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SAFETY INVESTIGATION REPORT

Serious incident between the Cessna Citation 525 CJ registered **F-HGPG** operated by Valljet and the Embraer 170 registered **F-HBXG** operated by HOP! on 12 January 2022 en route south of Auxerre (Yonne)

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Safety investigations

The BEA is the French Civil Aviation Safety Investigation Authority. Its investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.

BEA investigations are independent, separate and conducted without prejudice to any judicial or administrative action that may be taken to determine blame or liability.

SPECIAL FOREWORD TO ENGLISH EDITION

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.

Contents

Glossary

Abbreviations	English version	French version
ACAS	Airborne Collision Avoidance System	
ACC	Area Control Centre	
ADC	Air Data Computer	
ADS-B	Automatic Dependent Surveillance – Broadcast	
ANAC	Brazilian civil aviation authority	
ANS	Air Navigation Services	
AOC	Air Operator's Certificate	
AOG	Aircraft On Ground	
ASR	Air Safety Report	
ATC	Air Traffic Control	
BIS	Best Intervention Strategy	
CAA-UK	UK Civil Aviation Authority	
CAME	Continuing Airworthiness Management Exposition	
CAMO	Continuing Airworthiness Management Organisation	
CARI	Continuing Airworthiness Review Item	
CAT	Commercial Air Transport	
CCER	Test and acceptance traffic control centre	Centre de Contrôle de la circulation d'Essais et de Réception
CENIPA	Brazilian safety investigation authority	
CNOA	National air operations centre	Centre National des Opérations Aériennes
CPL	Commercial Pilot Licence	
CVR	Cockpit Voice Recorder	
DMC	Military coordination detachment	Détachement Militaire de Coordination
DO	DSNA operations directorate	Direction des Opérations de la DSNA
DOA	Design Organisation Approval	
DSAC	French civil aviation safety directorate	Direction de la Sécurité de l'Aviation Civile
DSNA	French air navigation service provider	Direction des Services de la Navigation Aérienne
EADI	Electronic Attitude and Direction Indicator	
EASA	European Aviation Safety Agency	
EHSI	Electronic Horizontal Situation Indicator	
EU	European Union	
FAA	Federal Aviation Administration	
FDR	Flight Data Recorder	
FL	Flight Level	
FSB	Flight Safety Bulletin	

Abbreviations	English version	French version
ft	Feet	
GNSS	Global Navigation Satellite System	
IAS	Indicated Air Speed	
ICAO	International Civil Aviation Organisation	
IR/ME	Instrument Rating / Multi Engine	
kt	Knot	
LIFUS	Line Flying Under Supervision	
MCC	Maintenance Control Centre	
MEL	Minimum Equipment List	
MSAW	Minimum Safe Altitude Warning	
MSM	Management System Manual	
NCC	Non-Commercial air operations with Complex motor-powered aircraft	
NCO	Non-Commercial operations with Other than complex-motor-powered aircraft	
NM	Nautical Mile	
NTO	No Technical Objection	
NTSB	National Transportation Safety Board (USA)	
OCC	Operations Control Centre	
OSAC	Civil aviation safety organisation	Organisme pour la Sécurité de l'Aviation Civile
PF	Pilot Flying	
PM	Pilot Monitoring	
PPL	Private Pilot Licence	
QNH	Altimeter setting for altitude above sea level	
QRH	Quick Reference Handbook	
RVSM	Reduced Vertical Separation Minimum	
S/B	StandBy	
SB	Service Bulletin	
SERA	Standardised European Rules of the Air	
SMS	Safety Management System	
SPL	Sailplane Pilot Licence	
STCA	Short Term Conflict Alert	
STCH	Supplemental Type Certificate Holder	
TCAS	Traffic Collision Avoidance System	
TCCA	Canadian civil aviation authority	
TCH	Type Certificate Holder	
TLB	Technical Log Book	
TSM	TroubleShooting Manual	
V/S	Vertical Speed	Vertical speed

Synopsis

Time	At 09:19[1]
Operator	Cessna Citation 525 CJ: Valljet Embraer 170: HOP!
Type of flights	Passenger commercial air transport
Persons on board	Valljet flight: Captain (PF), co-pilot (PM), 2 passengers HOP! flight: Captain (PM), co-pilot (PF), 2 cabin crew members and 42 passengers
Consequences and damage	None

Fault on an air data system en route, proximity with an aeroplane without activation of anti-collision systems

The crew of the Cessna 525 CJ registered F-HGPG were carrying out a flight between Paris-Le Bourget airport (Seine-Saint-Denis) and Geneva airport (Switzerland).

During the climb, following a sudden variation in the nose-up attitude with the autopilot engaged in IAS mode, the crew observed erratic speeds on the system 1 airspeed indicator. After a short manual flight phase, the climb was continued with the autopilot in VS mode. Later, when approaching the en-route level, the crew realised that there was a difference in altitude between the two altimeters (system 1 and system 2). The cross-check with the help of the controller who had the flight level transmitted by the aeroplane’s transponder displayed on his radar screen did not enable the crew to identify that the system 1 altimeter indications were erroneous. The climb was continued to the en-route level based on an erroneous altitude.

En route, after having observed that the left and right altimeters were giving different indications, the crew informed the controller of the onboard altimeter fault. The latter then informed the crew of converging traffic (the Embraer 170 registered F- HBXG) at a distance of 2 NM, in theory 1,000 ft higher than them. In reality, the traffic was lower than them (the minimum separation was estimated at 665 ft and 1.5 NM). No collision avoidance system warning, whether it be on the ground or onboard the Embraer 170 was emitted, as the systems had analysed erroneous data from the Cessna 525. Subsequently, the controller asked the crew to deactivate the transponder Mode C, he coordinated with the Swiss control services and the flight continued to Geneva, its destination.

The head of the control centre room attempted to determine the actual altitude of the aeroplane with the help of the National air operations centre (CNOA), however, the latter did not have additional altitude information. However, another parameter, the aeroplane’s altimeter setting, which the CNOA shared with the controller proved to be erroneous. The investigation was not able to determine the cause of this difference.

The investigation showed that the fault on air data system 1 (altimeter and airspeed indicator on captain’s side) had already occurred three times on this aeroplane in 2017, 2019 and 2021.

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

The BEA has issued six safety recommendations concerning five topics:

- maintenance documentation published by Textron Aviation;
- notification of technical faults at the operator, Valljet;
- DSNA quick reference card when a pilot has a doubt about the altitude of his flight;
- information transmitted by CNOA;
- EASA's analysis of the risk posed by an air data system fault.

Organisation of the investigation

The BEA on-duty officer was notified of the serious incident the day after it occurred, by an email from the operational duty manager of the Athis-Mons Area Control Centre (ACC). In accordance with Annex 13 to the Convention on International Civil Aviation and Regulation (EU) 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 investigation was opened by the BEA in order to determine the causes of this serious incident.

Valljet's ASR[2] was provided to the BEA on 17 January 2022. HOP!'s ASR was provided to the BEA on 21 January 2022. These two operators assisted the BEA during the investigation.

The BEA notified NTSB, its American counterpart, who appointed an accredited representative as State of manufacture and design of the Cessna Citation 525 CJ. Technical advisers from Textron Aviation (USA), the aircraft manufacturer, from Aerosonic, the Pitot tube manufacturer and from Ametek, the altimeter manufacturer assisted the NTSB and the BEA during the investigation.

The BEA notified CENIPA, its Brazilian counterpart, who appointed an accredited representative as State of manufacture and design of the Embraer 170. A technical advisor from Embraer, the aeroplane's manufacturer, was designated by the CENIPA.

The BEA also notified the European Aviation Safety Agency (EASA) and the International Civil Aviation Organisation (ICAO). EASA assisted the BEA during the investigation.

Lastly, the BEA informed the French civil aviation safety directorate (DSAC), the French air navigation service provider (DSNA), the French civil aviation safety organisation (OSAC) and the National air operations centre (CNOA) of the opening of the investigation. These organisations assisted the BEA during the investigation.

The draft of the final report was submitted to the American and Brazilian accredited representatives and their technical advisers for comment. It was also shared with the BEA's technical advisers (EASA, DSAC, DSNA, OSAC, CNOA, HOP! and Valljet). The consultation phase came to an end mid-April 2023.

[2] Air Safety Report.

1. FACTUAL INFORMATION

1.1 History of the flight

Note: The following information is principally based on statements made by the crew of F-HGPG and air traffic controllers, radio-communication recordings, radar data and flightradar24 data.

The crew of the Cessna 525 CJ took off from Paris-Le Bourget airport (Seine-Saint-Denis) bound for Geneva airport (Switzerland) with two passengers at around 08:55.

The climb to FL 270 was performed with the autopilot engaged in the indicated airspeed hold mode (IAS mode), with a selected speed of 200 kt.

At 09:04 (see *Figure **3***, point 1), on flying through FL 185, the crew observed that the aeroplane's pitch attitude was around 20° nose up after having felt a load factor. The PF (captain) read at this point, an indicated airspeed of around 250 kt on his airspeed indicator (system 1) while the PM read an indicated airspeed of around 150 kt on his indicator (system 2). The PF disconnected the autopilot and continued the climb by selecting a customary pitch attitude of approximately 10°. He then engaged the autopilot in the vertical speed hold mode (V/S mode) to continue the climb.

At around 09:09, the crew carried out a radio check with air traffic control[3] who replied that he was receiving them loud and clear.

One minute later, at around 09:10, the PM told the PF that he had overshot the level, his altimeter (system 2) was indicating a FL above FL 270. The PF replied that his altimeter (system 1) was displaying a FL below FL 270.

At 09:11:30 (point 2), the crew entered level flight and asked the controller what altitude he could see them at "to get a rough idea". The controller replied FL 263. The captain indicated in his statement that at this point, the altitude displayed on his system 1 was consistent with the information given by the controller whereas system 2 showed an altitude above FL 280. He specified that the standby altimeter indicated a different altitude, but that it was close to the system 2 display. The crew started climbing again to FL 270 (system 1) which they reached at 09:13:17. They then started processing the failure.

At 09:17:15 (point 3), the captain indicated to the controller that they had a small problem with their altimeters, that the information was inconsistent, and that he thought that they were in fact higher than the transponder information being sent.[4] The controller then gave him traffic information, indicating that there was traffic at their 12 o'clock, in theory 1,000 ft above them and that he was at a loss as to what to say. The crew then announced that they had passed an aircraft, the Embraer 170 operated by HOP![5], at around the same altitude, below them, and confirmed that they had a problem on board.

The controller then saw the aircraft crossing each other a few seconds later on his radar screen.

[3] Paris control, located in the Athis-Mons Area Control Centre (North ACC).

[4] The message lasted 20 s, 3 NM were covered during this time.

[5] The crew of this aeroplane indicated that they had not seen the traffic which they had crossed and that there had been no TCAS alert or warning. They had not detected anything.

The calculated minimum separation was 1.5 NM laterally and 665 ft[6] vertically at 09:17:45.

The crew indicated that they then proposed to descend using as a reference, the altitude indicated on system 2 which appeared to be operating but that their transponder was associated with system 1. Following the controller's request, the crew replied that altimeter 2 indicated FL 285 and altimeter 1 indicated FL 270, the value displayed on the transponder and thus transmitted to the ground.

At around 09:19, the controller asked the crew to descend to FL 230, the usual altitude for aeroplanes bound for Geneva and to deactivate the altitude encoder (see paragraph 1.6.3). The crew read back and then told the controller that the system 1 speeds were also erroneous. The controller replied that they were starting to worry him and that he was going to coordinate with the next control sector at Geneva to accept them in these conditions. He also told them that there might be an interception mission to check the aeroplane's flight level. The crew replied that system 2 seemed to be consistent with the altitude of their GNSS receiver.

At around 09:22, the head of the control room in the North ACC contacted the CNOA[7] to ask for an estimation of the aeroplane's altitude. The CNOA indicated that the aeroplane was at FL 234 (see paragraph 1.17.4). At 09:26:47, the aeroplane was transferred to the Geneva sector, the Swiss controllers having accepted the aeroplane's flight through their airspace. At around 09:27, the CNOA called back the head of the control room in the North ACC and informed him that the altimeter setting was thought to be 1040 instead of 1013. This information was passed on to the Swiss controllers who questioned the crew. However, the latter replied that it was effectively set at 1013.

At around 09:40, (point 4), during the descent, close to FL 105, the crew indicated that both systems were giving similar information again and were thus consistent with each other and that the malfunction of system 1 (altimeter and airspeed indicator) had disappeared.

At around 09:42, after the last turn and in descent through 6,000 ft, there was an *AP out of trim* failure (unconnected with the previous event). The emergency procedure for this failure was complied with. This did not affect the end of the flight. The crew landed without further incident.

A ferry flight under special authorization conditions was carried out on 19 January 2022 to transfer the aeroplane to the maintenance workshop based at Paris-le Bourget airport. The aeroplane manufacturer, Textron Aviation[8] (USA), had specified restrictions for carrying out this flight. No fault occurred during this flight.

1.2 Injuries to persons

Not applicable.

1.3 Damage to aircraft

Not applicable.

[6] Based on the GNSS data of the two aeroplanes.
[7] Military body.
[8] Cessna parent company.

1.4 Other damage

Not applicable.

1.5 F- HGPG personnel information

1.5.1 Captain

The 36-year-old captain held a CPL(A) licence obtained in 2019 with the IR/ME and Cessna 525 ratings (PPL(A) obtained in 2008). He had logged approximately 2,000 flight hours, including around 1,000 hours on type. He also held a SPL with the instructor rating and had logged around 1,300 glider flight hours. Lastly, he held a microlight pilot certificate with the instructor rating and had flown 1,300 microlight flight hours.

1.5.2 Co-pilot

The 22-year-old co-pilot held a CPL(A) licence obtained in 2019 with the IR/ME and Cessna 525 ratings (PPL(A) obtained in 2018). He had logged approximately 370 flight hours, including around 110 hours on type.

1.5.3 Statement

The two members of the crew specified that the first part of the flight went smoothly. They checked the consistency of their airspeed indicators when selecting the QNH correction 1013 and when flying through FL 100 by complying with the Climb checklist. They climbed at a speed of 160 kt up to 3,000 ft and then at 180 kt up to FL 100, and then 200 kt. It was planned to fly the en-route phase at an indicated airspeed of 230-240 kt.

The two members of the crew indicated that they felt a load factor during the climb. The captain explained that he saw the speed significantly increasing up to 250 kt. The autopilot requested a nose-up input to maintain the selected speed of 200 kt. On the co-pilot's side, the indicated airspeed had substantially decreased. The crew indicated that the Stick shaker[9] was not activated. The captain disengaged the autopilot in order to take control of the flight path. The autopilot was then engaged in VS mode as the IAS mode could no longer be used given the erratic speed values of system 1.

When the co-pilot mentioned that the level had been overshot, the three altimeters gave different values.

The two members of the crew said that they could not troubleshoot the altimeters in these conditions. The captain then asked the controller for the altitude displayed for them on his radar screen. The controller gave an altitude consistent with the altitude of the captain's altimeter (system 1). The captain thus considered that his altimeter was correct and continued the climb based on this. En route at FL 270, the difference between the two altimeters (systems 1 and 2) was stabilized at around 1,400 ft. After the two crew members had troubleshot the fault, they questioned whether the altimeter of system 1 was operating correctly. They did not envisage switching over to transponder 2 (see paragraph 1.6.3).

[9] It is the Angle Of Attack (AOA) system which activates the stick shaker at a predetermined AOA according to the configuration of the aeroplane.

When the flight path of F- HGPG crossed the flight path of F-HBXG at a visually higher altitude than the latter which was at FL 280, the two members of the crew analysed that the altimeter of system 1 was giving false information and that the altimeter of system 2 was more consistent with reality. This analysis was confirmed by reading the altitude provided by the GNSS receiver.

As far as they could remember, during the en-route phase, the altimeters indicated:

- System 1 = FL 270 (identical to transponder);
- System 2 = FL 285;
- Standby = FL 280.

The crew indicated that everything happened very quickly. They estimated that the sequence only lasted a few minutes, whereas the radar data and radio-communication recordings showed that it lasted around 15 min.

The captain specified that during the flight, for nearly 30 min, the needle of his airspeed indicator went round the dial several times. During the descent, the malfunction disappeared and the altitudes and speeds of the two system were consistent again.

Lastly, the crew members explained that during the occurrence, they exchanged PM and PF roles so that the captain could analyse the situation and start troubleshooting once the aeroplane's altitude was stabilized. The latter specified that no procedure regarding this malfunction existed in the aeroplane's QRH[10]. For the rest of the flight, the co-pilot remained the PF given that the parameters of system 2 seemed to them to be correct.

The captain indicated that after the flight of the serious incident, he was informed that there had been a similar fault on the air data system during a flight a month earlier (see paragraph 1.11.2.1), on 11 December 2021. He specified that had he had knowledge of this occurrence before the flight, he might have been able to analyse the failure more quickly.

1.6 F-HGPG information

1.6.1 General

F-HGPG is a Cessna 525 Citation Jet CJ built in 1995. It is a certified (according to CS 23 criteria) single-pilot aircraft, nevertheless Valljet operates it in multi-pilot Commercial Air Transport (CAT) operations, in accordance with requirement ORO.FC.200 (c) (1) of the consolidated European Regulation (EU) No 965/2012 related to air operations ("Air Ops")[11].

The aeroplane is equipped with an EADI[12] and an EHSI[13] with a digital display, conventional instruments with a pointer (notably the electronic airspeed indicators and altimeters), two EHS transponders[14] and two GNSS systems.

[10] Quick Reference Handbook.
[11] Commission Regulation of 5 October 2012 laying down technical requirements and administrative procedures related to air operations (Version in force on the day of the serious incident).
[12] Electronic Attitude and Direction Indicator.
[13] Electronic Horizontal Situation Indicator.
[14] Enhanced Surveillance.

It is also equipped with an autopilot which uses the values from air data system 1 to calculate the flight commands.

Figure 1: photo of instrument panel of F-HGPG/altimeter and airspeed indicator (source: BEA)

The aeroplane is not equipped with an ACAS[15]. This is not required by the regulations for this aeroplane. Furthermore, the aeroplane is certified for operations in RVSM airspace[16].

The aeroplane is based at Paris-Le Bourget airport. When it is not being flown, it is parked outside in the operator's parking areas. No protection is used for the static ports. The manufacturer does not require this and makes no recommendation on the subject. However, Pitot covers are used. The manufacturer does not advise against storing the aeroplane outside when snow or heavy frost is not forecast.

1.6.2 Aeroplane's air data system

The main elements of the aeroplane's air data system are (see *Figure* ***2***):

- system 1 (captain's side) made up of an altimeter (ALT ADC[17]) and an airspeed indicator (IAS[18]) connected to a Pitot tube located on the left side of the fuselage and to a static port on both sides of the fuselage;
- a standby altimeter (S/B[19] ALT) connected to the static system of system 1;
- system 2 (co-pilot's side) made up of an altimeter (ALT ADC) and an airspeed indicator (IAS) connected to a Pitot tube located on the right side of the fuselage and to a static port on both sides of the fuselage (different to those used by system 1);
- two vertical speed indicators (V/S[20]) connected respectively to the static system of system 1 and system 2.

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[15] Airborne Collision Avoidance System.
[16] Reduced Vertical Separation Minimum.
[17] Air Data Computer.
[18] Indicated Air Speed.
[19] Standby.
[20] Vertical Speed.

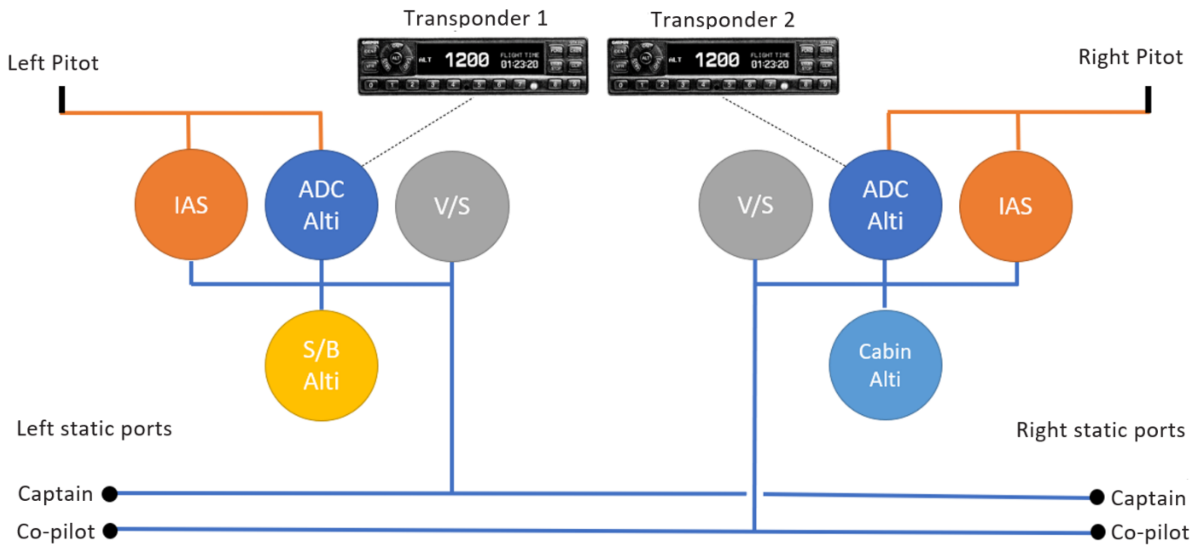

Figure 2: schematic diagram of F-HGPG air data systems (source: BEA)

Based on the operating principle of the airspeed indicators, the main effect, in climb, of a partial or total obstruction of a Pitot tube or the associated hoses will be an increase in the airspeed indicated by the corresponding system.

The altimeters of both systems are equipped with an ADC unit which corrects the "position" error of the altitude value. This error is due to the geometry of the fuselage around the static ports and varies according to the speed and altitude of the plane. The ADC has a built-in correction table which ensures that corrected altitude information is provided to the pilot. For example, for a flight at FL 270, with an IAS of 250 kt, the correction can be as much as 200 to 300 ft. To make this correction, each altimeter continuously uses the total pressure information provided by the corresponding Pitot. A total or partial obstruction of the Pitot system can therefore affect the altitude display. The standby altimeter (different from the other two altimeters) is not corrected however.

On the day of the serious incident, neither the manufacturers Flight manual nor the aeroplane's QRH contained procedures concerning the detection of a difference in the altitude shown on the altimeters. However, the QRH contained a procedure concerning a fault on an altimeter/ADC; in this case, the crew were to use the other altimeter/ADC and the transponder associated with it. Neither did these documents contain procedures regarding a fault on an airspeed indicator.

Furthermore, the Minimum Equipment List (MEL) did not contain an item regarding a fault on the air data system. In this case, the aeroplane must be considered as unairworthy.

1.6.3 Transponders

The aeroplane is equipped with two Mode S transponders with the ADS-B capability. Transponder 1 is associated with system 1 and transponder 2 with system 2. Transponder 1 is selected by default to transmit the information to the ground; the crew can switch the transmission to transponder 2.

Each transponder is capable of sending:

- Mode S data frames to the sensors which query it, such as the civil aviation secondary radars;
- spontaneously, ADS-B data frames to sensors in its zone.

The Mode S data frames and the ADS-B data frames are practically identical. The main difference is in the horizontal position information which:

- for Mode S, is calculated by the ground radar sensors (calculation based on a distance *rhô* and a bearing *thêta*);
- for ADS-B, is generated on board the aircraft using the GNSS data.

The other information which the transponder transmits to the sensors is:

- Mode S address or ICAO address which is unique to each aircraft;
- Mode A or transponder code;
- Mode C, pressure altitude (based on 1013) transmitted as a flight level or quarter flight level. In general, this data is generated by the transponder's altitude encoder electrically connected to the altimeter. The pressure altitude transmitted by the transponder is therefore equal to the pressure altitude read on the altimeter to which it is connected (without the QNH correction);
- aircraft identification, in generals its registration number or flight number;
- onboard parameters, such as IAS, GNSS altitude and other flight parameters such as the altimeter setting or parameters linked to the autopilot.

All of these parameters for F-HGPG were retrieved in the ADS-B data (see paragraph 1.11.1). However, the autopilot and altimeter correction parameters do not seem to be consistent with the other factual information available (see paragraph 1.17.4).

The flight parameters which come from the aeroplane and are available for the Air Traffic Controller (ATC) are:

- pressure altitude (Mode C);
- selected altitude, displayed if different from current pressure altitude;
- heading and IAS on controller requesting this information from the system.

The controller does not have access to the altimeter correction or GNSS altitude parameters.

The altitude information is essential in airspaces. This data is used by air traffic controllers to ensure vertical separation standards. It is also used by the ACAS systems on board aircraft and by the ground systems used by the ATC services: STCA and MSAW safety barriers.

1.6.4 Maintenance

From 2020, the maintenance of the aeroplane was carried out by the Part-145 maintenance company, R&O (Repair & Overhaul) based at Paris-Le Bourget airport. The companies, R&O and Valljet are managed by the same person. Prior to this, the maintenance had been carried out by the Part-145 maintenance company, Textron Aviation Paris Service Center based at the same airport.

F-HGPG embodied the modification to integrate the RVSM option through compliance with Service Bulletin SB525-34-41. The work was carried out in 2015 by the Part-145 maintenance company, Textron Aviation Düsseldorf Service Center (Germany), and involved major modifications to the aeroplane's air-data system. It was then operated by a Swiss operator under the registration HB-VWP.

The last scheduled maintenance inspection of the aeroplane before the serious incident took place between 27 December 2021 and 6 January 2022. The maintenance report did not specify work carried out on the air data system. The serious incident flight was the first flight since this inspection.

A TSM[21] for the Cessna 525 does not exist. However, a task to troubleshoot the air data system exists in the maintenance manual. This task is only applicable to the Cessna 525s that have not been modified in accordance with SB525-34-41. This task explicitly specifies that in order to identify a fault in the air data system, all the components and associated hoses in the system must be visually inspected. This maintenance task does not exist in the documentation applicable to the Cessna 525s embodying SB525-34-41, such as F-HGPG.

The maintenance procedures concerning the air data system are detailed in the following chapters of the Textron Aviation Maintenance manual applying to the Cessna 525s embodying SB525-34-41:

- ***34-11-01 - PITOT-STATIC SYSTEM - MAINTENANCE PRACTICES***
  This chapter notably deals with bleeding the Pitot-static (air data) system to check that there is no contamination in the hoses.
- ***34-11-02 - PITOT-STATIC SYSTEM - INSPECTION/CHECK***
  This chapter includes the following tasks:
  - inspection of fuselage skin around the static pressure ports;
  - leak test of Pitot-static system;
  - functional test of Pitot-static heating system;
  - test and calibration of instruments (altimeter, airspeed indicator and machmeter).

Following the occurrence of 8 November 2017 (see paragraph 1.11.2.3), Textron Aviation Paris Service Center carried out troubleshooting work in accordance with chapters 34-11-01 and 34-11-02; the Work Order concluded that the tests were satisfactory. However, the analysis of the occurrence by the operator reported dirt found inside the Pitot tube.

[21] TroubleShooting Manual.

Following the occurrence of 28 February 2019 (see paragraph 1.11.2.2), Textron Aviation Paris Service Center also carried out troubleshooting work in accordance with chapters 34-11-01 and 34-11-02. It focused on the air data system. The aeroplane's static pressure ports and Pitot tubes were visually inspected, a leak test was carried out and no difference in altitude between the two systems was detected. The two altimeters were crossed over, the checks carried out on the Pitot-static system were satisfactory. The maintenance workshop did not identify the cause of the failure.

The aircraft manufacturer, Textron Aviation, specified that its Flight Safety department is not aware of a similar event on the fleet.

1.6.5 On-aircraft examination of air data system following serious incident

At the end of the flight during which the serious incident occurred, the captain detailed the following faults in the TLB:

- "*RH speed and LH speed inconsistent;*
- *At FL 270, difference of 1 400 ft between Alt1 and Stby and Alt2*."

The BEA carried out troubleshooting in cooperation with the maintenance workshop and with the manufacturer's support. The examination took place in the R&O workshop in February 2022.

The BEA examination protocol was based on the maintenance procedures and was applied to systems 1 and 2, after validation of the steps by Textron Aviation. The protocol went beyond the recommendations of the Textron maintenance manual applicable to this aeroplane and included, in particular, disassembly actions enabling a detailed visual examination of each element of the air data system. These actions are mentioned in the air data system troubleshooting task in the maintenance manual applicable to Cessna 525s that do not embody SB525-34-41 (unlike the F-HGPG).

The following observations were made:

- on disassembling the left EADI (system 1), moisture was found on the exterior of the unit;
- the static system hose was very slightly pinched where it was connected to the left altimeter (system 1);
- on bleeding the air data system, an insect was found in the static system of system 1, on the right static port side;
- leak tests did not reveal any system anomaly, even when the cabin was pressurized;
- the calibration test of the air data instruments did not reveal any anomaly;
- the on-aircraft test of the Pitot tube and static port heating system did not reveal any anomaly;
- just above the captain's pedals, the left Pitot hose formed an elbow which created a low point in the system.

The part number and length of the hose complied with the manufacturer's (Textron Aviation) specifications. The latter indicated to the BEA that there must be no low point in the air data system and that the hose must follow a continuous slope from the airspeed indicator and altimeter to the Pitot tube. The manufacturer added that liquid water can accumulate in a low point. After the serious incident, the hose was reinstalled on the aeroplane without any low point appearing.

Note: according to the maintenance work reports, the routing of the hoses of the air data system was not inspected during the troubleshooting operations carried out in 2017 and 2019.

Textron Aviation indicated that when the aircraft was certified, there was no specification for draining the Pitot system, unlike the static system. The specification changed in 1996. The documentation for Textron Aviation aeroplanes certified after this date therefore included a reference to draining the hoses leading to the Pitot tubes and static ports. The manufacturer added that a circular[22] issued by the American civil aviation authority (FAA) does exist which specifies that the hoses (static and Pitot system) must have a slope to ensure drainage. It specified that technicians are generally taught that it is important not to have a low point in the hoses, which could trap liquid water.

The manufacturer, Textron Aviation, also indicated that, although it had never carried out a test or study, if the air entering the Pitot system is sufficiently cold, it is possible that water that may have accumulated at a low point will freeze, even if the hose is located in the cockpit. It added that this would depend on the air temperature, the quantity of water, the position of the low point where the water had accumulated and the duration of the flight. The manufacturer of the Pitot tube, Aerosonic, indicated that the temperature of the air entering the Pitot is not low enough to freeze the water present in a low point; however if the temperature surrounding the position of the low point is low enough, the water can freeze. Lastly, these two manufacturers indicated that as the low point was located in a temperate environment, approximately 1.2 m from the Pitot tube, it remains unlikely that ice formed at this point.

Note: at the request of the BEA, the installation of this hose was checked on another Cessna 525 CJ belonging to the operator, Valljet, during the investigation. The maintenance workshop indicated that it also had a low point, with a different routing to that of F-HGPG. The BEA had not been informed of any fault on the air data system of this aeroplane.

Lastly, the manufacturer, Textron Aviation, added that it had not received any feedback from customers about the length of this hose.

1.6.6 Test of left Pitot tube heating system at the BEA

The left Pitot tube (system 1) was removed from the aeroplane at the beginning of March 2022. The heating system test took place in the BEA laboratories. This system was activated and then the temperature was measured at three positions on the Pitot tube for a dozen minutes. The results obtained complied with the manufacturer's specifications.

1.6.7 Examination of left Pitot tube at the manufacturer's

The left Pitot tube was examined by Aerosonic at the end of November 2022. It underwent electrical tests as well as leak and flow tests under pressure; the tests all complied with specifications. The diameter of the drain to evacuate moisture complied with the specifications.

[22] FAA Advisory Circular 43.13-1B, Acceptable Methods, Techniques, and Practices – Aircraft Inspection and Repair / paragraph 12-61(c).

1.6.8 Examination results

The technical examinations carried out on the air-data system after the serious incident did not identify with certitude, the cause of the fault. However, the symptoms reported by the pilots during the occurrences (see paragraph 1.11.2) in 2017, 2019, 2021 and 2022 (increase in indicated airspeed during climb, difference between the two altimeters and disappearance of anomalies during descent) suggest that:

- the fault was probably situated in the hoses between the Pitot tube and the airspeed indicator of system 1. It might have been a total or partial obstruction in one place;
- the cause of the obstruction was very probably environmental (liquid water or ice which would have disappeared during the descent).

The presence of a low point in the left Pitot tube hose could have created conditions conducive to partial or total obstruction.

Following the examinations carried out with the BEA which led to the removal and replacement of the Pitot tube of system 1 and the hose with the elimination of the low point, the aeroplane was returned to service at the beginning of March 2022. At mid-April 2023, no fault of the air data system had been reported again.

1.7 Meteorological information

At the time of departure, the wind was calm at Paris-Le Bourget airport. Visibility was reduced to 600 m due to freezing fog. The air temperature and dew point temperature were - 1°C. The QNH was 1039 (difference of 730 ft with respect to isobar 1013 in a standard atmosphere). The crew indicated that the fog bank was a few hundred feet thick. During the night preceding the serious incident flight, the weather conditions were practically the same.

En route, the sky was clear. The French met office (Météo-France) indicated that there was a north-easterly wind of around 30 kt and that there was no risk of icing. The temperature at FL 280 was -45°C. The freezing level was situated on the ground and at 5,000 ft.

On arriving at Geneva airport, the wind was from 040° of 14 kt, visibility was greater than 10 km, cloud cover was broken at an altitude of 1,900 ft, the temperature was 0°C and the QNH was 1034.

1.8 Aids to navigation

Not applicable.

1.9 Communications

At the time of the serious incident, the crews of F-HGPG and of F-HBXG were in contact with the controllers of the Paris control UT sector (frequency 133.505 Mhz) located in the North ACC.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

F-HGPG was not equipped with a flight recorder. This is not required by the regulations for this aeroplane.

F-HBXG was equipped with two flight recorders, a FDR and a CVR. Only the FDR data was read out.

1.11.1 F- HGPG ADS-B and radar data

The analysis of the flight's ADS-B data and radar data transmitted by active transponder 1 during the serious incident flight, revealed that:

- in the first part of the flight, in climb up to FL 170, there was a stabilized difference between the pressure altitude of system 1 and the GNSS altitude of around 700 ft (difference close to the QNH correction);
- from FL 180 in climb, during the en-route phase and down to FL 105 in descent, the changes in the indicated airspeed of system 1 exactly followed the actual changes in altitude (GNSS altitude) which was consistent with a blocked Pitot tube;
- the difference between the system 1 pressure altitude and the GNSS altitude reached 2,075 ft.

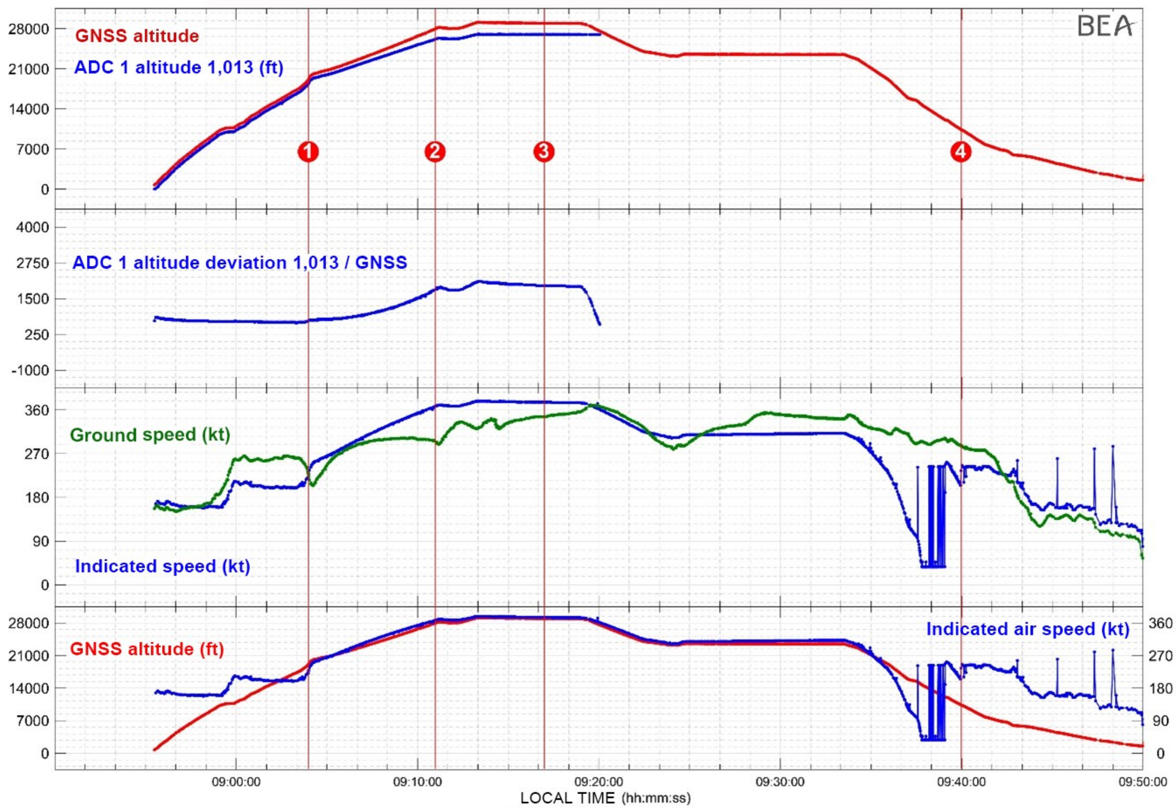

Figure 3: curve diagram (source of data: ADS-B)

1.11.2 Similar events concerning F-HGPG

1.11.2.1 Occurrence on 11 December 2021

The day of this occurrence, the crew were carrying out the outbound leg of a rotation between Paris-Le Bourget and Cannes-Mandelieu airports.

The analysis of the flight's ADS-B data and radar data transmitted by active transponder 1 during the occurrence flight, revealed that:

- in the first part of the flight, in climb up to FL 210, there was a stabilized difference between the pressure altitude of system 1 and the GNSS altitude of around 150 ft (difference close to the QNH correction[23]);
- from FL 210 in climb, during the en-route phase and down to FL 105 in descent, the changes in the indicated airspeed of system 1 exactly followed the actual changes in altitude (GNSS altitude);
- the difference between the system 1 pressure altitude and the GNSS altitude reached 650 ft.

The members of the crew specified that they realised that there was an anomaly on the system 1 airspeed indicator at the end of the climb. The needle of the airspeed indicator exceeded the maximum speed whereas on system 2, the indicated airspeed was consistent with the flight phase. They therefore decided to trust the system 2 airspeed indicator. The aeroplane did not enter an abnormal attitude. During the en-route phase, they observed a difference in altitude of several hundred feet between the two altimeters and decided to trust the altimeter of system 1 because the data was consistent with the transponder information. During the descent, the fault disappeared.

At destination, the captain[24] and the co-pilot discussed the fault described above (see paragraph 1.17.2.7.5) over the telephone with the operator's head of the Citation sector. The latter told them that this problem had already occurred two times previously, including once when he was on board the aeroplane and that the maintenance personnel had not identified the malfunction (see paragraph 1.11.2.2). According to the captain, the head of the Citation sector was confident that the return leg to the base at Paris-Le Bourget airport would be uneventful and added that the aeroplane would be inspected at its return. The captain decided not to mention anything in the TLB of the aeroplane and envisaged recording the fault if it re-occurred during the return flight.

After a pre-flight inspection with particular attention being given to the Pitot tubes and static ports, the crew carried out the return flight with five passengers the following day. No fault occurred. The captain specified that no information was recorded in the TLB but that the head of the Citation sector was informed of the problem.

The co-pilot indicated that he was concerned but sided with the captain's decision. The weather forecast for the return flight was favourable. They decided to take extra fuel on board.

At the end of the return flight, the co-pilot exchanged messages with the head of the Citation sector about this Pitot and static system failure which he indicated could be more dangerous according to when it occurred. The head of the sector replied that as there had been no failure during the return flight, it was not possible to troubleshoot a failure if there was no failure and that it would be followed up in the next inspection (see paragraph 1.6.4). The co-pilot indicated that he wrote an ASR. However, he had the impression that the final step was not correctly completed. When validating the step, the software froze and he did not receive confirmation that the ASR had actually been recorded in the software. He did not try again. No ASR was transmitted. However, he did discuss the in-flight fault encountered with a few pilots.

---

[23] The QNH at the departure airport was 1020, i.e. a difference of 200 ft with respect to the isobar 1013.

[24] The captain was not one of the operator's employees, but a freelance pilot regularly flying for the operator.

Notably, he warned the captain of the serious incident flight of 12 January by telephone but the latter explained that he did not pay particular attention as his mind was elsewhere during this telephone call. He understood that it was an autopilot failure and was just one more failure on an aeroplane.

1.11.2.2 Occurrence on 28 February 2019

The day of this event, the crew carried out three flights: a flight from Paris-Le Bourget airport to Zurich airport (Switzerland) with one passenger, then a flight to Berlin-Schönefeld airport (Germany) with no passengers and then a return flight to Paris-Le Bourget with two passengers. The head of the Citation sector (see paragraphs 1.17.2.3.2 and 1.17.2.7.5) was sat in the right seat in order to carry out Line Flying Under Supervision (LIFUS) for a captain in training. As the supervisor, the head of the Citation sector was the designated captain on these flights.

According to the crew's statements, the fault occurred in the second leg between Zurich and Berlin, during the climb and disappeared during the descent. They indicated that during the climb with the autopilot engaged and a speed of around 210 kt, the indicated airspeed and the aeroplane's attitude slowly increased. The crew did not notice anything until the autopilot disconnected itself at around 130 kt (true speed of aeroplane). The crew indicated that the Stick shaker was not activated. They determined that the system 1 airspeed indicator information was false. They could no longer remember the difference in altitude between the altimeters.

The analysis of the flight's ADS-B data revealed a difference between the system 1 pressure altitude and the GNSS altitude while the fault was present of around 700 ft; the QNH at the time was 1011. There was probably a difference in the order of 600 ft between the two altimeters. The system 1 airspeed indicator values followed the altitude changes. The data showed that the crew switched to transponder 2 when intercepting the en-route level. The crew could no longer remember this action.

The fault was recorded in the aeroplane's TLB on their return to Paris with the wording "*Static cdb inop*" (see paragraph 1.6.4). This occurrence was not the subject of an ASR.

The head of the Citation sector indicated that he asked the captain under LIFUS to write an ASR and realised later that it had not been done. He indicated that the failure was only recorded in the TLB during the return leg to the base and not during the intermediate leg in order not to penalize the operation of the aeroplane (see paragraph 1.17.2.7.5).

The captain in training indicated that he was reticent about carrying out the last leg to return to Le Bourget. It was a night flight and he was tired. He did not try to impose his viewpoint on the head of the Citation sector as he was in training. According to him, the head of the Citation sector had told him that he would note the failure in the TLB and would pass on information about the occurrence himself. The captain in training explained that he only remained eight months with the operator (between November 2018 and July 2019) as he considered that the safety level at that time was not what he had hoped for. He added that in his opinion, safety was not the operator's main concern at that period. Lastly, he specified that one of the instructions given by the head of the Citation sector had been not to write anything in the TLB and to call him first (see paragraph 1.17.2.7.5).

1.11.2.3 Occurrence on 8 November 2017

The day of this occurrence, the crew were carrying out a flight between Paris-Le Bourget and Cracovie-Jean-Paul II (Poland) airports. According to the ASR written following this event, during the climb the crew observed a fault on the system 1 airspeed indicator followed by the altimeter. They decided to return to Le Bourget airport. During the descent, the crew observed that the differences between the altimeters and between the airspeed indicators were slowly absorbed until becoming normal at around FL 080. The fault was recorded in the TLB as a failure of the left airspeed indicator followed by a left altimeter error (see paragraph 1.6.4).

According to the ASR, the difference between the two altimeters was around 4,000 ft; the QNH at the time was 1020. The pointer of the system 1 airspeed indicator went past the maximum value and continued around the dial to 40 kt. Furthermore, the ASR specified that the crew informed ATC of the failure and their choice to turn around.

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 Organisational and management information

1.17.1 Regulations concerning notification and processing of an occurrence

When a fault occurs during a flight (system has not operated as designed to), the captain[25] must record this fault in the TLB after landing so that the appropriate maintenance actions can be carried out. The type of fault may result in the aircraft being grounded (AOG[26]), the maintenance work conditioning the return to service of the aircraft. Certain faults, described in the MEL or in the maintenance data, can lead to deferred maintenance work, thus avoiding the immediate grounding of the aeroplane. If there is no MEL item for a fault or if the fault is not within acceptable tolerances, the aeroplane must be considered as unairworthy. In these conditions, the maintenance personnel have to analyse the symptoms described in the TLB, comply with the associated procedures and lastly give their approval for the aeroplane's return to service.

[25] In the scope of a LIFUS flight, this is the responsibility of the designated captain (supervisor).
[26] Aircraft On Ground (or NO GO).

European regulation "Air Ops"[27] specified in paragraph CAT.GEN.MPA.105:

"Responsibilities of the commander

(a) The commander […] shall:

[…]

(14) record, at the termination of the flight, utilisation data and all known or suspected defects of the aircraft in the aircraft technical log or journey log of the aircraft to ensure continued flight safety.

[...]"

Consolidated European regulation No 1321/2014[28] specifies in paragraph M.A.306:

"*Aircraft technical log system*

(a) In addition to the requirements of point M.A.305, for CAT, commercial specialised operations and commercial ATO or commercial DTO operations, the operator shall use a technical log system containing the following information for each aircraft:

[…]

4. all outstanding deferred defects rectifications that affect the operation of the aircraft, and;

[…]"

It specifies in paragraph M.A.403:

"Aircraft defects

(a) Any aircraft defect that hazards seriously the flight safety shall be rectified before further flight.

(b) Only the certifying staff referred to in point M.A.801(b)(1) or in Subpart F of this Annex or in Annex II (Part-145) or in Annex Vd (Part-CAO), or the person authorised in accordance with point M.A.801(c) of this Annex can decide, using maintenance data referred to in point M.A.401 of this Annex, whether an aircraft defect hazards seriously the flight safety and therefore decide when and which rectification action shall be taken before further flight and which defect rectification can be deferred. However, this does not apply when the MEL is used by the pilot or by the authorised certifying staff.

(c) Any aircraft defect that would not hazard seriously the flight safety shall be rectified as soon as practicable, after the date the aircraft defect was first identified and within any limits specified in the maintenance data or the MEL.

(d) Any defect not rectified before flight shall be recorded in the aircraft continuing airworthiness record system referred to in point M.A.305 or, if applicable in the aircraft technical log system referred to in point M.A.306."

Lastly, consolidated commission regulation (EU) No 376/2014[29] specifies in article 4:

"Mandatory reporting

[27] Op. cit. paragraph 1.6.1.

[28] Commission regulation of 26 November on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks (Version in force on the day of the serious incident).

[29] Regulation of the European parliament and of the council on the reporting, analysis and follow-up of occurrences in civil aviation (Version in force on the day of the serious incident).

1. Occurrences which may represent a significant risk to aviation safety and which fall into the following categories shall be reported by the persons listed in paragraph 6 through the mandatory occurrence reporting systems pursuant to this Article:

(a) occurrences related to the operation of the aircraft, such as:

[…]

(iv) in-flight occurrences;

(b) occurrences related to technical conditions, maintenance and repair of aircraft, such as:

[…]

(ii) system malfunctions;

[…]

[…]

2. Each organisation established in a Member State shall establish a mandatory reporting system to facilitate the collection of details of occurrences referred to in paragraph 1.

[…]

6. The following natural persons shall report the occurrences referred to in paragraph 1 through the system established in accordance with paragraph 2 by the organisation which employs, […]:

(a) the pilot in command, or, in cases where the pilot in command is unable to report the occurrence, any other crew member next in the chain of command […];

(b) a person engaged in designing, manufacturing, continuous airworthiness monitoring, maintaining or modifying an aircraft, or any equipment or part thereof, […];

(c) a person who signs an airworthiness review certificate, or a release to service in respect of an aircraft or any equipment or part thereof, […];

[…]"

1.17.2 Valljet information

The operator, Valljet, held an Air Operator's Certificate (AOC) obtained in 2008. It is a European business aviation company, which carries out on-demand flights.

1.17.2.1 Key figures

On the date of the serious incident, the operator had a fleet of 28 aeroplanes:

- 11 Cessna 525 (Citation Jet): 3 CJ, 2 CJ1, 1 M2, 3 CJ2, 1 CJ2+ and 1 CJ3;
- 4 Cessna 550 Citation II;
- 2 Raytheon Hawker 800XP and 4 Raytheon Hawker 900XP;
- 2 Embraer EMB145-EP and 1 Embraer EMB145-MP;
- 4 Embraer EMB135-BJ.

Figure 4 below shows the evolution in the number of aeroplanes in the operator's fleet:

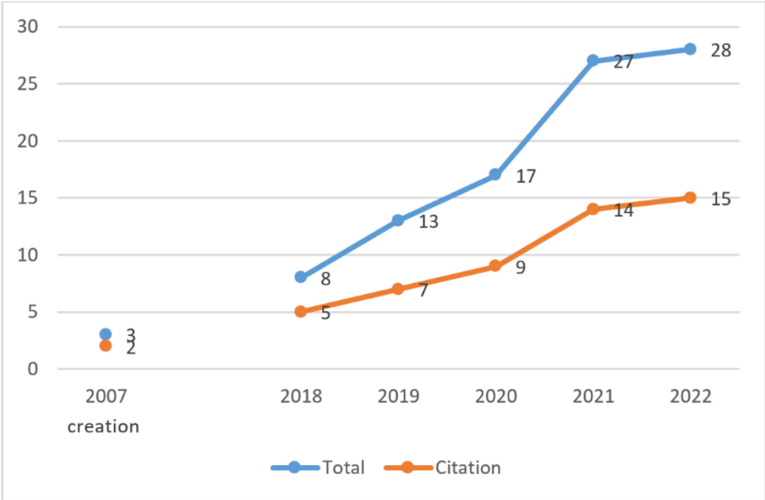

Figure 4: evolution in number of aeroplanes in fleet (source: Valljet)

The graph below shows the number of movements of the operator's fleet, in particular in the Citation sector:

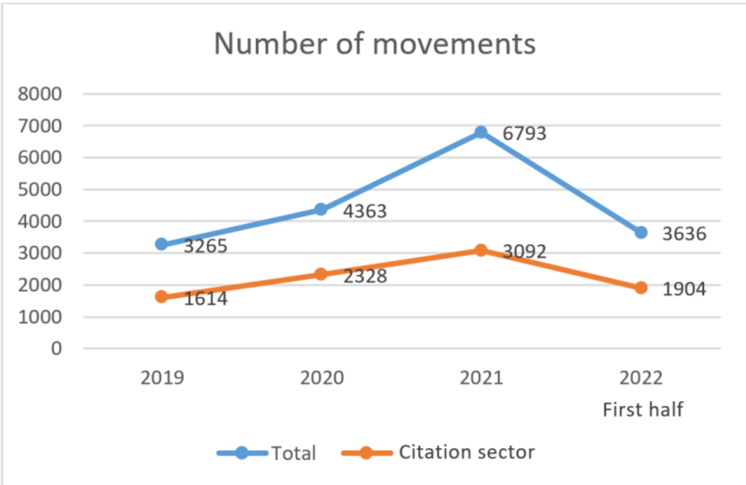

Figure 5: number of movements of operator's fleet (source: Valljet)

1.17.2.2 Notification of a failure

Chapter A-08, paragraph 1.11 of Valljet's Operations Manual specified with reference to the TLB:

"In accordance with the requirements of Part M.A. 306, it contains the details of any information considered necessary to ensure the safety of the flight. This information includes:

In accordance with the requirements of Part M.A. 306, it contains details of any deferred defects that affect or could affect the airworthiness and safety of use of the aircraft and should therefore be brought to the attention of the Captain.

[…]

5. *Details of any aircraft failure, defect and malfunction affecting or not the airworthiness or safe operation of the aircraft including standby systems, any cabin defects, failures or malfunctions affecting or not airworthiness or safety of the occupants brought to the attention of the Captain.*

Note: If the airworthiness is not affected, following the return to normal operation of the temporarily faulty system after a "RESET" type action by the crew, the "Defect" must be reported to the techlog specifying the action which was carried out followed by the mention "RESET SUCCESSFULLY". The information reporting must be preceded by the words FOR CAMO INFO and the "Maintenance" part crossed out with a diagonal line.

6. The registration of the APRS following the rectification of a defect or of the tolerance state (accompanied by the associated maintenance procedure) or maintenance visit carried out. The APRS appearing on each page of this section should make it possible to identify the defects to which it relates to or the maintenance visit carried out.
[…]."

In this same chapter, in paragraph 1.11.2 about completing the TLB, it is specified that crews shall "*report in the Techlog any technical abnormalities encountered during the flight* " and "*The flight crew notes the technical malfunctions of the aircraft including those identified on ground (during preflight check for example) with the number of the leg where the failure was reported […]"* in the defects box of the TLB.

These provisions were adopted in the scope of a Flight Safety Bulletin[30] of October 2021 issued by the operator.

1.17.2.3 Duties and responsibilities

1.17.2.3.1 Head of continuing airworthiness

Paragraph 0.3.2 of the operator's CAME[31] specifies the duties and responsibilities of the CAMO[32] designated head of continuing airworthiness:

- *"He is responsible for managing the airworthiness of aircraft operated by Valljet;*
- *He reports to the Accountable Manager;*
- *He defines the organisation and operating procedures necessary to comply with the regulations;*
- *He ensures that these procedures are correctly described in the CAME, and if necessary arranges for amendments to the CAME;*
- *He ensures that the maintenance of aircraft operated by VALLJET is carried out in timely manner, in accordance with the standards of Part 145 and in accordance with the approved maintenance programs;*
- *He ensure that the organisation always complies with the applicable regulations;*
- *To this end, he sets up maintenance contracts, after making sure that the contracted organisation has the appropriate facilities, equipment and tools, qualified and sufficient staff;*
- *He establishes relations with the competent authorities;*
- *He is responsible for providing feedback to the competent authorities and to the manufacturers of faults observed during events in operation;*
- *He defines the policy for the implementation of service bulletins and optional modifications;*
- *He ensures the implementation and monitoring of corrective actions resulting from the monitoring of the Compliance Monitoring Manager and the competent authorities;*
- *He has the aircraft log book and maintenance programs approved by the Authority;*

[30] Flight Safety Bulletin (see paragraph 1.17.2.7.6).
[31] Continuing Airworthiness Management Exposition.
[32] Continuing Airworthiness Management Organisation.

- *He is in communication with flight crews to ensure feedback on the quality of maintenance, the aircraft log book filling procedures and its improvement, the use of the MEL;*
- *He ensures the link with flight operations in order to ensure correct scheduling of necessary maintenance actions;*
- *He ensures that all tasks listed in MSG 2.3.4 are performed."*

The CAMO agents of the various sectors answer to the designated head of continuing airworthiness.

1.17.2.3.2 Sector flight operations manager[33]

Paragraph A-01 3.10.2 of the operator's Operations Manual specifies the duties and responsibilities of the flight operations managers[34] for the Embraer, Hawker and Citation sectors:

- *"Responsible for pilots sharing the same qualification:*
    - *Report any operational issues and suggests solutions*
- *Technical support :*
    - *Flight Operations communications (MEMO, Incident analysis…)*
    - *Flights feasibility (Performance, Cat. C airports...)*
- *Minor amendments of OM.B*
- *Establish a weekly report about:*
    - *Staffing situation (Flight Crews)*
- *Helps to prepare response to SANA/SACA compliance of the involved sector*
- *Manage updates of FMS databases*
    - *Anticipates AIRAC cycles updates*
    - *Alert crews who will have to perform the updates*
    - *Receive and acknowledgment of FMS update effectiveness."*

The flight operations managers of the various sectors are commonly referred to as "heads of sectors" by the operator and answer to the designated head of flight operations.

1.17.2.3.3 Safety management manager

Paragraph 2.3.2 of the operator's Management System Manual (MSM) specifies the duties and responsibilities of the safety management manager:

- facilitate the identification of risks, analyse and manage the risks, in particular those arising from changes;
- monitor the implementation of actions taken to mitigate the risks in accordance with the safety action plan;
- provide regular reports on the performance of the SMS;
- update documents relating to the SMS;
- ensure that the personnel follow a SMS training course which complies with acceptable standards;
- provide advice about safety-related subjects;
- ensure the implementation and follow-up of internal events/accident investigations.

The safety management manager answers to the accountable manager.

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[33] See paragraph 4.3.

[34] Referred to as "*Flight Ops Referents" in the operator's Operations Manual.*

1.17.2.4 Setting up of Maintenance Control Centre (MCC)

In July 2021, OSAC carried out an oversight mission at the operator's. One of the deviations observed during this oversight mission concerned failures and faults which were opened and processed by the maintenance personnel (after being informally advised of the problem by crews) whereas no failure appeared in the TLB for the flights preceding the maintenance work.

The operator specified that following this oversight mission, it set up, by means of a service note, the MCC on 15 November 2021 to support the growing fleet and as a consequence, the increased number of problems encountered in operation. Its responsibilities were the following:

- instantaneous monitoring of all aircraft in the fleet in "flight" condition;
- reply to, warn and coordinate 24/7 calls from OPS, crews, CAMO and PART 145s;
- assist crews and technicians for the MEL management;
- decide on AOGs;
- supervise work and the return to service in the scope of failures;
- ensure the traceability of all the activity.

Thus the purpose of the MCC was to help crews with respect to the technical problems that they encountered and to guide their decision making.

When the MCC was created, only one person was appointed to it, its manager.

On the date of the serious incident, the MCC was not defined in the operator's Operations Manual. The role of MCC was performed by the Part 145 maintenance company, R&O (see paragraph 1.6.4).

With respect to the flight of 11 December 2021, although the MCC was in service, the captain chose to exchange solely with the head of the Citation sector about the fault that they had encountered in flight. An executive at the operator's explained that it was true that certain captains continued to contact the operator's sector managers or those with significant experience on the aeroplane in question. He specified that as there was no clearly defined procedure at the operator's, this was rather a habit or a good practice that had been acquired between the flight crews and the different departments of the company during its first years in order to be able to be reactive when managing failures (operational, technical and commercial aspects). He added that the company had developed very rapidly over the last two years, and that previously no formal procedures had been established. The service note communicated in November 2021 therefore aimed to formalise an official procedure for managing failures, between crews and the operator's various departments.

The operator also specified that after contacting the MCC, the captain had several resources available for dealing with a failure:

- consult the Minimum Equipment List (MEL) to identify whether the aircraft is airworthy for a limited period of time;
- perform resets on certain aircraft systems after authorisation by a qualified aircraft technician;
- declare the aircraft unairworthy.

In all cases, the captain had the final responsibility for entering all the information relating to the management of the failure in the TLB either through a For CAMO Info (Procedure in part A08.1.11), or by opening a MEL item or by the decision to declare the aircraft unairworthy (Aircraft On Ground (AOG)).

The operator added that since 2021, (old and new) crews also received CAMO course material. This enabled them to understand more precisely how to write information in the TLB.

Several MCC managers succeeded each other:

- a first manager held this position between 15 November and mid-December 2021;
- between mid-December 2021 and mid-January 2022, the position of MCC manager remained vacant;
- on 12 January 2022, the position of MCC manager was entrusted to a pilot (second manager) who had contacted the operator a few months before;
- on 21 June 2022, the MCC was reorganised and the manager position was dropped. The MCC was transferred from the Part 145 maintenance company, R&O, to the operator Valljet. A manager (the head for each sector) and a back-up were appointed for each sector to reply to the crews' requests.

1.17.2.5 Safety management by operator

In the scope of its Safety Management System (SMS), the operator produced a risk map which it regularly updated. The version of the risk map in force at the time of the serious incident on 12 January 2022 contained several elements relating to equipment malfunction risks. These risks were present in this occurrence.

Danger/Threat	**Undesirable event**	**Barriers**
Total or partial loss of an equipment item	Fault on an onboard system/equipment item disrupting flight management	• Emergency/abnormal procedures • Warning • Crew cooperation • Flight crew training
Fault on an aircraft navigation system	Loss of separation in flight	• TCAS[35] system • Emergency/abnormal procedures • Flight crew training • ATC communication • Crew cooperation

Figure 6: excerpt of operator's risk map in force on date of serious incident (source: Valljet)

The operator used this model to analyse the occurrences, to assess the level of criticality of the associated risks and to check that these were controlled. In this respect, each undesirable event was assigned corresponding ASR numbers. The document did not show any of the three previous events identified in this report.

1.17.2.6 DSAC audit

The "Air Ops" regulation[36] specified in paragraph ARO.GEN.300:

> *"Oversight*
>
> a) *The relevant authority:*
>
> *[…]*
>
> *(2) continued compliance with the applicable requirements of organisations it has certified, specialised operations it has authorised and organisations from which it received a declaration;*
>
> *[…]'*

[35] Collision-avoidance equipment meeting ACAS standard

[36] Op. cit. paragraph 1.6.1.

The DSAC is the oversight authority of operators holding an AOC. To this end, the DSAC regularly conducts audits. In particular, it audits the organisation and the safety management system of operators. The DSAC specified that the aim of this type of audit is to assess the handling of safety occurrences on the basis of information that the operator has made available to the inspectors, or that has been obtained during interviews. It added that the process does not permit the identification of any deliberately deviant practices in this area.

The last audit carried out on the operator and its organisation and flight safety management was in May 2021. This audit did not reveal any malfunctions in the operator's SMS nor deviations such as those observed with respect to the occurrences analysed during the investigation (no reporting of a technical fault in the TLB, certain reports deferred until back at base and no ASR regarding a safety occurrence linked to a technical fault).

The audit report showed that in 2021, the operator was in a safety promotion dynamic, with efforts undertaken by the company since 2019 that were starting to bear fruit. The teams on the ground were considerably strengthened with the appointment of SMS contacts, the setting up of an OCC composed of flight coordinators and the creation of a design office. This has enabled the management system to reach a satisfactory level of maturity, capable of detecting and dealing with its weaknesses.

1.17.2.7 Statements

1.17.2.7.1 MCC managers

The first manager of the MCC (R&O), in this position between 15 November and mid-December 2021, indicated that he found the idea of providing technical support to help crews make decisions interesting. He was a maintenance technician. He specified that he was not systematically informed of the technical faults on the aeroplanes, the crews had tended to keep the reflex of calling the head of the sector in question. Sometimes even if he was consulted, other managers or the management could interact and give instructions without involving him. In his opinion, the operator lacked organisation. He indicated that the pilots were under enormous pressure and that sometimes, even if he recommended making an entry in the TLB, the captains did not take this into account. He stated that the operator did not provide the necessary means for the MCC to operate correctly. According to him, he tried to implement the standards that he had known working for another operator, with a larger fleet. He felt a certain pressure because the instructions were not to block the planes for too long. He also regretted that there was a high turnover among the operator's pilots, which meant that the collective experience could not be consolidated, despite the qualities and initial motivation of the individuals.

The second MCC manager from 12 January 2022, indicated that his main role was to assist crews with the technical problems which they had encountered. He helped with the decision making. He added that his role was to relieve the designated head of crew training and the designated head of flight operations, as well as the heads of the various sectors, who were often called on by the crews. He specified that he had no responsibility with respect to the airworthiness of the aeroplanes, however, he could call in the maintenance personnel in order to intervene quickly when the aeroplane was at Paris-Le Bourget airport. He considered that he received few calls from the Citation sector crews. He produced an activity report on a daily basis listing the exchanges that he had had with the crews. Lastly, he indicated that he had pilot training and not maintenance technician training.

The analysis of the MCC reports produced in February and March 2022 shows that he was contacted:
- 6 times for the Citation sector;
- 4 times for the Embraer sector;
- 31 times for the Hawker sector.

1.17.2.7.2 Citation sector CAMO agent

The Citation sector CAMO agent joined the operator in June 2020 and left in November 2022. He indicated that he had had no knowledge of the occurrences in 2017 and 2019, neither had he heard about the occurrence of 11 December 2021 prior to the serious incident. He indicated that there was a culture of not reporting technical malfunctions (in the TLB) or safety occurrences (in the form of an ASR) within the company. He said that pilots generally went along with the decisions of certain executives or managers at the operator’s, and that it was complicated for them to make entries in the TLB or produce ASRs, as these managers had access to the information. In his opinion, the pilots were afraid of sanctions.

He considered that the various managers and executives often interfered in subjects that did not form part of their main activity. He also added that the operator still needed to structure itself, become more professional and stop acting as if it were a flying club.

He gave as an example that the pilots exchanged with each other via instant messaging software about the operational follow-up of the aeroplanes (in general, one discussion per aeroplane). Certain pilots also mentioned the technical condition of the aeroplane in these discussion threads. Managers or executives (recipients of these messages) took the opportunity to communicate with the crews to give them advice. He specified that he had not been on the distribution list for each aircraft, although some pilots contacted him directly. According to him, these technical conditions were not always recorded in the aeroplane's TLB. Nevertheless, the Citation sector CAMO agent kept a list of the technical events which he had knowledge of via other channels, for each aeroplane. He used this list to have entries added to the TLBs of the aeroplanes before they went into maintenance, by relying on some trusted pilots. He specified that the pilots concerned accepted this degraded operation so that they could continue to fly on aeroplanes with faults which would be dealt with at a later time. He indicated that there were similar although less organised practices in the operator's other sectors (deviation observed by OSAC during its oversight mission(see paragraph 4.3). He specified that he acted "*under the radar*" and maintained good relationships with both the operator's pilots and managers. He added that he chose this way of doing things and not to act in opposition when he was not responsible for and did not have control of the subjects in question in order to have a more beneficial action in the long term. According to him, all of the management endorsed events not being reported as the head of the Citation sector was close to the company's senior management. He also indicated that certain failure were only recorded in the TLB during the return leg to Paris-Le Bourget airport although they had occurred during an intermediate flight, so as not to have an aeroplane on the ground away from the base.

He also added that the Citation sector was a very heterogeneous fleet, which did not facilitate the swapping of parts. He specified that the aeroplanes were not kept in hangars and that this could contribute to technical events linked to the environmental conditions. As some failures were not always confirmed on the ground, a number of these recurrent failures became "normal" and part of the "aeroplane's DNA", with it being up to the pilots to be vigilant.

1.17.2.7.3 Operator's pilots

Five pilots from the Citation sector spoke to the BEA in the scope of the investigation and shared information regarding the operator's organisation. Three of them were concerned by the occurrences described in this report, a fourth pilot was contacted during the investigation and a fifth pilot spontaneously called the BEA following the serious incident of 12 January 2022. The latter specified that he wanted to exchange with the BEA as he feared that one day there would be a serious occurrence. According to him, the safety culture in the company was under developed. This impression was shared by three other pilots.

These four pilots reported that there was a feeling shared by most pilots in the Citation sector of there being operational and commercial pressures to the detriment of the technical condition of the aircraft. They considered that the "just culture" was under developed in the company. During telephone calls to the operator's managers following a technical event, some of the latter often tended to minimize the event and encourage the crew to continue the mission. Some of the pilots in the Citation sector, mainly the young pilots, had a great deal of confidence in the judgement and advice of the head of the Citation sector, given his seniority with the operator and, above all, his experience. However, this confidence was degraded for the more experienced pilots in the same sector. These pilots said that they tried to be accommodating, but sometimes they considered that the limits were exceeded. Some considered these practices were more like flying club practices. However, feeling under pressure, at times they followed the instructions given. Some pilots also took advice from the technical managers (Citation sector CAMO agent) in order to provide the operational manager with the least penalizing solution.

The pilots reported that there was an oppressive atmosphere, difficult to describe, but nevertheless present. They explained that they came to perceive certain operational decisions (e.g. not being programmed flights) as sanctions following them refusing certain requests deemed unsafe or on taking certain decisions not favouring commercial operations. However, they indicated that they did not have knowledge of proven sanctions.

The pilots specified that the MCC was not of a sufficient size and did not have enough hindsight or experience on the aeroplane to give them help that was the equivalent of what they got from the sector managers. There were also times that the MCC manager obtained information, or even asked for instructions, from the sector manager before making a decision. They indicated that there had been several MCC managers in succession and they found it difficult to know who they had to contact. The pilots had a tendency to keep their habits from before the creation of the MCC, even after the reminder given on 18 January 2022 (see paragraph 4.1).

Lastly, two pilots added that the freelance pilots working as captains, who are often experienced, tended to make fewer entries in the TLB. They believed that these pilots were afraid of being put to one side by the operator if they reported too many faults that could potentially ground the aeroplanes.

One of the pilots who was interviewed by the BEA had already left the operator and several others had taken steps to leave the operator, for various reasons, before the serious incident of 12 January 2022. Another pilot left the operator a few months after the serious incident.

1.17.2.7.4 Citation sector operations coordinator

The person who held the position of Citation sector operations coordinator for the Operations Control Centre (OCC) from the summer of 2021 to the summer of 2022 indicated that there was an oppressive atmosphere at the operator’s maintained by one of the executives; a form of psychological pressure which he said was confirmed by the pilots. The coordinator stated that, to his knowledge, no sanctions had been taken against pilots.

1.17.2.7.5 Head of Citation sector

The head of the Citation sector indicated that for the occurrence of 11 December 2021, he had understood during the call made by the captain, that it was a transient fault of the airspeed indicator that had only lasted a few minutes. He directly made the link with the occurrences in 2017 and 2019. He specified that he explained the situation to the two crew members of this flight. He indicated that he did not try to influence the crew about carrying out the return flight, as for the other crew calls. He considered that as the failure had not reoccurred during the return flight, it was not necessary to initiate a maintenance action. He observed that it was the captain’s responsibility to record the fault in the TLB and not his. Likewise, he observed that it was the captain who was supposed to complete an ASR.

Based on his experience, he considered that he had good knowledge of flying and aeroplanes, and notably faults that could be linked to incorrect use. He advised crews about actions to be taken when he was contacted by telephone about technical faults. He explained that when he asked crews to call him before entering a fault in the TLB, it was to help crews write the entry in the TLB to make it easier for maintenance to troubleshoot the fault. He added that he was a certified maintenance Technician for the Daher TBM. He specified that he had never encouraged a crew to take an aeroplane with a fault and that he obviously left crews free to record a failure in the TLB. He said that the operator's culture was in no way one where crews were asked not to record failures in the TLB.

He considered that there was a good safety culture at the operator's and that nothing was hidden. He stated that the practice of differing the recording of faults in the TLB until the crew were back at their base was common practice among operators of this type.

He indicated that in his opinion, the first MCC manager had received a very high number of telephone calls and that he had not supported the workload. He added that the latter was an Embraer maintenance technician and was lacking in experience in the Citation sector. The MCC managers frequently redirected crews to the head of the Citation sector as he had knowledge of a large number of situations. Lastly, he specified that the first MCC manager had experienced difficulties using modern communication means such as instant messaging. As a consequence, the head of the Citation sector and the crews directly contacted each other. According to him, several maintenance specialists, at least one per sector, could be appointed to the MCC, but this configuration was not financially viable for the operator.

1.17.2.7.6 Safety management manager

The SMS manager on the date of the serious incident had arrived at the operator's in the summer of 2021 and left in the summer of 2022. He was not aware of the previous occurrences linked to the fault of the air data system before the occurrence of the serious incident.

According to him, a difference existed between the Citation sector and the other two sectors, Hawker and Embraer. In the Citation sector, the majority of the operator's staff pilots were young with a small amount of experience and did not stay for a very long time with the operator. The operator also used freelance pilots who had more experience but felt less concerned by the operator's culture. In the other two sectors, the pilots were more experienced. He considered that the SMS manager could have received still more ASR from the Citation sector pilots even though he had observed a major improvement in the last two years.

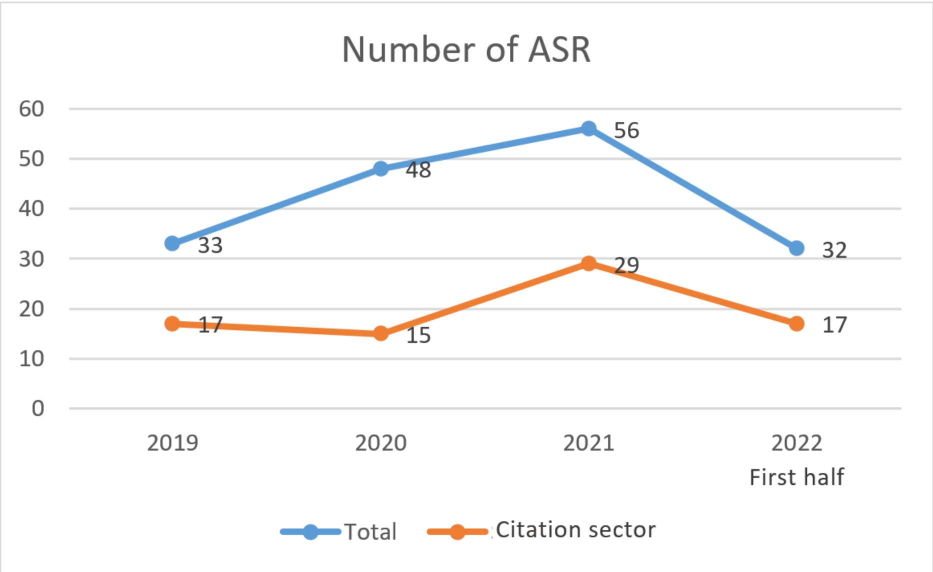

Figure 7: number of ASR (source: Valljet)

This SMS manager specified that for certain occurrences, he had sometimes been the last person to be informed, notified for example by the CAMO. As a result, he contacted crews at a late date to obtain the ASRs for occurrences that required them. The SMS manager indicated that the operator regularly communicated with pilots through Flight Safety Bulletins or Safety Flashes to encourage them to report occurrences. He explained that pilots were sometimes reluctant to report an occurrence, because the company was small and it was easy to identify a flight or a crew.

An analysis and discussion could then follow with the operator's managers or executives who did not have the SMS function. Furthermore, he had noted that certain managers or executives lacked awareness of the seriousness of certain events.

The SMS manager stated that the MCC could be improved, as the mission had been entrusted, in the first half of 2022, to a pilot and not to a maintenance operator, who could not reasonably be available "24/7".

Lastly, he felt that the operator still needed to structure itself, noting that pilots with little experience mainly contacted the sector managers.

1.17.2.7.7 C525/C550 flight SMS contact

The operator named several pilots as SMS contacts for each sector in its Safety management manual. One of their responsibilities was to report occurrences that they were aware of. The C525/C550 flight SMS contact had not been informed of the occurrences prior to the serious incident.

The C525/C550 flight SMS contact, who was also a pilot, indicated that he was mostly contacted by the safety management manager asking him to provide an analysis of the various occurrences reported by the pilots. He was rarely directly contacted by the pilots in his role of SMS contact as the pilots preferred exchanging with the head of their sector.

1.17.3 Air traffic information (North ACC)

1.17.3.1 Controller information and statements

The control position was manned by two controllers:

- the tactical controller, responsible for ground-aircraft radio exchanges, radar vectoring aircraft and the tactical resolution of conflicts. The controller in position had been qualified for the North ACC since 2000;
- the planning controller, responsible for the coordination with the other sectors and centres. The controller in position had been qualified for the North ACC since 2006.

The controllers specified that the radar situation was quiet at the time of the serious incident. There were few aeroplanes in the sector. The tactical controller specified that when the crew reported that they were not sure about the altitude, their path was about to cross the path of the Embraer 170 at 2 NM; it was important not to give any vectoring instructions. He indicated that below 5 NM (standard horizontal separation in this area), the positions of the aircraft were not accurately defined due to the imprecision of the radar systems and the lag in displaying the actual position of the aircraft. According to him, this information about the accuracy is acquired during the controller basic training[37]. The crew reaction time also had to be taken into consideration.

He added that after having asked the crew for more details about their altitude, he requested them to switch off Mode C. The coordination with the following sector (Switzerland) was also carried out. He then planned to have the aeroplane cross the path of other aircraft with a separation of 5 NM. He also explained that he called the head of the control room to suggest initiating an interception mission but given how he perceived the situation on the aeroplane, he subsequently considered that this solution was not useful.

[37] This information is also regularly given in briefings.

The tactical controller specified that he knew the procedure by heart at the time of the serious incident and considered he had good knowledge of altimeter information. The controllers indicated that they then checked the quick reference card[38] which could be accessed from their position on a supplementary screen displaying general information[39].

The tactical controller indicated that when the crew asked him what altitude he could see them at during the climb, this did not "ring any alarm bells". They did not realise that there was a problem on board and that the crew were uncertain about their altitude. He dealt with this check as if it were a radio check. The aeroplane was climbing and the crew had not made any comments at this point. The aeroplane was then perfectly stabilized at the assigned flight altitude. The controllers would have liked the crew to have informed them of the altimeter problem earlier, on the basis of a "reasonable doubt on board". The planning controller added that crews regularly asked for confirmation of the altitude.

The controllers specified that they had been made aware of this uncertainty about altimeter information problem, in particular during continuous training where the serious incident of 2 June 2010 (see paragraph 1.18.1) is presented.

1.17.3.2 Head of control room information and statement

The head of the North ACC control room present at the time of the serious incident had been qualified for this position since 2000.

He explained that he was asked by the tactical controller and the planning controller to try to determine the aeroplane's altitude. He felt that initiating an interception mission would not have been effective enough. He then contacted the CNOA to determine the aircraft's altitude using military organisation resources. He recalled that some military radars were able to measure elevation angles. However, during the exchange, he realised that the person he was speaking to had no additional means of determining the altitude than those available to him in the North ACC.

A few minutes after this exchange, he was called back by the CNOA who indicated that the aircraft had an erroneous altimeter setting, that it was set at 1040 instead of the standard (1013). This information, transferred to the crew via the Swiss air traffic control unit, turned out to be false, as the aircraft was correctly set to 1013. This information was passed on to the CNOA, which stated that it used the SEPIA tool, specific to military organisations to determine this information.

The head of the control room considered that, as a controller, he had few, if any, requests for altitude confirmation. However, he felt that this question could mean one of two things:

- Are you receiving my altitude transmissions from the transponder?
- Is the altitude transmitted by the transponder consistent with that read on the altimeter?

Thus, he indicated that this rare event did not necessarily alert the controller to a possible altimeter fault on board the aircraft.

[38] They consulted the transponder failure quick reference card.
[39] Cigale tool (aviation general information system).

1.17.3.3 Procedure if pilot reports having a doubt about the altitude of his flight

The North ACC Operations Manual includes the operational directive 11-158/10 (refer to paragraph 1.18.1.2) in paragraph 13.2.5 concerning doubts about the altimeter equipment. When the controller observes an inconsistent altitude on his radar (difference of more than 300 ft), he indicates this to the crew and asks them to check their altimeter setting and to confirm their altitude/flight level. If the anomaly persists or if the crew report having doubts about the integrity of its altimeter information, the following procedure must be complied with:

- for the other flights where a separation has to be applied, apply as soon as possible, a lateral or if necessary, vertical separation from the moment when the pilot affirms knowing in what altitude or level range he is situated;
- ask the pilot to stop emitting in Mode C;
- inform the crew that the control services cannot resolve any doubt by a cross-check;
- inform the control sector(s) or centre(s) partially concerned by the situation;
- inform the CMCC[40]/DMC[41] (military centre located in the ACC zone) concerned and the CCER[42].

In addition, depending on the perceived seriousness of the situation, one or more of the following actions can be taken:
[…]
Provide flight assistance to the crew, either immediately if they consider themselves to be in distress, or at their request if they consider themselves to be in a state of emergency. Flight assistance may be conducted, if necessary, with the help of the military in the case of assistance to a person in danger. As such, it may in certain cases lead to an interception.

During the serious incident, the STCA was not activated as the radar data processing system considered that the aircraft were separated by 1,000 ft and stable. When the crew of F-HGPG had finished their message reporting an inconsistency in their air data information (message lasting around twenty seconds), they were only 3.3 NM from F-HBXG, which was below the ACC radar separation minimum of 5 NM.

As a result, the controller was not in a situation where it was foreseeable that the minimum separation standard would be breached (a situation for which there are specific actions), but in a situation where this standard had already been breached (a situation in which various solutions are applicable and depend on the situation). On his radar image, the controller estimated the separation at 2 NM without confirmation or assurance as to the actual (relative) position of the two aeroplanes. He then took the action he considered most appropriate: issuing traffic information to make the pilot aware of the situation and enable him to identify the conflicting traffic.

1.17.4 CNOA information

The CNOA, a military organisation in charge of air safety and security, is one of the main contacts for air traffic controllers should there be a doubt about the safety or security of a flight.

[40] Military control and coordination centre.
[41] Military coordination detachment.
[42] Test and acceptance traffic control centre.

The CNOA has several sources of information for its flight path analyses, processed in the SEPIA tool:

- civil radar data;
- military radar data;
- ADS-B data, available on several websites.

During the serious incident, the head of the North ACC control room contacted the CNOA which indicated:

- initially that the altitude of the aeroplane, although the transponder Mode C had been switched off was FL 234. The investigation was unable to find the source of this information, but it is likely that this information was based on the ADS-B data, as the GNSS altitude of the aircraft at that moment was close to 23,400 ft, but by nature, different from the pressure altitude;
- then that the aeroplane's altimeter setting was 1040, whereas it was at 1013.

During the serious incident, the ADS-B data recovered by the CNOA concerning the altimeter setting was as follows:

- at the beginning of the flight, a setting of 1013;
- en route, a setting of 1040;
- at the end of the flight, a setting of 1013.

Based on the flight profile and the crew's statements, this data appears to be erroneous. Furthermore, the selected altitude observed in the ADS-B data also appeared to be erroneous. Both parameters were only partially available during the flight.

The investigation did not determine whether this was a problem with:

- the aeroplane transponder;
- the processing of the data by the websites providing ADS-B data;
- the SEPIA tool used by the CNOA.

1.18 Additional Information

1.18.1 Similar serious incident investigated by the BEA, into a barometric system fault, in 2010[43]

1.18.1.1 Description and conclusion of BEA investigation

On 2 June 2010, a near-collision occurred between an Airbus A318[44] operated by Air France and a Pilatus PC 12[45]. The A318 was at FL 290 and the PC 12, cleared for FL 270, was at FL 290 due to an altimeter problem. The Airbus crew made an emergency evasive manoeuvre. The minimum separation between the two aeroplanes could not be measured on the radar recording, it was estimated by the crews as being between 15 and 30 m horizontally and around 100 ft vertically.

[43] Serious incident to the Airbus A318 registered F-GUGJ operated by Air France and to the Pilatus PC 12 registered EC-ISH on 2 June 2010 en route.
[44] Aeroplane complying with certification criteria CS 25.
[45] Aeroplane complying with certification criteria CS 23.

In the conclusion of its investigation report, the BEA indicates:
"This incident was due to a leak at level of the static pressure line supplying the left side barometric and speed unit. This leak caused erroneous altitude and speed information to be supplied and led the PC 12 to fly at a level that was in conflict with flight AF 850 NE, without the risk of collision between the 2 airplanes being detected either by the ATC, or by the anti-collision systems such as the STCA or the TCAS.

The flight level displayed on the ground systems did not make it possible to dispel the doubt and thus led all of those involved (crew and controllers) to believe a flight level for the airplane that was erroneous. Due to this, the crew did not search any further for the causes of the inconsistency in the speed observed on the left side unit."

1.18.1.2 Safety recommendations and measures taken following this serious incident

Crew procedures
The investigation "*showed that the crew possessed information to detect the pilot side speed error. On the other hand, reading the altimeters alone did not allow the error to be detected*.

Considering the design of the circuits, a failure on a barometric and speed circuit can have consequences on the values indicated on board, such as the indicated speed, the flight level and the vertical speed. For example, an inconsistency in indicated speed can be linked to an error in the altitude displayed and vice versa.

A study undertaken among several airplane manufacturers showed that the procedures for the course of action for crews to follow in case of inconsistency in altitude are either incomplete, or non-existent."

Consequently the BEA recommended to EASA:

- *"that procedures in the flight manual relating to situations of doubtful or erroneous altitude be completed or developed by manufacturers;*
- *that these cases be considered as emergency situations that must be declared without delay by crews to the ATC services."*

In response to the BEA's first recommendation, EASA replied that Pilatus' had updated the procedures in its flight manual and it considered that this recommendation could be closed. In 2021, EASA told the BEA that no other specific action had been carried out since this occurrence, in particular with respect to other manufacturers (see paragraph 1.18.2.3).

ATC Services
"This type of particularly serious incident has a specific feature in that it is undetectable by ATC services and by the various conflict detection systems, such as the short term conflict alert system or the TCAS. Further, under the existing regulations, there is no provision for the specific management of a flight when a pilot casts doubt on his vertical position."

The BEA recommended to the DSNA that it *"...implement, in the shortest possible time, an emergency procedure so that ATC ensures that there is a safety space around an aircraft as soon as the crew casts doubt on its vertical position, without waiting for the latter to declare a distress or emergency situation."*

Following the serious incident, the DSNA produced and circulated an operational directive 11-158/10 applicable when a pilot of an IFR flight expresses doubts about the altitude of his flight. All the control organisations (ACC and ANS) implemented this directive on 21 July 2010.

In compliance with this directive, when there is a doubt about the altitude of an IFR flight, the controller must apply a lateral separation with other flights as soon as possible, ask the pilot to stop transmitting in Mode C and tell him that the control services cannot carry out a cross-check.

1.18.2 Similar serious incident investigated by the BEA, into an air data system fault, in 2020[46]

1.18.2.1 Description and conclusion of BEA investigation

On 14 August 2020, the pilot of a Cessna 525A CJ2[47] encountered technical difficulties during the take-off at Paris-Le Bourget airport. In particular, he observed inconsistencies in the altitude and speed information given by the various instruments at his disposal. The pilot did not comply with the onboard procedure dedicated to inconsistent altitude and speed information on the PFD. He tried to clarify the situation with the help of the controller. This led the actors to rely on the air data system that was associated with the transponder, resulting in a confirmation bias situation - it was in fact this system that was providing the erroneous information. During the serious incident, the controller asked the pilot who was flying in the cloud layer to descend to 1,500 ft, the altitude displayed on the radar being close to 3,000 ft whereas the aeroplane was actually flying at an altitude of around 1,300 ft. An EGPWS warning was activated onboard the aeroplane. During the examinations of the aeroplane after the serious incident flight, an insect and sand were found in a static port.

1.18.2.2 Procedures and training for controllers when a pilot expresses doubt about the altitude of his flight

Paragraph 3.4.4 of the investigation report mentioned: *"The operational directive (11-158/10) to be complied with when a pilot announces that he has a doubt about the altitude of his flight, is incorporated in chapter 2 Emergency Procedures of the Paris-Charles de Gaulle TWR/APP Operations Manual.*

At the time of the event, a fault on an air data system was not mentioned during the initial and continuous training at Paris-Charles de Gaulle.

The emergency procedure was available in the Operations Manual but it had not been given any particular treatment and duplicated as an emergency to-do sheet or a checklist.

The DSNA indicated that between 2010 and 2016, this safety topic was systematically included in the programme of the recurrent training courses for the controllers of all its units. The operational directive (11-158/10) was mentioned and the serious incident in 2010 was used as an illustration. For information, each controller must follow recurrent training every three years. The support material for this training is the same for all the controllers in the same control unit and modified every three years.

[46] Serious incident to the Cessna 525A registered N222NF on 4 August 2020 close to Bourget (Seine-Saint-Denis).

[47] Aeroplane complying with certification criteria CS 23.

The DSNA explained that different units subsequently privileged other safety topics in some of their three-year training courses."

1.18.2.3 Safety recommendations (issued in October 2022) and measures taken following this occurrence

"Manufacturers' procedures in cases of doubtful or erroneous altitude situations"
The BEA recommended that:

- *"whereas the "AMBER ROLL, PIT, ATT, HDG, ALT or IAS (Comparator monitor alerts)" procedure is common to all Cessna Citation C525s whatever their equipment;*
- *whereas the "AMBER ROLL, PIT, ATT, HDG, ALT or IAS (Comparator monitor alerts)" procedure is both incomplete and not adapted to a Cessna Citation 525-A equipped with the option of a third PFD and a second ADC: in the event of a fault on air data system 2, the procedure leads to the pilot using an erroneous air data source;*
- *whereas the Cessna procedure omits to mention the selection of the transponder supplied with information from the air data system identified as valid;*

the FAA ensure that the procedure in the Cessna Citation 525 flight manual is updated to provide pilots with a specific procedure for processing inconsistent air data information, adapted to the configuration of the aeroplane concerned.
[Recommendation FRAN-2022-012].

During the investigation carried out by the BEA in 2010, it was identified that the procedures of several manufacturers, setting out crew actions in case of inconsistent altitudes were either incomplete, or non-existent. Consequently, the BEA recommended to EASA that procedures in the flight manual relating to situations of doubtful or erroneous altitude be completed or developed by manufacturers. EASA replied that Pilatus had updated its procedure during the investigation and that the agency could consider the status of this recommendation as being closed.

The BEA recalls the safety recommendation made in 2010 which, to date, has not been applied to aircraft other than the Pilatus PC 12: Consequently, the BEA recommends to EASA that procedures in the flight manual relating to situations of doubtful or erroneous altitude be completed or developed by manufacturers;"

Consequently, the BEA recommended again that:

- *"whereas the investigation carried out ten years later shows that there are still incomplete procedures on what to do in the event of inconsistent altitude information;*

EASA, in liaison with the primary airworthiness authorities of the aeroplanes, implement the recommendation by not limiting itself to the particular case of the Pilatus PC 12
[Recommendation FRAN-2022-013]"

"*Emergency procedures for air navigation services linked to doubtful or erroneous altitude situations"*
The BEA recommended that:

- *"whereas a certain number of controllers are not aware that the altitude information they see on their control screens comes solely from the aeroplane's transponder;*

the DSNA ensure, in addition to the teaching of the emergency procedure to be applied when the pilot expresses doubt about the altitude of his flight, that all active controllers have correct knowledge of how the air data information, available to them on their screens, is obtained.
[Recommendation FRAN-2022-016]"

1.18.2.4 Responses given to safety recommendations (issued in October 2022)

Recommendation [FRAN-2022-012]
At mid-April 2023, the FAA had still not replied to the BEA's recommendation.

Recommendation [FRAN-2022-013]
At the end of January 2023, EASA informed the BEA, in response to its recommendation, that it had sent a CARI[48] to the various TCH[49] of aircraft covered by the CS 23, CS 27 and CS 29 certifications, as well as to STCH[50] relating to avionics and/or "air data" systems for these aircraft. This CARI asks DOA[51] holders to review operational procedures with regard to inconsistencies or deviations in "air data".

The BEA considered the response from EASA as adequate.

In May 2023, EASA stated that it had only received feedback from organisations with an EASA DOA (which is not the case for Textron Aviation). EASA indicated that for aeroplane types comparable to the Cessna 525, the appropriate procedures seem to be available, but that they can be improved on in terms of changing the source of the transponder and informing the controller. EASA added that some TCHs and STCHs have already modified their procedures along these lines. The subject will be discussed shortly within EASA to determine whether actions are necessary.

EASA explained that the CARI was sent to the FAA as well as to the Canadian (TCCA), Brazilian (ANAC-Brazil) and United Kingdom (CAA-UK) civil aviation authorities and that it had not received any reply from them at this stage. Lastly, EASA added that Textron Aviation, as well as the FAA, the competent authority, have been made aware of the matter.

Recommendation [FRAN-2022-016]
In February 2023, the DSNA Safety Directorate informed the BEA that the BEA's recommendation [FRAN-2022-016] had been taken into account and that it would undertake a global action to remind active air traffic controllers of the principle of how the air data information, available to them on their screens, is obtained.

The BEA is awaiting confirmation of the implementation of concrete measures before ruling on this response. At mid-April 2023, this action was still in progress at the DSNA.

1.19 Useful or effective investigation techniques

Not applicable.

[48] Continuing Airworthiness Review Item.
[49] Type Certificate Holders.
[50] Supplemental Type Certificate Holders.
[51] Design Organisation Approval.

2. ANALYSIS

2.1 Introduction

During the climb of the Cessna 525, following a sudden variation in the nose-up attitude with the autopilot engaged in IAS mode, the crew observed erratic speeds on the system 1 airspeed indicator. After a short manual flight phase, the climb was continued with the autopilot in VS mode. Later, when approaching the en-route level, the crew realised that there was a difference in altitude between the two altimeters (system 1 and system 2). The cross-check with the help of the controller who had the flight level transmitted by the aeroplane's transponder displayed on his radar screen did not enable the crew to identify that the system 1 altimeter indications were erroneous. The climb was continued to the en-route level based on an erroneous altitude.

En route, after having observed that the left and right altimeters were giving different indications, the crew informed the controller of the onboard altimeter fault. The latter then informed the crew of converging traffic (an Embraer 170) at a distance of 2 NM, in theory 1,000 ft higher than them. In reality, the traffic was lower than them (the minimum separation was estimated at 665 ft and 1.5 NM). No collision avoidance system warning, whether it be on the ground or onboard the Embraer 170 was emitted, as the systems had analysed erroneous data from the Cessna 525. Subsequently, the controller asked the crew to deactivate the transponder Mode C, he coordinated with the Swiss control services and the flight continued to Geneva, its destination.

The head of the control centre room attempted to determine the actual altitude of the aeroplane with the help of the CNOA, however, the latter did not have additional altitude information. However, another parameter, the aeroplane's altimeter setting, which the CNOA shared with the controller proved to be erroneous. The investigation was not able to determine the cause of this deviation.

The analysis of the serious incident covers the following points:

- the cause of the fault on the air data system of F-HGPG;
- the processing of the fault on the air data system of F-HGPG by Valljet;
- the reporting of safety occurrences at Valljet;
- the crew's doubt about the altitude of their flight;
- the analysis of the risk posed by the air data system fault.

2.2 Cause of the fault on the air data system of F-HGPG

The fault on air data system 1 (altimeter and airspeed indicator on captain's side) had already occurred several times on the aeroplane.

In 2017, the captain noted a left airspeed indicator failure followed by a left altimeter error in the TLB. This was followed by a maintenance operation during which pollution was found in the left airspeed indicator system (Pitot pressure measurement).

In 2019, the designated captain recorded in the TLB, that there was a static system fault on the captain's side. No faults were identified during the maintenance operation. The maintenance work focused on the altimeter measurement system.

In view of the work undertaken during these maintenance operations, it appears that Textron Aviation Paris Service Center did not connect the two reported faults. It did not carry out any work that went beyond Textron Aviation's maintenance manual and, in this case, not all the hoses were subject to a detailed inspection.

In 2022, following the serious incident, examinations were carried out by the BEA that went beyond the recommendations of the manufacturer's maintenance manual in the version applicable to this aircraft, modified in accordance with SB525-34-41 (RVSM). These examinations were essentially based on the maintenance manual, but also included disassembly actions to allow a detailed visual examination of each element of the air data system. These detailed disassembly and inspection actions are mentioned in the air data system troubleshooting task in the maintenance manual applicable to Cessna 525s that do not embody SB525-34-41 (unlike the F-HGPG). These examinations did not identify with certitude, the cause of the fault.

The symptoms reported by the pilots during the occurrences in 2017, 2019, 2021 and 2022 (increase in indicated airspeed during climb, difference between the two altimeters and disappearance of anomalies during descent) suggest that:

- the fault was probably situated in the hoses between the Pitot tube and the airspeed indicator of system 1. It might have been a total or partial obstruction in one place;
- the cause of the obstruction was very probably environmental (liquid water or ice which would have disappeared during the descent).

The presence of a low point in the left Pitot tube hose could have created conditions conducive to partial or total obstruction.

The examination of another Cessna Citation in the Valljet fleet seems to show that the routing of the hose can produce a low point depending on how it is installed.

The manufacturer, Textron Aviation, stated that:

- it was not aware of any in-service event relating to a fault on the air-data system;
- it had had no feedback concerning the length of the hose from its customers;
- the routing of the hoses must comply with good practice in order to avoid the appearance of a low point. Textron Aviation mentioned an FAA circular as a reference for this good practice, but did not include any information about it in its documentation applicable to Cessna 525s produced before 1996.

Following the examinations carried out with the BEA which led to the removal and replacement of the system 1 Pitot tube and the hose with the elimination of the low point, the aeroplane was returned to service at the beginning of March 2022. At mid-April 2023, no fault of the air data system had been reported again.

2.3 In service history and processing of faults on the air data system of F-HGPG

The fault on air data system 1 (altimeter and airspeed indicator on captain’s side) had already occurred several times on the aeroplane:

- in 2017, with the aeroplane returning to the departure airport (operations base), the fault was recorded in the TLB and an ASR was written; following this, a maintenance action was carried out;

- in 2019, partial information was recorded in the TLB when back at the operations base and no ASR was written; this led to a maintenance action focusing on troubleshooting a barometric fault;
- in 2021, one month before the serious incident, no fault information was recorded in the TLB and there was no ASR, solely informal verbal exchanges with the head of the Citation sector and a few other pilots.

2.3.1 Recording information in TLB

The situation observed, of a significant difference between the two altimeters (a difference of 4,000 ft observed in 2017), and the erroneous indications of the system 1 airspeed indicator from the middle of the climb to the middle of the descent, must under the regulations, lead:

- to the failure being recorded in the TLB by the captain at the end of the flight;
- as there is no corresponding item in the MEL, the aeroplane being considered as no longer meeting airworthiness conditions and being grounded (AOG). A maintenance operation was necessary to return the aeroplane to service.

These actions were carried out after the occurrence in 2017.

For the occurrence in 2019, the head of the Citation sector used his personal experience to characterise the failure based on the occurrence in 2017 brought to his knowledge at that time, and the maintenance actions carried out. Based on this experience, he indicated the system which he thought was faulty in the TLB (static port) rather than specify the symptoms encountered in flight. He chose to maintain the following flight, with passengers, to the operator's operations base where he filled in the TLB.

In 2021, again based on his personal experience, he discussed the matter with the crew and the return flight with passengers was maintained. As the fault did not appear during the return flight, the crew did not indicate the failure in the TLB.

Informed of all the occurrences, the head of the Citation sector did not contact the SMS and CAMO entities to inform them of the repetitive fault. The reporting of this occurrence deteriorated over time, until there was no regulatory reporting of the fault in the TLB one month before the serious incident.

The fault was recorded in the TLB in 2017, partially recorded in the TLB in 2019 and not recorded in the TLB in 2021; these actions did not lead to appropriate maintenance steps, in cooperation with the manufacturer, to identify and address the repetitive fault. In the absence for this aeroplane, of a TSM or specific troubleshooting task for this type of failure, the help of the manufacturer is recommended in order to effectively process the failure.

The head of the Citation sector told the BEA that his objective, when contacted by telephone, was to help crews write the entry in the TLB in order to facilitate the troubleshooting by the maintenance personnel. However, for the occurrence in 2019, the entry made by the head of the Citation sector of a fault in the static port (which he believed to be the cause of the deviations observed on the altimeter and airspeed indicator) was not such as to help maintenance identify the possible link with the 2017 occurrence or to prompt maintenance to undertake a more thorough examination of the entire air data system, in contact with the manufacturer if necessary.

In 2021, after the occurrence flight, the captain contacted the sector head, whose analysis probably contributed to the failure not being mentioned in the TLB. The absence of any mention of this occurrence in the TLB meant that maintenance organisation was not aware of the repetitive nature of an air data measurement problem on F-HGPG and the need to resolve it before any further flights. The tendency of the head of the Citation sector to try and carry out a technical analysis of the faults before reporting them in the TLB, rather than inviting the pilots to simply report in the TLB the functional faults observed in flight, as required by Air Ops[52] requirement CAT.GEN.MPA.105, may have complicated the maintenance organisation's search for any technical faults and their rectification, thus going against the stated objective.

As the operator carries out on-demand flights, it is more difficult for it to have line maintenance support at all the aerodromes to which its aeroplanes have to fly. This probably encouraged the practice mentioned by the head of the Citation sector of deferring the recording of malfunctions in the TLB until back at the base, particularly when these are transitory malfunctions. According to him, this is common practice among operators carrying out similar operations. This practice may have led the captain concerned by the occurrence of 2021 to make no mention of the fault in the TLB, as it did not occur again on the return flight. It is the responsibility of the operator (and its CAMO) to set up the necessary procedures for dealing with failures, including those occurring away from sites benefiting from a maintenance organisation.

Lastly, it is possible that the status of certain captains employed by the operator, and the nature of their relationship with the operator, encourage these practices. The operator employs freelance pilots to carry out certain flights. This was notably the case for the flight on 11 December 2021, during which the fault was not recorded in the TLB. These captains may want to avoid compromising flight operations and grounding aeroplanes. Some pilots interviewed during the investigation mentioned that certain freelance captains minimised failures in this way, possibly for fear that too systematic a reporting of the faults observed by them would lead the operator to stop using their services. This can be put in parallel with the SMS manager's statement that these freelance pilots felt less involved in the operator's operation.

2.3.2 Analysis from an SMS perspective

The occurrences in 2019 and 2021 were not the subject of a mandatory report (see paragraph 1.17.1), unlike the occurrence in 2017 and the serious incident in 2022:

- in 2019, there seems to have been a misunderstanding between the two pilots on board as to who was to write the report;
- in 2021, the co-pilot said he tried to complete an ASR but his first attempt was unsuccessful and he did not try again.

The regulations state that it the captain who has primary responsibility for reporting events.

In 2019, the crew seemed to have quickly used the transponder of system 2 after the failure occurred. The analysis of the situation was probably correct, contrary to the analysis carried out by the crew in the 2021 event, which had concluded that the system 2 altimeter was faulty. The 2019 occurrence was therefore rich in information for both analysing the failure and identifying the risk of stalling. During the occurrences, the crews reported that the stick shaker was not activated, probably because the angle of attack was less than its activation value and, a fortiori, the stall angle.

[52] Op. cit. paragraph 1.6.1.

The document submitted to the BEA (see paragraph 1.17.2.5), containing the operator's safety model, which included the ASRs considered relevant to each identified risk, did not show any of the three previous occurrences identified in this report. As a result, these occurrences, as they were not notified or appropriately taken into account in a transversal manner, were not analysed using this safety model. Thus, before the serious incident of 12 January 2022 occurred, the operator had not been able to:

- determine the repetitive nature of this malfunction and therefore realise its level of exposure to the various risks associated with the malfunction of an air data system;
- question its real control of these risks.

In particular, although the operator had a risk analysis methodology based on an assessment of the barriers separating the event that occurred from the ultimate undesired event, the three previous occurrences had not led it to:

- note the absence of an operational procedure relating to an air data fault;
- note the absence of a specific warning for this type of malfunction on this aeroplane;
- note that the ACAS system could not be considered a reliable barrier to the risk of mid-air collision resulting from this type of malfunction;
- raise awareness, or even train the crews in this type of malfunction and all its possible consequences and in particular, remind them of the importance of rapidly informing the controller;
- examine the barrier composed of the TLB analysis relating to equipment faults and their correct processing by maintenance.

Following the serious incident, in parallel with the BEA investigation, the operator undertook various actions aimed at reinforcing some of the barriers pre-identified in the risk map (see paragraph **Erreur ! Source du renvoi introuvable.**).

2.4 Reporting safety occurrences at Valljet

The investigation showed that in the operator's Citation sector, practices regarding the reporting of safety occurrences and particularly the reporting of technical faults observed in flight were inadequate.

This resulted in the sector head being excessively and nearly exclusively asked for his opinion, even about technical problems. The setting up of the MCC a few months before the serious incident of 12 January 2022 could have changed some of these practices. The effectiveness of this action was not demonstrated prior to this serious incident.

In addition, it was observed that formal reporting in the TLB was not systematic or that entries were made in the TLB after the occurrence, notably when back at the base. These observations, as well as the statements collected from several pilots and operator managers, tend to show that the aim of certain practices was not to compromise the operational and commercial commitments, even when airworthiness-related malfunctions were identified. To compensate for this reporting shortfall, the Citation sector CAMO agent set up an unofficial list for each aeroplane, of faults which he learnt about through channels other than the TLB, so that they could be dealt with as part of maintenance despite everything. The flight of 28 February 2019, being a supervision flight for a captain in training with the head of the Citation sector on board, may suggest that this is a deep-rooted culture at the operator’s, as this type of flight should logically be exemplary.

The implementation of a parallel management system for the reporting of faults (instant messaging, CAMO agent's unofficial list, verbal exchanges between pilots) is consistent with the existence of such a culture at the operator's. This parallel management, probably linked to an unstable and variable organisation, did not favour the effective processing of these faults, for example in the scope of the SMS. The operator had experienced strong growth in recent years. The statements gathered point to a lack of structure within the organisation.

The MCC initially had a clearly defined technical role when it was created in November 2021. However, in June 2022 (several months after the serious incident), the sector heads became the MCC managers. This transformation seems to confirm the prioritisation of operational aspects over technical aspects at the operator's. Moreover, the very nature of the MCC, as defined at Valljet, and the addition of an intermediary or indeed a filter between a captain and the TLB, seems to run counter to the regulatory requirement that the captain should record at the end of the flight, utilisation data and all known or suspected defects of the aircraft in the aircraft technical log or journey log to ensure continued flight safety.

These shortcomings observed with respect to the notification of occurrences and the recording of malfunctions may be explained by the feeling of a lack of a "just culture" expressed by pilots and certain managers. Pilots explained to the BEA that they came to perceive certain operational decisions (e.g. not being programmed flights) as sanctions following them refusing certain requests deemed unsafe or on taking certain decisions not favouring commercial operations. They indicated that they did not have knowledge of proven sanctions. Under the regulations, the obligations relating to the reporting of safety occurrences are formulated in a fairly broad way and are accompanied by solid guarantees of protection for those reporting these events. As a result, a sanction taken following the declaration of a technical fault could easily be legally challenged.

The safety level seems to be perceived differently by pilots and some of the management. All these points jeopardise the safety culture at Valljet.

Lastly, the investigation showed that inappropriate practices subsisted:

- no entry in the TLB, or postponement of the entry until the return to the base;
- parallel management for reporting faults (the head of the Citation sector being almost systematically contacted, non-compliant procedure set up by the CAMO agent in the Citation sector);
- absence of ASR.

The management or managers, in particular the first MCC manager, the head of the Citation sector and the CAMO agent for the Citation sector, and some pilots were aware of such practices. The investigation was not able to determine whether the accountable manager was aware of these practices.

2.5 Crew's doubt about altitude of their flight

After detecting the difference in altitudes, the crew of F-HGPG asked the controller for the altitude of their flight. The latter replied to the question by giving the information which he read on his radar screen. The information transmitted initially reinforced the crew's erroneous analysis of the failure. Indeed, at this stage in the analysis of the failure, the crew did not realise that the information provided by the controller was none other than that generated by the aeroplane's systems, in this case by system 1 (on the captain's side).

This type of check at the request of the crew (which in the serious incident followed a radio check request) seems to be a relatively common occurrence, according to the statement of the controller on duty. This did not lead him to suspect an altimeter problem on board the aeroplane, even though he had been made aware of the serious incident in 2010 (see paragraph 1.18.1). He did not try and clarify if they had any doubts nor did he provide any further assistance.

Several minutes later, the captain informed the controller of the inconsistencies in the altimeter indications on board and of the fact that, very probably, the aeroplane was higher than indicated on the controller's screen (information transmitted by the transponder). It was only at this point that the controller became aware of the situation. At this stage, only having two onboard altitude measurement systems, the crew were not able to definitively confirm which altimeter was faulty. The inconsistencies in the indications of the system 1 airspeed indicator were, however, useful information that could have led the crew to suspect a fault on air data system 1.

In the occurrence a month earlier, the crew made an erroneous analysis of the fault. They considered that the system 1 altimeter information was correct, as it was identical to that indicated by transponder 1.

The onboard documentation did not contain any procedure for dealing with this failure. The absence of onboard procedures on a PC 12 in 2010 (see paragraph 1.18.1) and a Cessna Citation in 2020 (see paragraph **Erreur ! Source du renvoi introuvable.**) was identified by the BEA during the investigations into these serious incidents. Safety recommendations addressed to EASA were issued in this respect. The associated actions had not improved the situation with regard to procedures on aircraft other than the PC 12 at the time of the serious incident.

After managing the emergency situation related to the crossing of the flight paths of F-HGPG and F-HBXG, the controller, having the procedure in mind when a crew expresses doubt about the altitude of their flight:

- asked them to deactivate the altitude encoder of F-HGPG;
- considered initiating an interception mission by the CNOA, to check the flight's altitude.

This second point was quickly dismissed in view of the crew's analysis of the failure and the proximity of the destination.

During his discussions with the CNOA, the head of the control centre room asked for an estimation of F-HGPG's altitude. However, he quickly realised that the CNOA did not have more reliable information than him as it was all information coming from the aircraft and potentially erroneous. The CNOA transmitted data to him, in particular an altitude, which was probably from a GNSS source and, later, information about the aircraft's altimeter setting, which turned out to be incorrect (unrelated to the system 1 altimeter fault).

Lastly, to close the occurrence, the controller referred to the transponder failure quick reference card, which he felt was the most appropriate for the situation; the procedure when a pilot expresses doubt about the altitude of his flight was not available in the form of an quick reference card (nor inserted in the Cigale tool), but solely described in the North ACC Operations Manual. It had already been observed that there was no quick reference card for when a pilot expresses doubt about the altitude of his flight during the investigation into the serious incident in 2020 and that the emergency procedure put in place by the air navigation services following the 2010 incident was not known to the controller and was not available from the control position.

Moreover, these procedures, as well as the DSNA operational directive 11-158/10, do not include a reminder that the altitude indicated on the radar screen is onboard information transmitted by the transponder.

2.6 Analysis of risk posed by an air data system fault

The minimum vertical separation between F-HGPG and F-HBXG is estimated at 665 ft based on GNSS data. On board F-HGPG, the difference in altitude between the two altimeters was around 1,400 ft. The investigation showed, through the analysis of previous occurrences, that this difference was not constant, that it depended on the altitude and speed of the aeroplane, and could reach up to 4,000 ft (2017 occurrence). There was a definite risk of a mid-air collision with F-HBXG or any other aircraft in the sector.

An air data system fault is a distinctive and real threat for aviation safety.

Firstly, this type of in-flight malfunction is likely, simultaneously, to:

- generate a flight path deviation in the vertical profile which could cause a dangerous loss of separation between aircraft (or between an aircraft and the ground);
- deprive pilots and air traffic controllers of elements permitting them to have full situational awareness;
- compromise the effectiveness of the ACAS (aircraft) and STCA or MSAW (air traffic control) barriers.

In addition, aircraft may coexist in the same airspace:

- with different certification criteria (e.g. CS 25 or CS 23) which do not guarantee the same level of integrity of altitude information;
- performing different types of operation (such as CAT, NCC or NCO operations), involving single or two-pilot crews with different experience and training to deal with a complex failure.

Thus, when faced with the risk of a mid-air collision, in the absence of segregation, traffic covered by the most demanding regulatory requirements (e.g. aircraft covered by CS 25 or equivalent and/or operated for commercial air transport) will in reality be subject to the level of safety provided by the minimum requirements applicable to other traffic (e.g. aircraft covered by CS 23 or equivalent and/or operated in a non-commercial context).

In such a context, to determine whether the risk is acceptable, it must be assessed globally. In the course of the investigation, the BEA questioned EASA on its perception of the risk posed by an air data system fault. In its *ATM/ANS safety risk portfolio*, EASA identified a safety item relating to a transponder malfunction. EASA specified that a Safety Issue Assessment (SIA) "*Deconfliction with aircraft operating with a malfunctioning/non-operative transponder"* (SI-2002) (Amended)[53] was in progress, that it should have been finished at the end of 2022 but that the calendar had been pushed back in order to deal with other more urgent matters requiring resources. The assessment started in 2023 and should be finalised in the second quarter. Following this work, EASA should develop a Best Intervention Strategy (BIS) on this topic.

[53] EPAS 2022-2026 volume III, page 36.

3. CONCLUSIONS

3.1 Findings

- The crew of F-HGPG held the licenses and ratings to carry out the flight.
- The last maintenance inspection of F-HGPG took place between 27 December 2021 and 6 January 2022. The maintenance report did not mention work carried out on the air data system.
- When F-HGPG was not being flown, it was parked outside in the operator's parking areas. No protection was installed on the static ports, it was not a manufacturer requirement. However, covers were installed on the Pitot tubes.
- The weather conditions were compatible with carrying out the flight, freezing fog of a few hundred feet was present at the departure airport.
- During the climb, the crew of F-HGPG observed abnormal operation of the system 1 airspeed indicator.
- At the end of the climb, the crew of F-HGPG observed a difference in altitude between the two altimeters (system 1 and system 2) of around 1,500 ft.
- The crew of F-HGPG asked the North ACC controller to indicate their altitude displayed on the radar screen.
- The controller did not consider that there might be an onboard fault following this request.
- Neither the flight manual (manufacturer's documentation) nor the QRH (operator's documentation) of F-HGPG contained procedures concerning an airspeed indicator fault, an altimeter fault, a fortiori an air data system fault.
- The BEA has twice recommended to EASA, following investigations into serious incidents that occurred in 2010 and 2020 (recommendation issued at the end of 2022 for the latter investigation), following a failure of the air data system, that the manufacturer's documentation on crew procedures should be updated on this subject.
- After the crew of F-HGPG had analysed the onboard failure, they informed the controller that they had doubts about their actual flight level.
- The controller gave traffic information concerning an aeroplane registered F-HBXG situated at their twelve o'clock, at a distance of around 2 NM and 1,000 ft higher than them based on the information available to him; the aeroplanes crossed paths a few seconds later.
- Based on the GNSS data of the two aeroplanes, it was calculated that the minimum separation was 1.5 NM laterally and 665 ft vertically. F-HBXG was in reality lower than F-HGPG;
- The crew of F-HBXG were not aware of the dangerous loss of separation.
- F-HBXG's systems, in particular its anti-collision system (ACAS) and transponder, did not have any faults.
- The controller and the crew of F-HGPG discussed the altitudes displayed on the aircraft instruments.
- After analysing the various information available to them, the crew of F-HGPG deduced that the system 2 altimeter and airspeed indicator information was valid and used this to continue the flight.
- The controller then asked the crew of F-HGPG to deactivate the altitude encoder (Mode C).
- The controller considered initiating an interception mission by the CNOA, but this idea was quickly dismissed.
- The head of the North ACC control room asked the CNOA for an estimation of the altitude of F-HGPG.

- The CNOA communicated an altitude information provided by its tools. It is possible that this information was based on a GNSS source, generated on board F-HGPG.
- The controller used the transponder failure quick reference card to close the incident.
- The emergency procedure when a pilot expresses a doubt about the altitude of his flight was available in the North ACC's Operations Manual but not in the quick reference cards at the control position, which reveals the small degree of effectiveness of the actions taken by the DSNA following the serious incidents of 2010 and of 2020.
- The CNOA informed the controllers that the altimeter setting of F-HGPG was incorrect.
- The crew of F-HGPG checked the altimeter setting which was correct.
- The CNOA did not assess the validity of the parameters available on its tool, the parameters were based in particular, on ADS-B data available on internet.
- A fault on the air data system had already appeared several times on F-HGPG: on 8 November 2017, 28 February 2019 and 11 December 2021, i.e. one month before the serious incident.
- The occurrence in 2017 was recorded in the Technical Log Book (TLB) with the information, airspeed indicator fault followed by altimeter fault; the occurrence in 2019 was recorded in the TLB with the partial information, static port fault; the occurrence of 2021 was not recorded in the TLB, the crew solely exchanged with the head of the Citation sector about the fault encountered.
- The failure which occurred in 2019 was not recorded in the TLB at the end of the occurrence flight, but at the end of the following flight, when the aeroplane had returned to the base.
- During the flight of 28 February 2019, the operator's head of the Citation sector was the designated captain for a supervision flight of a captain in training.
- Troubleshooting was carried out in 2017 and 2019 by the Part-145 maintenance workshop, Textron Aviation Paris Service Center, based on the different information recorded in the TLB.
- The manufacturer, Textron Aviation had not produced a TroubleShooting Manual (TSM) for F-HGPG.
- Troubleshooting with the possible collaboration of Textron Aviation was not carried out with respect to the repetitive fault on air data system 1 of F-HGPG.
- The troubleshooting carried out with the BEA in 2022 after the serious incident found that the hose connected to the system 1 Pitot tube had a low point which prevented natural draining; the hose and Pitot tube were replaced, the hose bearing the same part number was installed without a low point; the examinations were not able to identify with certitude the cause of the fault, however, at mid-April 2023, the fault had not reoccurred.
- The manufacturer, Textron Aviation, specified that its Flight Safety department was not aware of a similar event. There had been no information about the Pitot tube hose.
- The occurrence of 2017 was the subject of an ASR, unlike the occurrences of 2019 and 2021.
- Safety occurrences (both technical and operational) were not always reported in a formal manner or in compliance with regulatory requirements within the Citation sector at Valljet.
- The Citation sector crews frequently and nearly exclusively asked the head of the Citation sector for his advice, even with respect to technical problems despite a Maintenance Control Centre (MCC) having been set up a few months before the serious incident.
- The head of the Citation sector at Valljet knew of all the occurrences; he did not share this information with the SMS.

- A non-compliant way of proceeding with respect to regulatory requirements had been set up, particularly by the Continuing Airworthiness Management Organisation (CAMO) of the Citation sector so as to be able to process certain faults not recorded in the TLB at the end of the flights in which they had appeared.
- On several occasions, Valljet had reminded its crews about the importance of reporting occurrences (ASR and TLB) and explained the operation of the MCC.
- Valljet's safety culture was called into question by several members of the operator's staff (pilots, managers) during the investigation carried out by the BEA.

3.2 Contributing factors

The following factors may have contributed to the loss of separation with another aeroplane:

- the crew not giving immediate and explicit information to the controller concerning the differences in altitude indications observed between systems 1 and 2;
- the controller not giving clear information to the crew, concerning the nature and origin of the altitude information available to him on his screen, in response to the question from the crew who had not formalised their doubt;
- the captain's confirmation bias generated by the controller's response to the crew's question (similarity of indications in near-stabilised flight);
- the crew of F-HGPG giving late information to the controller concerning the altitude differences between the system 1 and 2 altimeters, limiting the options available to the controller to manage the conflict;
- the absence of a (manufacturer and/or operator) crew procedure to deal with cases of faults or uncertainties with respect to the air data system indications.

The following factors may have contributed to an air data system being kept in an unsafe technical condition:

- inappropriate practices with respect to the reporting and technical processing of occurrences in the Valljet Citation sector which have been shown to be ineffective and may reflect a deficient safety culture;
- shortcomings in the Textron Aviation maintenance manual, in particular the absence of a suitable troubleshooting procedure for this type of situation.

The absence of operational procedures for the crew may have contributed to inadequate operational management of an in-flight fault on an air data system because of:

- the limited scope of the actions taken by EASA after the serious incident of 2010, in particular with respect to the observed shortcomings of the flight manuals drawn up by the manufacturers and in relation to situations of doubtful or erroneous air data information;
- inadequate practices with respect to the reporting and operational processing of occurrences at Valljet which meant that it did not identify the need to produce this type of procedure.

4. SAFETY MEASURES TAKEN SINCE THE SERIOUS INCIDENT

4.1 Safety measures taken by Valljet concerning the reporting of faults

On 18 January 2022, the flight operations department issued an Information Note to the crew, Reminder about procedures for reporting technical events.

The note indicated that recent occurrences had shown that the handling of technical problems and the reporting of information to the accountable manager, the SMS manager and/or the designated head of flight operations was not always satisfactory.

Via this note, the flight operations department reminded the pilots that:

- technical incidents which cannot be resolved by complying with the QRH, or, possibly, after complying with the QRH, must be the subject of technical advice taken from qualified personnel;
- to this end, an MCC (Maintenance Control Centre) has been set up (e-mail from the deputy accountable manager dated 12 January 2022);
- […]
- the consequences of failures must also be assessed from a technical, operational and commercial point of view (FORDEC method, see Operations Manual B-03);
- the designated head of crew training, the designated head of flight operations, the designated head of ground operations and the safety manager are their trusted contacts;
- at the end of the flights, the pilot reporting system and ASR are the tools to formalise their feedback and to provide all the other crews with this information;
- in addition to these formal exchanges, where anonymity and the decriminalisation of errors are two basic rules, informal exchanges between crews are encouraged as part of the feedback and sharing of good practices.

It specified that it is essential that technical and flight safety information is passed on through the channels provided for this purpose, so that it can be analysed, processed and communicated by the competent and legitimate personnel, and that any other procedure could jeopardise flight safety, the airworthiness of Valljet aircraft and even the operation of the aircraft by Valljet.

With regard to this note on the reporting of technical events, the BEA notes that the operator's flight operations department does not refer directly to the captain's obligations to enter the fault or faults observed after the flight in the Technical Log Book (TLB). This measure taken by the operator is likely to maintain a system in which the captain must first interact with the operator's managers before entering a failure in the TLB, which does not correspond to the way of proceeding set out in CAT.GEN.MPA.105 of the "Air Ops" (see paragraph 1.17.1).

Furthermore, Valljet states that internal training has also been given to the captains, with the aim of reminding them of the regulatory framework, the procedures in force for reporting technical faults/events and responsibilities.

4.2 Safety measure taken by Valljet regarding air data system fault

On completion of the first series of examinations following the serious incident (see paragraph 1.6.8), the technical fault was not identified. At this time, the operator added two procedures to the QRH to provide crews with the steps to be taken in the event of a failure or incorrect altitude or speed indications.

68. LH or RH AIRSPEED INDICATOR ERRATIC or FAILED

1. **PF AUTOPILOT..DISCONNECT**
2. **PF DESCENT..INITIATE**
   Descent below RVSM to FL280
3. **PM ATC...ADVISE**

4. **PM** LH or RH & Standby Altimeter..........................**COMPARE / MONITOR**
5. **PM** LH & RH Altimeter & Transponder altitude..........**COMPARE / MONITOR**

IF UNABLE TO DETERMINE ACCURATE AIRSPEED

6. **C/P** Maintain VMC conditions
7. **C** Use the AOA for Vref
8. **C/P** Land as soon as possible

" LEFT AIRSPEED INDICATOR ERRATIC OR FAILED Checklist Complete."

69. LH or RH ALTIMETER ERRATIC or FAILED

1. **PF AUTOPILOT..DISCONNECT**
2. **PF DESCENT..INITIATE**
   Descent below RVSM to FL280
3. **PM ATC...MAYDAY MSG**

4. **PM** LH or RH & Standby Altimeter..........................**COMPARE / MONITOR**
5. **PM** G750 GSL Altitude...**CHECK and MONITOR**
6. **PM** LH & RH Altimeter & Transponder altitude..........**COMPARE / MONITOR**

IF UNABLE TO DETERMINE ACCURATE ALTITUDE

7. **C/P** Maintain VMC conditions
8. **PM** Advise ATC
9. **C/P** Land as soon as possible following instructions.

GSL Altitude accuracy is affected by factors such as satellite geometry, but it is not subject to variations in pressure and temperature that normally affect pressure altitude devices.

" LH or RH ALTIMETER ERRATIC or FAILED Checklist Complete."

Figure 8: excerpt from operator's QRH, updated after the occurrence (source: Valljet)

These procedures were newly revised by the operator to better meet safety objectives: holding the flight path, alerting air traffic control and singling out the faulty instrument. The operator stated that it had not received any assistance from the manufacturer, Textron Aviation, and that the latter had not given an opinion on the technical validity of these procedures in the form of an NTO[54].

[54] No Technical Objection.

1. UNRELIABLE SPEED INDICATIONS/ SPEED DISCREPENCY

1. PF AP/FD....................DISCONNECT
2. PF PITCH/TRHUST.................... ADJUST

IF BELOW MSA

3. PF PITCH 10°/ CLIMB THRUST

IF AT OR ABOVE MSA

4. PF LEVEL OFF

THEN

5. PF Adjust Pitch/Thrust according to the following dashboard

Cruise	Approach	Landing
- GND to FL150 : Flaps 0 / N1 = 85 % / Pitch = 0° - FL150 to FL250 : Flaps 0 / N1 = 90 % / Pitch = 0° - Above FL250 : Flaps 0 / N1 = 95 % / Pitch = 1°	APP, GND to FL100 : - Flaps 0° IAS = 3 x N1 - 5 Nm avant le FAF, N1 = 55% - 2 Nm avant le FAF, Flaps TO-App, N1 = 55%	Landing Conf. / N1 = 55 % / AoA = 0.6 (Vref)

6. PM Inform CTL of possibly unreliable ALT indications & request to CTL lateral separation with other traffic during situation assessment.
7. PF/PM Identify unreliable speed and validate with GPS/GS info corrected by wind charts info and/or AoA.
8. PF/PM Check ALT information and validate accurate system(s).
9. PF/PM Divert to the nearest suitable airport.

2. UNRELIABLE ALT INDICATIONS/ ALTIMETERS FAILED

1. PF AP/FD....................DISCONNECT
2. PM ATC............... ....INFORM & REQUEST LATERAL SEPARATION
3. PM COMPARE/VALIDATE/MONITOR ALT1/2 to S/B ALT AND GSL ALT

IF BELOW MSA

4. PF CLIMB TO MSA

IF AT OR ABOVE MSA

5. PF LEVEL OFF

6. PM ATC............... ....INFORM & REQUEST LATERAL SEPARATION
7. PM COMPARE/VALIDATE/MONITOR ALT1/2 to S/B ALT AND GSL ALT

In order to compare ALT1/2/S/B ALT to GSL ALT (which is a geometric altitude), apply QNH correction and temperature correction as follows:

- To ALT1/2 indication apply QNH correction (+27,5ft/mb if QNH>1013 or -27,5 ft/mb if QNH<1013) and
- Temperature correction (+4ft/1000ft/°C if outside average temperature if > STD, or -4ft/1000ft/°C if outside average temperature is below STD.

Altitude may be considered valid if difference is less than 200ft.

- Divert to the nearest suitable airport

8. PM Inform CTL of possibly unreliable ALT indications & request to CTL lateral separation with other traffic during situation assessment.

Figure 10: new procedures (source: Valljet)

4.3 OSAC oversight mission of October 2022

In October 2022, the OSAC carried out an oversight mission at the operator's. The documentation of an aeroplane in the Citation sector was reviewed. Following this oversight action, the accountable manager was informed of a level 1 deviation[55]. This deviation led to the suspension of the operator's CAMO approval and as a consequence the DSAC suspended its AOC.

The deviation concerned the faults and failures detected in operation not being recorded in the TLB. It was identified that troubleshooting and correction of a fault were initiated by the CAMO although no fault was present in the TLB for the flights preceding the maintenance work. This deviation was observed on an aeroplane in the Citation sector, undergoing maintenance work at the time of the oversight mission. The inspector also had access to the list of repairs initiated and carried out for the operator's entire fleet: this deviation was also observed on other aeroplanes in the Citation sector and on one aeroplane in the Hawker sector. This type of deviation had already been observed in July 2021 (see paragraph 1.17.2.4).

The operator analysed this situation and proposed immediate corrective actions. These measures enabled the level 1 deviation to be requalified as a level 2 deviation. The operator recovered his CAMO approval and AOC the same day he was officially notified, i.e. 48 hours after being informed.

The immediate corrective actions were the following:

1. The appointment of a new designated head of continuing airworthiness […].
2. Ceasing the sectorisation of the CAMO agents, the only contact between the CAMO and operations being the designated head of continuing airworthiness.
3. Creating an expanded department in the CAMO for AOG airworthiness actions such as MCC[56] work in order to oversee and carry out the associated actions in a continuous way (when an aeroplane is in operation).

[55] A level 1 deviation is a non-conformity that lowers the safety level or seriously endangers flight safety, and justifies immediate action by the Authority to prohibit or limit the activities carried out under the approval.
[56] The MCC became an entity of the R&O part 145 workshop again.

4. Abolishing the head of the Citation sector position with the associated duties being carried out by the designated head of flight operations.
5. Notifying the CAMO that “parallel” practices were prohibited.
6. Use of the TLB as the sole means for the Part 145 workshops to process failures identified in operation.
7. The processing and ceasing of Work Orders PR in AMOS.
8. The processing and ceasing of any parallel list (case of Citation sector).
9. Before returning any aeroplane from the Citation sector to commercial air transport flight, the carrying out of a check flight of at least one hour with a B1 or B1C technician. This flight was to be used to identify any possible technical failures affecting airworthiness which shall be corrected before the aeroplane is returned to service.
10. The incorporation of a Conformity procedure for the validation of the Work Orders so that no unscheduled work is started without an item reported in the TLB and so that the scheduled Work Order does not contain AOG elements to be processed.
11. The implementation of a single “MCC” type procedure to be built into the CAME which will be the same across all sectors. It will include the actions to be carried out by the pilots and their contact when they detect a failure, the exchange being used to initiate the failure processing operations, to enter it correctly in the TLB or to validate the report according to a MEL code.
12. The issuing of an Information Note so that all technical feedback from the pilots concerning the behaviour of an aeroplane is processed by the designated head of continuing airworthiness who will ask the pilot who gave the information to validate it, will validate this point with the other crews operating the aeroplane or ask the Part 145 workshop or the manufacturer for their opinion. Once the point is validated, the captain will record the information in the TLB or it will be the subject of MEL work if appropriate. This note will be countersigned by each pilot and will be part of the mandatory induction documents during the OCC (which will include a specific TLB training module given by the designated head of continuing airworthiness during the training).
13. The setting up of face-to-face training (remote training for crew living at a distance) for all captains to remind them of the regulatory framework, the procedures in force and their responsibilities. The training will be given by the designated head of flight operations.

Once all these measures are included in the CAME in the form of an internal approved revision, they will be distributed and explained to:

- the CAMO personnel, who will be asked to “read and sign”;
- the crews, who will be asked to “read and sign”.

Regarding point 4, the operator stated that the position of head of sector has been abolished and replaced by a fleet technical manager.

Regarding point 5, the operator’s analysis given to OSAC and the DSAC indicated that this deviation in the method of dealing with technical faults seems to have been effectively introduced by the CAMO under the authority of the head of the CJ sector, in order to "facilitate" the continuity of operations. The operator’s analysis also specified that there was no evidence of pressure from the accountable manager to fly the planes with failures.

It was on the basis of this information that OSAC requalified the level 1 deviation as a level 2 deviation.

A procedure with respect to the exchanges with the MCC (points 3 and 11) was set up on 10 November 2022.

No.	Description	Actor
1.	The pilot contacts the MCC on-duty agent and informs him of the failure, giving as much information as possible.	Pilot
2.	In coordination with the pilot, the technician, based on his rating, experience and knowledge of the aeroplane, tries to understand the failure and find a solution, to give instructions to test the faulty function in order to return the aeroplane to service.	MCC on-duty agent
3.	If the failure disappears, the crew continue operating the aeroplane, and their mission after having completed the TechLog with the information "Reset successfully".	Pilot
4.	If the MCC on-duty agent cannot find a solution on his own, he contacts the designated head of flight operations and/or the expert pilots of the Citation, Hawker and Embraer fleet according to needs.	MCC
5.	Like the MCC on-duty agent (action 2), the expert pilot also tries to find a possible solution to be carried out by the crew. The crew continue operating the aeroplane, and their mission after having completed the TechLog with the information "Reset successfully".	Expert pilots
6.	If not, with no other alternative but to give the aeroplane the AOG status. The MCC asks the pilot 1) to complete the TechLog, 2) if it is possible to consider it as an MEL item, the MCC and the pilot agree on the List of deferred work and its to-be-done-by limit to be recorded in the TechLog. The pilot sends the TechLog + MEL + LTR to the MCC by e-mail.	MCC and Pilot
7.	On receiving the data provided by the crew, the MCC must immediately send this same data to the CAMO.	MCC
8.	The MCC then prepares the Work Package to carry out the mission. He checks for the availability of the qualified and approved technician based on the Techlog, MEL and LTR, the technical data of the aeroplane, the tools, the equipment to be replaced and the consumable materials required for the work.	MCC
9.	The MCC organises the logistical aspects of the technician's mission.	MCC
10.	The qualified technician carries out all the steps of the procedure in order to close the MEL and LTR, and signs the CRS in the TechLog to allow the crew to continue their mission safely.	Technician
11.	On returning from his mission, the technician informs the MCC of the work performed, hands over all the technical documents to the production engineering department to update AMOS. The MCC sends a copy of this file to the CAMO.	Technician and MCC

Figure 9: MCC operational procedure PROC-15 (source: R&O)

The operator stated that a new organisation had been defined, in collaboration with the DSAC. The aim of this organisation was to improve operation working methods and the handling of technical contingencies, while meeting safety objectives and providing feedback to the accountable manager. The internal organisation of the CAMO was also reviewed, notably with the elimination of the sectorisation of CAMO agents, so that only the designated head of continuing airworthiness was the interface between the CAMO and operations.

In mid-April 2023, certain points in the action plan relating to organisational changes were still under discussion. In particular, the PROC-15 procedure was not deemed satisfactory by the DSAC. This is one of the reasons why the level 2 deviation had not been closed mid-April 2023.

The BEA notes once again that, more than six months after the serious incident and following an OSAC oversight mission, the operator still does not give the captain the initiative to complete the TLB after the flight. The PROC-15 procedure is in line with the reminder given to crews following the serious incident (see paragraph 4): it is only in step 6 that the captain is asked to enter the fault, after having contacted the MCC, the designated head of flight operations and/or the fleet's expert pilot. The need for the pilot to obtain validation from the designated head of flight operations or an expert pilot before entering an observed fault in the TLB seems to deviate from the spirit as well as the letter of the provisions of the requirements CAT.GEN.MPA.105 of the "Air OPS"[57] and MA.403 of Regulation (EU) No 1321/2014[58], which imply a direct exchange between the crews and the maintenance organisation.

4.4 Safety measures taken by the North ACC

Following the analysis of the serious incident by the North ACC, the following measures were proposed:

- propose explicit phraseology in response to a crew's query about what the controller is reading on his radar screen. The phraseology should reflect the fact that what is observed on the radar comes from the information that the aircraft is transmitting;
- review the "Transponder failure" quick reference card and include the case of "pilot doubt";
- plan a briefing (lessons learned) in order to:
  - remind controllers about the transponder/altimeter information using the event,
  - inform/remind controllers that the military have the same radar information as civil radars, and therefore the same regulatory altitude information.

At the end of the consultation phase of the draft final report, the DSNA informed the BEA that:

- the quick reference card for when a pilot expresses doubt about the altitude of his flight is now available;
- lessons learned with respect to the serious incident will be shared during the briefing scheduled for the summer of 2023.

With regard to the first measure taken, even though the North ACC has proposed a phraseology to the DSNA's Operations Directorate (DO), the latter is not in favour of introducing a regulatory phraseology. The Standardised European Rules of the Air (SERA)[59] specify that clear language must be used in cases not described by the regulatory phraseology. However, in mid-April 2023, the DSNA planned to evaluate the advisability of proposing a suggestion or good practice that could help the controller in a situation of this type, by enlisting the help of experts, in particular pilots.

[57] Op. cit. paragraph 1.6.1.
[58] Op.cit. paragraph 1.17.1.
[59] Implementing regulation (EU) No 923/2012, known as SERA (Standardised European Rules of the Air).

5. SAFETY RECOMMENDATIONS

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

5.1 Maintenance documentation published by Textron Aviation

Maintenance personnel base their troubleshooting actions on the manufacturer's documentation.

A TroubleShooting Manual (TSM) for the Cessna 525 does not exist. However, a task to troubleshoot the air data system exists in the maintenance manual. This task is only applicable to the Cessna 525s that have not been modified in accordance with Service Bulletin SB525-34-41. It explicitly specifies that in order to identify a fault in the air data system, all the components and associated hoses in the system must be visually inspected. This maintenance task does not exist in the documentation for the Cessna 525s embodying SB525-34-41, such as F-HGPG. The Cessna 525 maintenance manual contains only two chapters relating to the air data system that are applicable to F-HGPG: 34-11-01 and 34-11-02. The latter do not include the task of disassembling and inspecting the system's hoses. However, this inspection may be relevant for all versions of the Cessna 525, including those embodying SB525-34-41.

Following the occurrence of 28 February 2019 (see paragraph 1.11.2.2), the troubleshooting was carried out in accordance with chapters 34-11-01 and 34-11-02 of the maintenance manual. The tests carried out proved satisfactory, but the cause of the fault was not identified. Based on this, the head of the Citation sector at Valljet suggested in discussions with the crew involved in the event of 11 December 2021, that the maintenance workshop would again have difficulty identifying the cause of the fault.

Consequently, the BEA recommends that:

- ***whereas a TSM for the Cessna 525 does not exist;***
- ***whereas the tasks in the maintenance manual relating to the air data system exclude aeroplanes modified by Service Bulletin SB525-34-41, although some of the actions set out in this task may be relevant to these modified aeroplanes;***

  Textron Aviation supplement the maintenance documentation to specify the actions to be taken in the event of an air data system anomaly for all versions of the Cessna 525, including those modified by SB525-34-41.
  [Recommendation FRAN-2023-016].

5.2 Notification of technical faults at the operator, Valljet

The investigation revealed, in the Valljet Citation sector, non-compliant practices relating to the recording of technical faults in the Technical Log Book (TLB) at the end of the flight, contrary to requirement CAT.GEN.MPA.105 of the consolidated European regulation No 965/2012 laying down technical requirements and administrative procedures related to air operations ("Air Ops"). This resulted in:

- for the occurrence in 2019, a deferred entry, on return to the operations base, of a fault in the TLB;
- for the occurrence in 2021, no entry of a fault in the TLB.

In addition, the entry made in the TLB by the head of the Citation sector with respect to the 2019 occurrence referred to the failure of a static port, whereas the observations made in flight related to the airspeed indicator and the altimeter. This interpretation meant that maintenance tasks focused on the altimeter measurement system to the detriment of additional work on the Pitot tube system.

In general, within the Citation sector, pilots were encouraged to contact the sector head before entering a failure in the TLB. This could result in no entry being made in the TLB, a delayed entry or an interpretation that did not allow maintenance to carry out effective actions.

These practices relating to the TLB gave rise to another non-compliant practice within the Citation sector's CAMO[60] with the Citation sector CAMO agent collecting faults through other channels than the TLB, and carrying out the associated troubleshooting at a later time during scheduled maintenance operations on the aeroplanes concerned. This non-compliant practice was detected by OSAC during its oversight missions in August 2021 and again after the serious incident in October 2022.

All these practices contributed directly or indirectly to the absence of any work to try to resolve the air data system fault that occurred during the serious incident.

In November 2021, with the setting up of a Maintenance Control Centre (MCC), then in January 2022, with a reminder to the crews regarding the notification of technical faults, and finally in November 2022, following the level 1 deviation notified by OSAC, the operator continued to advocate procedures that seem to deviate from the provisions of the requirement in CAT.GEN.MPA.105 insofar as the captain is asked to first interact with the operator's managers before recording a fault in the TLB. Mid-April 2023, at the end of the consultation phase for the draft final report, the level 1 deviation, which had been reclassified as a level 2 deviation, had still not been closed.

[60] Continuing Airworthiness Management Organisation.

Consequently, the BEA recommends that:

- ***whereas the inappropriate practices observed during the investigation with regard to the reporting of technical incidents, in particular the failure to report faults in the TLB;***
- ***whereas some of these practices continued after the serious incident of 12 January 2022, in particular the failure to report faults in the TLB;***
- ***whereas the operator seems to persist in requesting that the detection of a technical fault in flight be subject to validation by the managers directly linked to flight operations;***
- ***whereas paragraph CAT.GEN.MPA.105 is one of the requirements applicable to the crews of commercial air transport operators;***

Valljet review its organisation, procedures and practices so that captains are encouraged, in accordance with requirement CAT.GEN.MPA.105 of the consolidated European regulation No 965/2012 known as "Air Ops", to immediately record themselves in the TLB, at the end of each flight, the faults observed, without having to obtain prior validation by an operations manager or by an expert pilot, and without being concerned that restrictive measures will be taken against them.
[Recommendation FRAN-2023-017].

- ***whereas the inappropriate practices observed during the investigation with regard to the reporting of technical incidents, in particular the failure to report faults in the TLB;***
- ***whereas some of these practices continued after the serious incident of 12 January 2022, in particular the failure to report faults in the TLB;***
- ***whereas the operator seems to persist in requesting that the detection of a technical fault in flight be subject to validation by the managers directly linked to flight operations;***
- ***whereas requirement ARO.GEN.300 requires the oversight authority to verify the "continued compliance with the applicable requirements of organisations it has certified";***
- ***whereas paragraph CAT.GEN.MPA.105 is one of the requirements applicable to the crews of commercial air transport operators;***

the DSAC ensure that the Valljet operator remains in full compliance with paragraph CAT.GEN.MPA.105 of the consolidated European regulation (EU) No 965/2012 known as "Air Ops", under requirement ARO.GEN.300 of the same regulation, by actively seeking all useful information, such as crew reports, data collected by OSAC as part of the oversight of the operator's CAMO and Part 145 maintenance workshop, and exchanges and correspondences between flight operations, the CAMO, as well as the Part 145 maintenance workshop(s) used by the operator.
[Recommendation FRAN-2023-018].

5.3 Quick reference card for controller

Following the near-collision between an Airbus A318 and a Pilatus PC 12 in 2010 (see paragraph 1.18.1), the DSNA developed a procedure enabling a controller to deal with a situation where the pilot has reported having a doubt about the altitude of his flight.

BEA

In October 2022, the BEA recommended, following the investigation into the serious incident involving N222NF in 2020[61] (see paragraph **Erreur ! Source du renvoi introuvable.**), that the DSNA ensure that all active controllers have a correct understanding of how the air data information, available to them on their screens, is obtained.

The investigations into the serious incidents of 2020 and 2022 showed that, although this procedure existed, it was only available in the Operations Manual and therefore was not easily accessible for a controller in position placed in an emergency situation.

Furthermore, the procedure, like operational instruction 11-158/10 (see paragraph **Erreur ! Source du renvoi introuvable.**), does not contain any explicit phraseology relating to the item about informing the crew that the control services cannot resolve any doubt by a cross-check.

Consequently, the BEA recommends that:

- ***whereas the emergency procedure for when a pilot announces that he has a doubt about the altitude of his flight is not directly accessible in the control position;***
- ***whereas a pilot contacting a controller about an altimeter issue should alert the controller;***

  the DSNA ensure that the emergency procedure relating to a pilot's doubt about the altitude of his flight is the subject of an quick reference card, made available to controllers at their control position and is accompanied by recurrent training on a simulator.
  [Recommendation* FRAN-2023-019*].

5.4 Information transmitted by CNOA

During a cross-check of the aircraft's altitude information, the National air operations centre (CNOA) transmitted erroneous information about the aircraft's altimeter setting. The CNOA has tools for processing ADS-B data from aircraft in flight, but this “onboard” data is sometimes not reliable.

Consequently, the BEA recommends that:

- ***whereas unreliable information may be transmitted by the CNOA to air navigation service providers in the course of a cross-check;***

  the CNOA determine the limitations of its systems and the data at its disposal in order to provide relevant information to air navigation partners.
  [Recommendation* FRAN-2023-020*].

5.5 Analysis of risk posed by an air data system fault

The serious incidents of 2010, 2020 and 2022, investigated by the BEA, showed that an air data system fault could be of a catastrophic nature, the undesired scenarios being a mid-air collision (demonstrated by the serious incidents of 2010 and 2022) or a collision with the ground (demonstrated by the serious incident of 2020).

Several safety recommendations were addressed to EASA in order to modify crew procedures.

An air data system fault is a distinctive and real threat for aviation safety.

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[61] Serious incident to the Cessna 525A registered N222NF on 4 August 2020 close to Bourget (Seine-Saint-Denis).

Firstly, this type of in-flight malfunction is likely, simultaneously, to:

- generate a flight path deviation in the vertical profile which could cause a dangerous loss of separation between aircraft (or between an aircraft and the ground);
- deprive pilots and air traffic controllers of full situational awareness;
- compromise the effectiveness of the ACAS (aircraft) and STCA or MSAW (air traffic control) barriers.

In addition, aircraft may coexist in the same airspace:

- with different certification criteria (e.g. CS 25 or CS 23) which do not guarantee the same level of integrity of altitude information;
- performing different types of operation (such as CAT, NCC or NCO), involving single or two-pilot crews with different experience and training to deal with a complex failure.

Thus, when faced with the risk of a mid-air collision, in the absence of segregation, traffic covered by the most demanding regulatory requirements (e.g. aircraft covered by CS 25 or equivalent and/or operated for commercial air transport) will in reality be subject to the level of safety provided by the minimum requirements applicable to other traffic (e.g. aircraft covered by CS 23 or equivalent and/or operated in a non-commercial context).

In such a situation, the notion of acceptable risk could be biased if the risk is not considered from a global point of view.

In its ATM/ANS safety risk portfolio, EASA identified a safety item relating to a transponder malfunction. The assessment of the safety issue "***Deconfliction with aircraft operating with a malfunctioning/non-operative transponder"*** **(SI-2002)** was in progress mid-April 2023.

Consequently, the BEA recommends that:

- ***whereas the failure of an air data system can simultaneously:***
  - ***lead directly to a deviation in altitude conducive to a loss of separation with other aircraft or to the ground in controlled flight,***
  - ***compromise the situational awareness of pilots and controllers due to the possibly erroneous information available to them,***
  - ***compromise the operation of protection systems against the risk of collision in flight or the risk of collision with the ground in controlled flight;***
- ***whereas aircraft with different certification criteria operate in the same airspaces, thus reducing the effectiveness of the most demanding requirements with respect to this risk;***
- ***whereas the analysis of the risk posed by a fault on the air data system is not carried out in a global manner;***

  EASA continue and complete the analysis of the risk posed by a fault on the air data system, taking into account the system as a whole, and draw, as applicable, any conclusions regarding safety actions.
  [Recommendation FRAN-2023-021].

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