GNSS) were published. This reflection around the rationalization of means was meant to anticipate alternative solutions in the event of a GNSS failure. NDBs were not retained as alternative means and the DGAC has programmed their suppression for 2030 at the latest.

1.18.7 Distribution of approaches made in commercial air transport

In 2016, the DGAC questioned French operators about the type of approaches made by their crews. It emerged from the replies received that only 5 % of the approaches carried out could be classed among non-precision approaches (including the 2D GNSS) while a large majority (75 %) were classed among precision approaches (including by extension, the various GNSS approaches with vertical navigation). The remaining 20 % were visual approaches.

[29] Resolution A37-11: https://www.ecologique-solidaire.gouv.fr/sites/default/files/Guide_PBN.pdf

[30] Source: Aviation safety report 2016: https://www.ecologique-solidaire.gouv.fr/sites/default/files/rapport_securite_aerienne_2016.pdf .

1.18.4 Studies concerning non-precision approaches

In 2008, during the 26th International Congress of Aeronautical Sciences (ICAS 2008), Boeing presented a paper[31] pointing out the advantages of performing precision approaches or approaches similar to precision approaches, such as the 3D GNSS. In this document, Boeing explained that the accident rate on non-precision approaches was four to eight times greater than on precision approaches.

Boeing also specified that the non-precision approaches were the most difficult to carry out and required a much higher level of concentration. In this document, Boeing underlined the critical importance of team work and of complying with standard procedures in these conditions. The study showed that the greatest risk was a premature descent.

The DGAC carried out a study covering the 2009-2013 period. According to the DGAC, the accident rate was seven times higher during non-precision approaches than during precision approaches. The DGAC's conclusions agreed with those of Boeing, notably concerning the premature descent risk.

In a presentation of this study during the Flight Safety Foundation conference in 2016, the DGAC drew attention to certain practices which consisted in mixing several procedures and navigation supports, notably the practices which consisted in relying on the FMS to programme a procedure which was not encoded in it.

1.18.9 Use of different types of headset by pilots

The captain used a headset provided in the aeroplane by the operator, with passive noise reduction characteristics.

The first officer used a personal ANR headset.

The ANR technology plunges the pilot into relative silence, inciting the wearer not to raise his voice when talking. The BEA has observed in other occurrences that when playing back CVR recordings, pilots equipped with these types of headset seem to generally speak more quietly, even a lot more quietly.

Furthermore, the ANR headsets generally differ from passive models by a lower impedance. Introducing headsets with a different impedance in the audio system may produce amplifications, attenuations or even distortions of the signal.

There are no operator directives ruling about the use of headsets which are different from those provided for the pilots.

1.19 Useful or effective investigation techniques

Not applicable.

[31] *"The safety gained by equipment and procedures used to perform constant angle approaches"*, Captain Dave Carbaugh, The Boeing Company, ICAS 2008 paper. http://www.icas.org/ICAS_ARCHIVE/ICAS2008/PAPERS/576.PDF.

2 - ANALYSIS

2.1 Introduction

The day of the incident, due to maintenance work on the ILS and DME, the approach procedures relying on this equipment could not be carried out. To determine the approach to be flown, the captain consulted the Bergerac-Roumanière Airfield Brief, prepared and provided by the operator. As the RNAV (GNSS) approaches (for runways 10 and 28) were not mentioned in the brief, he deduced they were not authorized by the operator.

The crew said that at the end of the en route phase or at the top of the descent, they carried out a standard briefing and then a supplementary briefing for an NDB approach. When the crew were in contact with Aquitaine-Approach, the controller asked them if they were able to carry out a RNAV (GNSS) approach. Besides the criteria which had initially led the captain to exclude the other approaches, he believed that an NDB approach was appropriate given his personal experience and the conditions of the day. He therefore replied that they would perform an NDB approach without specifying whether it was the "Z" or the "Y". The controller then informed them that it would be an NDB Y. Following this exchange, the first officer temporarily left the management of the path to the captain in order to reprogramme the FMS.

The results of this reprogramming did not satisfy the captain who was then said to have announced that the approach would be carried out in HDG and V/S modes. He did not know that the first officer had no experience in this type of conventional approach.

When they passed over the beacon, the LNAV and V/S modes were activated. Once past the beacon, the aeroplane started turning towards the outbound leg. In so doing, it followed a path which corresponded to that taken for a direct entry into a holding pattern or a racetrack procedure.

Still in LNAV mode, the aeroplane started its inbound turn after an outbound flight time which seems to correspond more to that of the holding pattern than the NDB Y racetrack procedure.

As the turn drew closer, the captain asked the first officer to descend. The first officer therefore selected an altitude of 900 ft and a vertical speed of -900 ft/min, and then -1 200 ft/min. This request seems directly correlated to the turn which was about to start. This descent below the sector safe altitude and below the procedure altitude, before the aeroplane was aligned on the final descent path, resulted in the aircraft being outside the procedure protection volumes. It was probably based on partial reasoning: the turn started at this point seemed to position the aeroplane above the approach path; it therefore seemed necessary to the captain to descend quickly.

During the descending turn, the captain probably detected an anomaly and asked the first officer to reduce the rate of descent. The first officer's input to reduce the rate of descent to 300 ft/min, was overridden by the activation of the autopilot ALT ACQ mode on approaching the selected altitude. The activation of this mode automatically led to the rate of descent increasing again.

The E-GPWS "TERRAIN" alert was activated shortly after. At this time, the altitude was 1,054 ft, the radio altimeter height 842 ft and the vertical speed was -970 ft/min. The first officer flew a missed approach; at the same moment, the "PULL UP" warning was activated.

The descent below the sector safe altitude lasted nearly two minutes. The incident took place in IMC, probably without external visual references.

2.2 Use of FMS and automatic system modes

The investigation was not able to determine if the Bergerac-Roumanière NDB Y 28 procedure was encoded or not in the FMS database.

The first officer thought that he had selected the NDB Y procedure in the FMS during flight preparation. However, he had to reprogramme the FMS after the approach controller had cleared them to carry out this procedure which seems to suggest that this procedure had not been initially selected, or was done so incorrectly. It is not possible to exactly determine what was initially programmed in the FMS from the available data. Plausible hypotheses include:

- The first officer selected the NDB Y procedure, but he incorrectly programmed it.
- The first officer selected NDB Z. According to the operator, this procedure was encoded in the FMS. It included a final approach of 10 NM as mentioned in the first officer's statement. However, it relied on the DME which the crew knew was unavailable the day of the incident.
- The first officer built a path himself in the FMS, using distance references (arc of circle on basemap and scale under vertical profile) shown on the NDB Y approach chart used by the operator. However, besides the fact that the distance is not a reference measurement for a timed procedure such as this, the operator's procedures do not provide for an approach being manually built by pilots in the FMS.

Whatever the anomaly, it seems that it was not detected by the crew during the first briefings that they said they had. The reprogramming of the FMS was directly linked to the clearance given by the controller.

The first officer probably started reprogramming the FMS with the intention of carrying out the cleared approach in LNAV and VNAV modes. This is suggested by the reference in his statement, to the 5 NM distance to lower the landing gear. Using the automatic systems in this way is in keeping with reducing the risks inherent in non-precision approaches but supposes that the procedure is correctly encoded in the FMS. It seems that the first officer tried to reprogramme the FMS several times and the results, at least with respect to the vertical profile, did not satisfy the captain. Several reasons can be envisaged:

- The NDB Y procedure was encoded in the FMS but its encoding did not meet the criteria which would permit an approach in VNAV mode.
- The NDB Y procedure was encoded in the FMS but the programming of the FMS by the first officer was incorrect.
- The NDB Y procedure was not encoded in the FMS and the first officer selected another procedure and/or built the path himself by inserting or removing points.

In any case, keeping the LNAV mode during all of the sequence seems to be contrary to the captain's decision to change to the HDG and V/S modes which he said he requested. In the absence of the CVR, it was not possible to determine the calls made with respect to the automatic system modes.

2.3 Altitudes selected during final approach

The exchange with the approach controller seems to have led the crew to modify their action plan. At the least, it required the reprogramming of the FMS. This change could have initiated a sequence which was both confused and rushed in character. The investigation showed that:

- The altitude selected by the first officer when starting the descent (900 ft) corresponded to the published MDA (840 ft rounded up to the next hundred) and not to the BGC beacon overflight altitude (1,450 ft) which was, however, a compulsory crossing point.
- The chosen MDA (840 ft) corresponded to what was published but did not take into account the addition of 300 ft specified by the operator for an approach which is not encoded in the FMS, if such was the case.
- The altitude of 900 ft was kept to a late stage instead of being replaced by the go-around altitude, at an altitude that the crew should have determined during the preparation for the approach. Consequently, the ALT ACQ mode was activated leading to the rate of descent increasing again.

With respect to this last point, the procedures drawn up by the operator did not fix a strict margin with respect to the MDA for the selection of the go-around altitude. In the case of the incident, it is not possible to know if the crew had previously determined the altitude at which the selected altitude would be modified to the go-around altitude.

2.4 Racetrack procedures and entry into holding pattern

While outbound, the captain seems to have had a doubt as to the sequence the aeroplane was starting, and notably whether the LNAV mode was making them follow a holding pattern or racetrack procedure. This doubt along with the LNAV mode being kept active contrary to the request that he said he made to switch to HDG mode could have justified him asking for a holding pattern to be flown before starting the racetrack procedure. On the contrary, without clarifying the situation with the first officer, the captain asked him to start descending and thus abandoned the possibility of gaining time.

Irrespective of initiatives which may be taken by crews, in the case of racetrack procedures such as the Bergerac-Roumanière airport NDB Y 28 procedure, the French reference documents (AIP France, paragraph ENR 1.5.2.3) indicate that the entry manoeuvre must be carried out, by default, in the holding pattern.

It seems that the purpose of these instructions is to ensure that the entry manoeuvre is made in protected areas. Indirectly, complying with these instructions guarantees that the racetrack procedure is correctly started in terms of heading, altitude and speed which is particularly important in the case of a procedure without a FAF. However, these instructions do not seem to be based on international regulations, are not widely known and are subject to various interpretations. This results in varying practices.

2.5 Non-precision approaches: risks linked to changing means and practices

The first officer, recently trained ab initio and released to line operations the month prior to the incident was not trained in or had little training in performing timed approaches in HDG and V/S modes. It is not possible from the data available, to precisely determine to what extent this small amount of experience affected his preparation for the approach, in particular, when he twice programmed the FMS and his management of the beginning of the approach as PF. However, at the very least, he seems to have not perceived the inconsistency of the captain's request to descend as soon as they reached the end of the outbound leg.

The captain, although more experienced in these approaches, seems to have been unable to disregard the path displayed by the FMS in order to monitor that the approach was flown as he wanted it to be flown. This mixture between different practices and between the associated means probably contributed to his confusion and to his early request to start the descent.

For the last few years, dedicated approach procedures have been drawn up due to the development of GNSS means. At numerous aerodromes, the RNAV (GNSS) approach procedures have progressively replaced those relying on radio equipment which is more costly in terms of maintenance.

Parallel to this, the FMS databases have been enriched. In particular, approach procedures have progressively become available in the FMS which traditionally rely on radio equipment, including procedures which do not require DME as is the case of the Bergerac-Roumanière airport NDB Y 28.

These changes have progressively reduced the sometimes already small number of non-precision approaches flown conventionally by crews of certain operators, such as timed approaches in HDG and V/S modes. Given all the types of approach likely to be encountered in operation, this small percentage may not incite these operators to allocate a large amount of training time to them. However, if some of them intend to actually keep the possibility of carrying out such approaches, then the level of technicality required and the small amount of experience in operation could, on the contrary, justify reinforced recurrent training. Indeed, several studies have shown that the safety level associated with non-precision approaches was a lot lower than that of precision (or comparable) approaches.

Abandoning these procedures is another option for the operators who already consider that they no longer rely on them to a great extent. This is in keeping with the rationalization of means which plans, for example, to withdraw NDBs and the associated procedures in France between now and 2030.

Be that as it may, during this period of transition for IFR aviation and thus commercial air transport, it seems important that operators ensure that crews favour or, at the very least, have no doubt as to their possibility of carrying out precision or comparable to precision approaches, such as certain RNAV (GNSS). This calls for clear instructions and documents without any ambiguity.

2.6 Use of different types of headsets and noise nuisance

In the absence of instructions from the operator governing this type of practice, the captain and first officer used headsets with different characteristics.

It is probable that the use of two different headset models introduced at the audio system level (mix of signals), some differences in the wearer's ability to perceive sound and listen to speech. In these circumstances, messages from the controllers or first officer may not have been heard by the captain. Moreover, these differences probably led the latter to adopt an uncomfortable volume setting which may have produced a feeling of auditory fatigue associated with discomfort from the concentration, indeed partially debilitating pain.

2.7 Detection and management of situation by controllers

The ANSP analysed the incident from an air traffic management point of view. The factors identified by the ANSP included:

- Air traffic services not detecting the difficulties that crews may experience in carrying out NDB approaches without DME.
- Controllers' lack of monitoring of the radar display.
- Approach controller's ignorance of the radar image at the Bergerac controller's disposal, notably with respect to the display of MSAWs.
- The Aquitaine-Approach and Bergerac controllers' ignorance of the NDB procedure without DME.

The BEA agrees with the ANSP's analysis concerning these factors.

Furthermore, the MSAW could have constituted a pertinent barrier nearly 30 seconds before the E-GPWS. Only available in the approach room (at Bordeaux-Mérignac), this barrier proved ineffective as the Aquitaine-Approach controllers no longer had the crew on the frequency when its was activated. The installation of a MSAW system or the remote display of the Bordeaux-Mérignac MSAW at Bergerac would have probably enabled the airport controllers to intervene earlier. Failing this, the absence of coordination procedures between Aquitaine-Approach and Bergerac meant that the warning which had in fact been activated, was not made use of.

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.

3.1 Findings

- The crew held the necessary licences and ratings to carry out the flight; they were authorized to carry out RNAV (GNSS) approaches.
- The aircraft held a valid airworthiness certificate; its equipment enabled it to carry out RNAV (GNSS) approaches.
- The ILS and DME equipment at Bergerac-Roumanière was not available; the Aeronautical Information Publication mentioned this.
- The two instrument approach procedures available for runway 28 in service at Bergerac-Roumanière were NDB Y 28 and RNAV (GNSS) 28.
- The approach controller proposed the RNAV (GNSS) approach to the crew.
- The RNAV (GNSS) approaches for runways 10 and 28 were included in the FMC database and navigation charts available to the crew. However, unlike the other IFR procedures, they were not referenced in the Bergerac-Roumanière Airfield Brief, prepared and made available to crews by the operator.
- The crew read back the performance of the NDB Y 28 approach.
- The Bergerac-Roumanière NDB Y 28 approach is a timed approach. This procedure requires that the last turn is made at the safe altitude of 2,500 ft and that the final descent starts on exiting the last turn.
- The LNAV guidance mode was activated for all of the approach until the initiation of the go-around.
- The aeroplane entered descent in V/S mode and descended below the safe altitude of 2,500 ft at the end of the outbound leg.
- The activation of the autopilot ALT ACQ mode at the end of the inbound turn, when the altitude was close to the MDA, led to the vertical speed increasing from -300 ft/min (as selected with the MCP) to -1,050 ft/min.
- The MSAW was activated in the approach room (Aquitaine-Approach at Bordeaux-Mérignac).
- The Bergerac-Roumanière local control unit had neither the MSAW system nor the remote display of the Aquitaine-Approach MSAWs.
- The E-GPWS "Terrain" alert and "Pull up" warning were recorded in the aeroplane's parameters.
- At the point at which the crew flew a missed approach, the aeroplane was more than 8 NM from the runway threshold and at an altitude of 1,018 ft (i.e. a radio altimeter height of 797 ft). The rate of descent was 986 ft/min and the indicated airspeed 164 kt.
- The telephone call to the Bergerac unit, following the activation of the MSAW in the approach room, was made after the crew had begun a missed approach and after the crew had announced this to the Bergerac controller.

3.2 Contributing factors

The incident occurred while performing an NDB approach without DME equipment, probably without external visual references.

The first preparation of the approach was probably incomplete or not precise. The clearance given by the controller, although it concerned the procedure that the crew thought they had prepared, seems to have called into question their action plan and obliged them to reprogramme the FMS.

This late modification probably meant that the crew did not have enough time to agree with each other about what guidance mode was to be used. This resulted in the captain's confusion with respect to the horizontal path actually being followed by the aeroplane. Faced with these doubts, rather than opting for a holding pattern or returning to a conventional management of the procedure, this state of confusion led him to request the anticipated start of descent, below the safe altitude. The following factors may have also contributed to this manoeuvre:

- The captain's concerns, notably with respect to the noise nuisance in his headset which he perceived as extremely uncomfortable, and his concerns as to the first officer's participation.
- The first officer's small amount of experience in this type of approach, which, at the very least, did not enable him to perceive the inconsistency in the request given by the captain.

The following factors may have contributed to the descent being continued below the safe altitude for nearly two minutes until the activation of the E-GPWS "TERRAIN" alert, even after the activation of a MSAW:

- The two pilots' situational awareness which was at that time seriously impaired.
- The controllers' lack of knowledge of the NDB procedures which meant that they did not effectively monitor the aeroplane's path.
- The absence at Bergerac of a MSAW system (or a remote MSAW display) and, failing this, the absence of emergency coordination procedures between Aquitaine-Approach and Bergerac on the activation of a MSAW.

4 - SAFETY ACTIONS TAKEN SINCE THE INCIDENT

4.1 Measures taken by operator

After the incident, the operator amended its operations manual as follows: "*the use of V/S mode for timed Non-Precision approaches is prohibited*."

A reminder about this proscription was included in the post-incident amended version of the Bergerac-Roumanière Airfield Brief.

Furthermore, the operator no longer indicates the list of existing approaches in these Airfield Briefs, whatever the airport. Instead, the operator refers the pilots to the published approach charts.

4.2 Measures taken by ANSP and reflections

The emphasis was placed on the training of controllers. In particular, the absence of MSAWs at airports is indicated in the initial training and the warnings in general were the subject of specific points in the 2017-2019 three-year recurrent training course. In addition, the training plan of the south-west regional approach and control centre (SNA-SO) mentions a visit to the Bergerac control unit as part of the programme about satellite airports.

Furthermore, the inbound traffic transfer procedure between Aquitaine-Approach and Bergerac was modified, leaving the approach controller the possibility of carrying out the transfer between flight over the BGC beacon and the moment when the aeroplane leaves 2,500 ft aligned on the final path.

In addition, the usefulness of having a remote display of the warnings in the Aquitaine-Approach centre was studied. However, a remote radar display at Bergerac would come from the south-west en-route control centre where the MSAW function is not implemented. The ANSP indicated that in order to provide the MSAW function at Bergerac, they would have to carry out an in-depth review of the radar distribution architecture at this type of airport, which they do not envisage doing.

Lastly, the ANSP considered that a coordination between the approach unit and the local control unit, once the inbound aeroplane had been transferred, might, in addition to taking time and thus not constituting a significant increase in safety, disrupt the actions in progress at the time when the local controller has to manage the arrival. Consequently, the ANSP does not envisage establishing emergency coordination procedures for the cases where a MSAW is activated for an aircraft whose crew is likely to be in radio contact with another control unit.

4.3 Safety promotion by civil aviation authorities

In 2018, the French civil aviation safety directorate (DSAC) published a "Safety Information"[32] about the proficiency of crews in non-precision approaches. In this document, the French authority reminds the reader of related French and international accidents. The risk factors mentioned include the following points:

- Most crews have small, sometimes even no experience in NPA approaches according to the operator's network; the appearance of GNSS approaches reduces the frequency at which these standard NPA approaches are carried out (NDB, VOR, LOC[33]) without glide, etc.) even more.

[32] https://www.ecologique-solidaire.gouv.fr/sites/default/files/IS2018_01_approches_non_precision.pdf

[33] Localizer.

- The wide variety of NPA approaches, including NPA GNSS approaches, with significant variations for each type, does not permit effective recurrent training to be carried out in this area.
- The most common errors include distance reference errors, QNH errors, and errors in the management of automatic systems in the scope of unusual use.

By means of this publication, the DSAC invites operators to assess their own exposure to the specific risks represented by non-precision approaches and to take the necessary management measures in the scope of their Safety Management System (SMS).

Also in 2018, EASA published a Safety Information Bulletin (SIB) regarding the approach and landing[34]. While not specifically about non-precision approaches, the document recalls certain good practices to be adopted which seem relevant with regard to the incident investigated, notably in connection with situational awareness, the monitoring of the approach by the PM or the use of automatic systems.

[34] https://ad.easa.europa.eu/blob/EASA_SIB_2018_06.pdf/SIB_2018-06_1

5 - SAFETY RECOMMENDATION

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 the safety recommendations shall 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.

5.1 Instructions in the AIP France concerning entry into holding pattern

Paragraph ENR 1.5.2.3 of the AIP France indicates that when the holding pattern and racetrack are shown separately, entries must be made in the holding pattern, the racetrack can only be flown once the aeroplane is stabilised in and at the minimum altitude of the holding pattern; if racetrack entries are nevertheless possible for certain aircraft, this possibility is mentioned (category and/or maximum speed).

It seems that the purpose of these instructions is to ensure that the entry manoeuvre is made in protected areas. Indirectly, complying with these instructions guarantees that the racetrack procedure is correctly started in terms of heading, altitude and speed which is particularly important in the case of a procedure without a FAF.

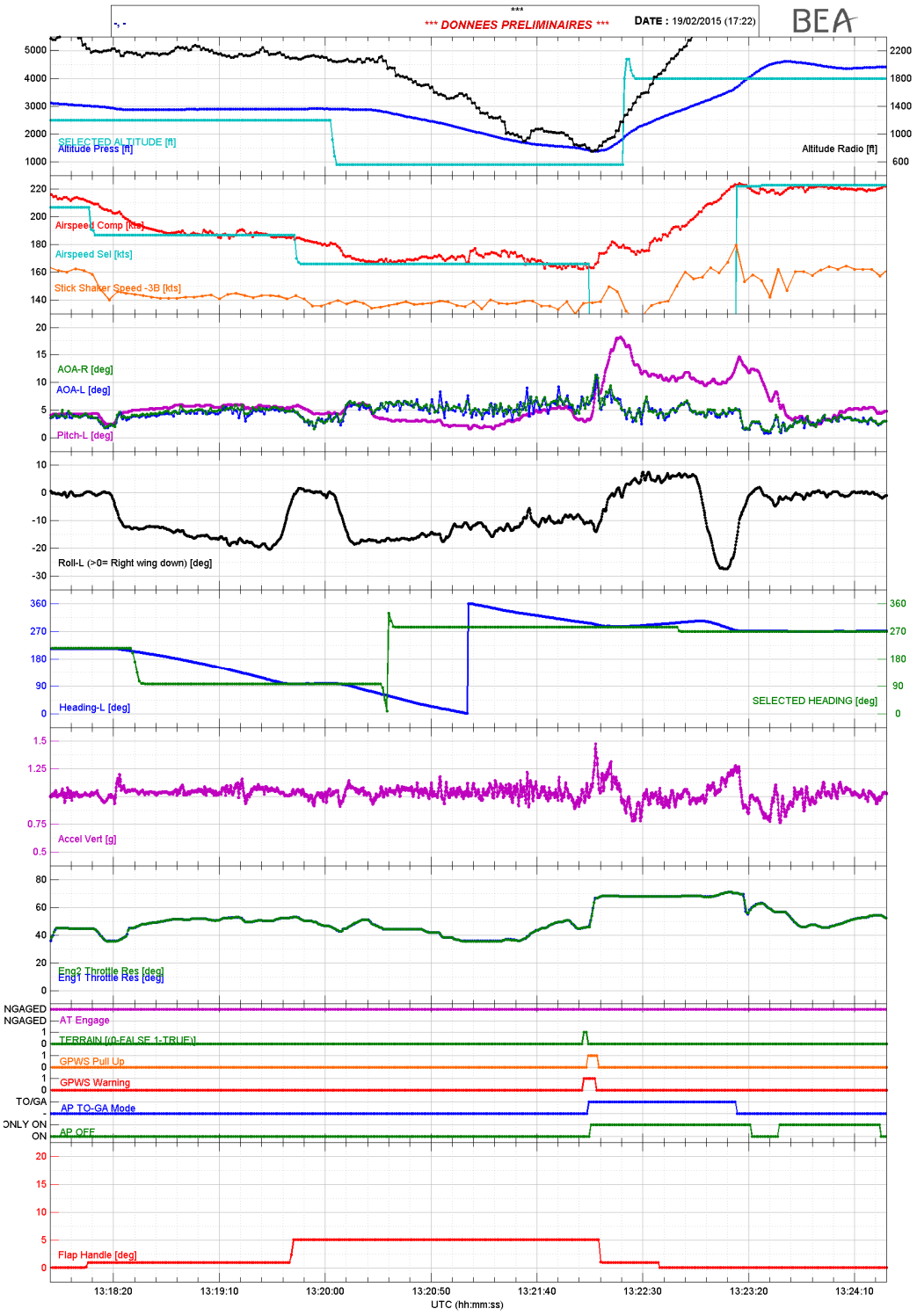
However, these French instructions do not seem to be based on international regulations, are not widely known and are subject to various interpretations. This results in varying practices. The possible consequences include air traffic controllers adopting a wait-and-see attitude, not conducive to monitoring paths and detecting anomalies.

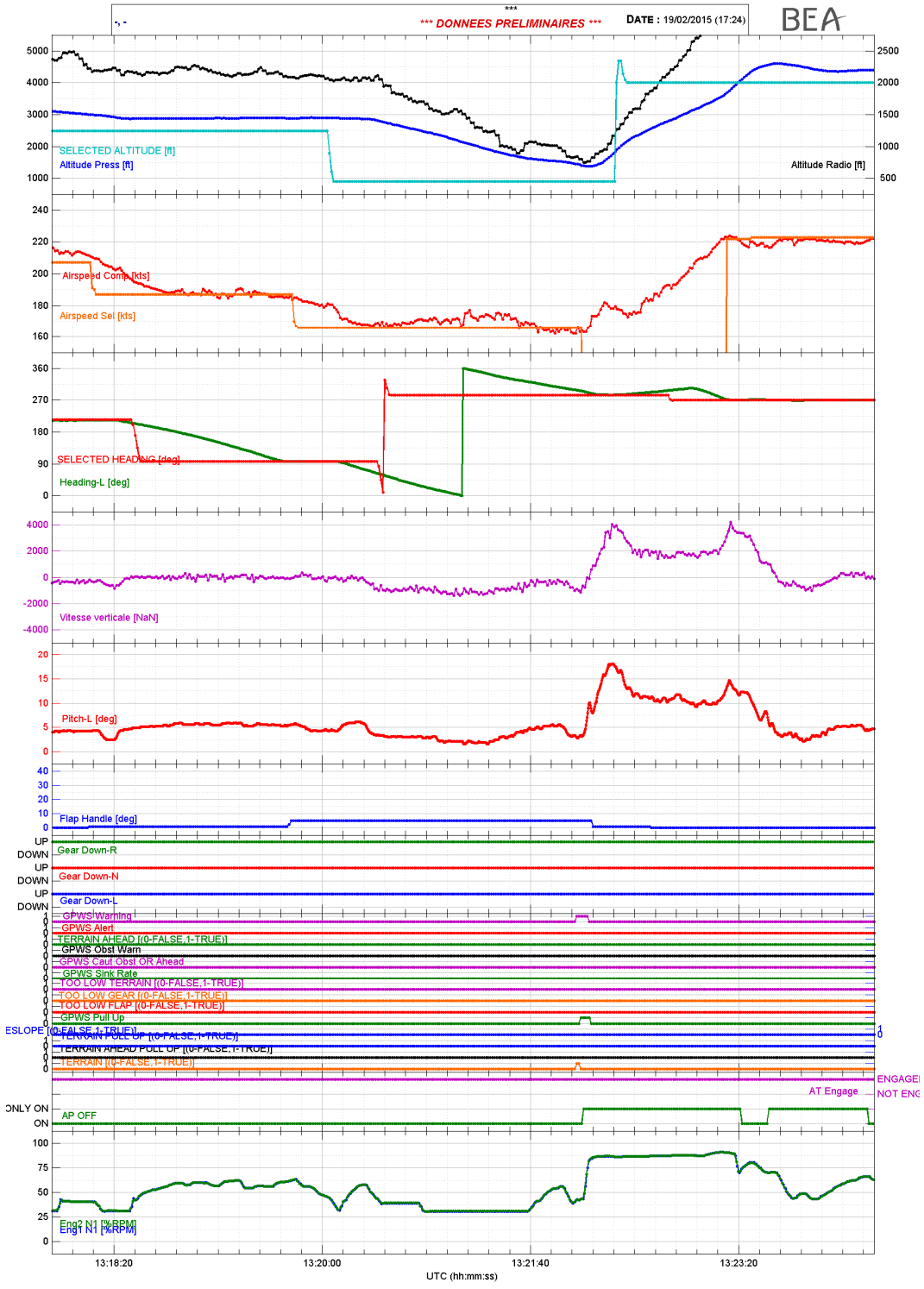
Consequently, the BEA recommends that:

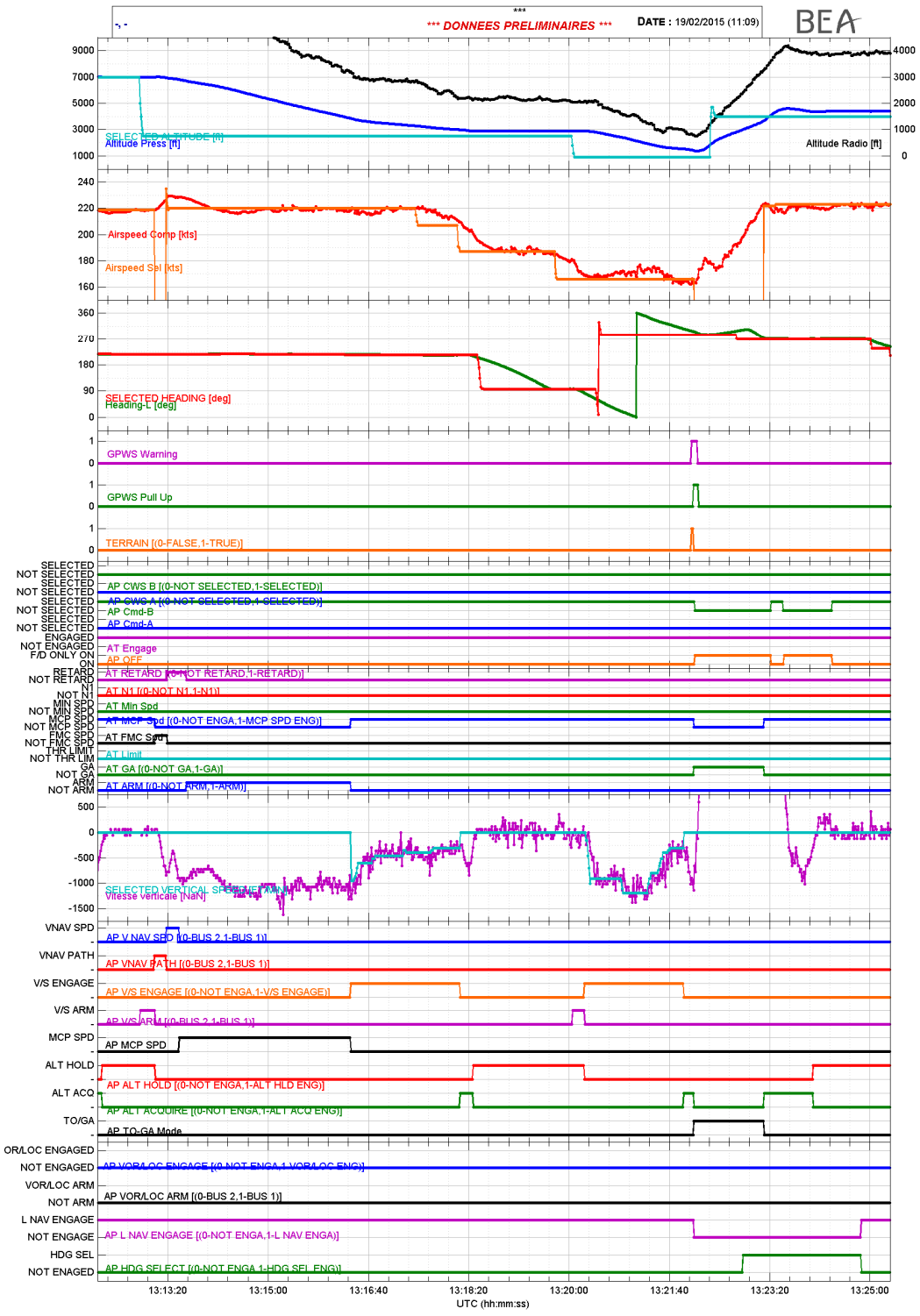
- **The DGAC check the validity and relevance of this excerpt from paragraph ENR 1.5.2.3 of the AIP and according to the results of this check, ask the DSNA to show these instructions more clearly on the approach charts or to delete this paragraph in the AIP France.**
  [Recommendation FRAN-2020-005]

APPENDIX

Recorded flight parameters




*** DONNEES PRELIMINAIRES ***
DATE : 19/02/2015 (17:24)
BEA
SELECTED ALTITUDE [ft]
Altitude Press [ft]
Altitude Radio [ft]
Airspeed Comp [kts]
Airspeed Sel [kts]
SELECTED HEADING [deg]
Heading-L [deg]
Vitesse verticale [NaN]
Pitch-L [deg]
Flap Handle [deg]
Gear Down-R
Gear Down-N
Gear Down-L
GPWS Warning
GPWS Alert
TERRAIN AHEAD [(0-FALSE,1-TRUE)]
GPWS Obst Warn
GPWS Caut Obst OR Ahead
GPWS Sink Rate
TOO LOW TERRAIN [(0-FALSE,1-TRUE)]
TOO LOW GEAR [(0-FALSE,1-TRUE)]
TOO LOW FLAP [(0-FALSE,1-TRUE)]
GPWS Pull Up
TERRAIN PULL UP [(0-FALSE,1-TRUE)]
TERRAIN AHEAD PULL UP [(0-FALSE,1-TRUE)]
TERRAIN [(0-FALSE,1-TRUE)]
AT Engage
AP OFF
Eng2 N1 [%RPM]
Eng1 N1 [%RPM]
13:18:20
13:20:00
13:21:40
13:23:20
UTC (hh:mm:ss)


*** DONNEES PRELIMINAIRES ***
DATE : 19/02/2015 (11:09)
BEA
SELECTED ALTITUDE [ft]
Altitude Press [ft]
Altitude Radio [ft]
Airspeed Comp [kts]
Airspeed Sel [kts]
SELECTED HEADING [deg]
Heading-L [deg]
GPWS Warning
GPWS Pull Up
TERRAIN [(0-FALSE,1-TRUE)]
AP CWS B [(0-NOT SELECTED,1-SELECTED)]
AP CWS A [(0-NOT SELECTED,1-SELECTED)]
AP Cmd-B
AP Cmd-A
AT Engage
AP OFF
AT RETARD [(0-NOT RETARD,1-RETARD)]
AT N1 [(0-NOT N1,1-N1)]
AT Min Spd
AT MCP Spd [(0-NOT ENGA,1-MCP SPD ENG)]
AT FMC Spd
AT Limit
AT GA [(0-NOT GA,1-GA)]
AT ARM [(0-NOT ARM,1-ARM)]
SELECTED VERTICAL SPEED [FPM]
Vitesse verticale [NaN]
AP V NAV SPD [(0-BUS 2,1-BUS 1)]
AP VNAV PATH [(0-BUS 2,1-BUS 1)]
AP V/S ENGAGE [(0-NOT ENGA,1-V/S ENGAGE)]
AP V/S ARM [(0-BUS 2,1-BUS 1)]
AP MCP SPD
AP ALT HOLD [(0-NOT ENGA,1-ALT HLD ENG)]
AP ALT ACQUIRE [(0-NOT ENGA,1-ALT ACQ ENG)]
AP TO-GA Mode
AP VOR/LOC ENGAGE [(0-NOT ENGA,1-VOR/LOC ENG)]
AP VOR/LOC ARM [(0-BUS 2,1-BUS 1)]
AP L NAV ENGAGE [(0-NOT ENGA,1-L NAV ENGA)]
AP HDG SELECT [(0-NOT ENGA,1-HDG SEL ENG)]
UTC (hh:mm:ss)

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