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Report

Accident on 6 August 2014
at Saint-Jean-les-Deux-Jumeaux (77)
to the Socata TBM700
registered N129AG

BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile
Ministère de l'Environnement, de l'Enérgie et de la Mer

Safety Investigations

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SPECIAL FOREWORD TO ENGLISH EDITION

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

Table of Contents

Glossary

ATM	Air Traffic Management
CRNA	En-route ATC centre
EASA	European Aviation Safety Agency
ETM	Engine Trend Monitor
FAA	Federal Aviation Administration
HPA	High Performance Aircraft
IMC	Instrument Meteorological Conditions
KIAS	Indicated airspeed in knots
MCTOW	Maximum Certified Takeoff weight
AP	Autopilot
PPL	Private Pilot License
SB	Service Bulletin
SL	Service Letter
STC	Supplemental Type Certificate
TSN	Time Since New
VMO	Velocity Maximum Operating

Synopsis

Loss of control in flight, flat spin, collision with terrain

Aircraft	Socata TBM700 registered N129AG
Date and time	6 August 2014 at 12 h 23[(1)]
Opertor	Private
Place	Saint-Jean-les-Deux-Jumeaux (77)
Type of flight	General aviation
Persons on board	One pilot and four passengers
Consequences and damage	Pilot and one passenger killed, three passengers injured, aeroplane destroyed

[(1)]Except where otherwise indicated, all times in this report are local.

The pilot, accompanied by four passengers took off from Cannes-Mandelieu aerodrome (France) at about 10 h 40 min bound for Courtrai aerodrome in Belgium, under an IFR flight plan. Cruise was performed at FL240 in a thick cloud layer. After about 1 h 40 min of flight, the aeroplane dived suddenly in a right turn, down to FL149. During this descent, the speed increased significantly and the overspeed warning (VMO warning) was triggered. About forty-five seconds after the beginning of the dive, the aeroplane climbed back up, reaching a climb rate of over 10,000 ft/min. The speed dropped until a stall at around FL201, while the aeroplane was still in IMC. The aeroplane then went into a spin, which flattened out during the descent. When the aeroplane came out of the clouds at an altitude between 1,000 and 2,000 ft, in a flat spin, the height was insufficient to allow the pilot to take the necessary actions to pull out of the spin and regain control of the aeroplane.

The difficulty in identifying the spin and applying the appropriate recovery inputs, when there were no visual references, made it impossible for the pilot to regain control of the aeroplane and to avoid the collision with the ground.

In the absence of flight recorders, the investigation was unable to establish with any certainty the circumstances of the accident. Eight safety recommendations have already been issued by European safety investigation authorities aimed at introducing installation of recorders on light aircraft. In response, EASA studied this subject through a regulatory task. The BEA thus addressed two additional safety recommendations to EASA to include the case of this accident in the evaluation of the regulatory task under way and to install flight recorders on aeroplanes classified as "*high performance*".

ORGANISATION OF THE INVESTIGATION

On 6 August 2014, the BEA was informed of an accident to a Socata TBM700 aeroplane, registered N129AG, which had occurred in the commune of Saint-Jean-Les-Deux-Jumeaux. In accordance with the provisions of European regulation (EU) n°996/2010 of the European Parliament and Council of the 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a Safety Investigation was immediately initiated by the BEA.

A team of three BEA investigators went to the site of the accident on 6 and 7 August 2014. This made it possible to study the distribution of the wreckage and to gather the first testimony.

Three working groups were formed in the following areas: aircraft, aeroplane systems and operation.

In accordance with the international provisions Annex 13 to the Convention on International Civil Aviation, the BEA associated the following foreign counterparts with the safety investigation:

- the NTSB (USA), the aeroplane being registered in the US;
- the TSB (Canada), the engine being of Canadian manufacture, which made it possible to benefit from the assistance of technical advisors from Pratt & Whitney Canada;
- the AAIU (Belgium), the pilot being of Belgian nationality.

1 - FACTUAL INFORMATION

1.1 History of Flight

Note: the following elements are based on radar data, radio communications, testimony and an examination of the accident site. The speeds were calculated based on the recorded positions.

On Wednesday 6 August 2014, the pilot accompanied by four passengers took off from Cannes-Mandelieu aerodrome at about 10 h 40 min bound for Courtrai aerodrome, under an IFR flight plan. The aim of the flight was to take home the President of the company that owned the aeroplane, who had been on vacation in Cannes. The passengers seated in the rear seats were children of the pilot's friends.

At 11 h 02 min the aeroplane reached its cruise altitude at FL240.

A 12 h 20 min 16 (point❷ on the flight path below)[2], while the aeroplane was about 25 NM to the east of Paris in IMC with a ground speed of about 270 kt (that's to say an indicated speed of around 190 kt), it swerved to the right and started to descend to flight level FL149. The average vertical speed during this descent was about 11,500 ft/min and the ground speed reached 390 kt (that's to say an indicated speed of around 300 kt).

[2]The flight path presented in figure 1 is also analysed in part 1.16 of this report

At 12 h 21 min 03 (point❸), the aeroplane was still in IMC and started to climb again.

At 12 h 21 min 09, the pilot, in response to a call from ATC, transmitted a brief incomprehensible radio message on the Paris ATC frequency. At 12 h 21 min 15 (point❹), the pilot told ATC ''*We have a problem*'', then the aeroplane reached FL201 (point❺). The ground speed reached about 100 kt. The aeroplane then started to descend again, with an average vertical speed of more than 10,000 ft/min.

Witnesses saw the aeroplane come out of the clouds between 1,000 and 2,000 ft from the ground. The aeroplane was in a flat spin, turning anti-clockwise (to the left). It collided with the ground at 12 h 23, with a virtually vertical flight path, flat (point❻).

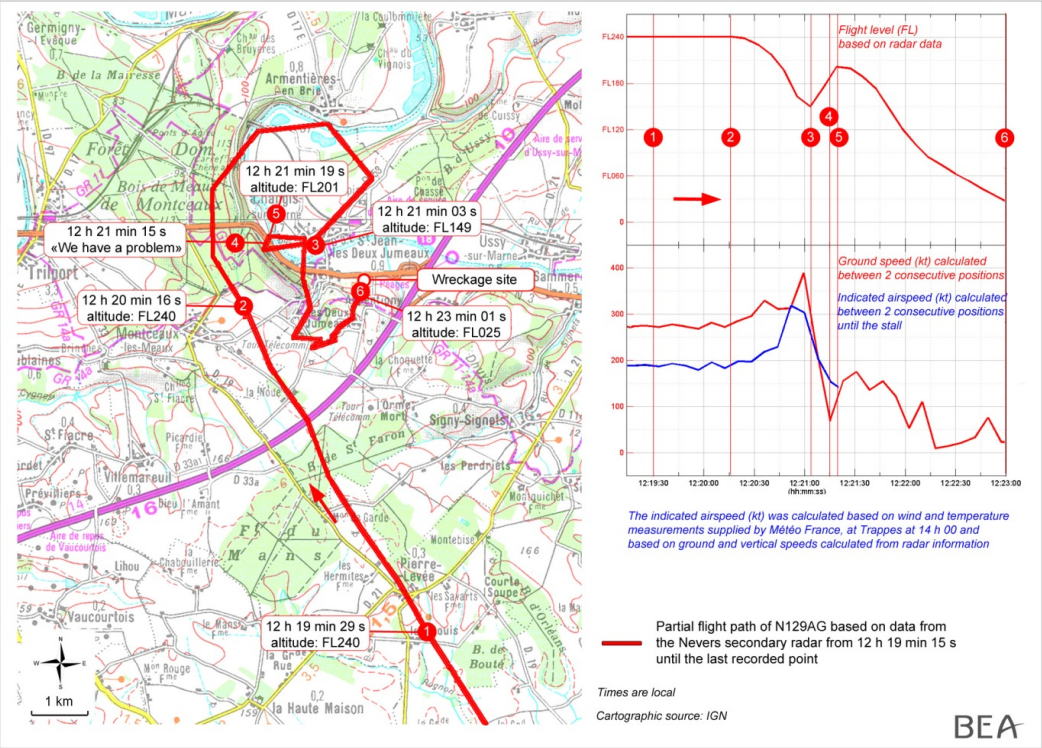


Figure 1 : flight path

1.2 Injuries to Persons

	Injuries		
	Fatal	**Serious**	**Minor/none**
Crew members	1	-	-
Passengers	1	3	-
Others	-	-	-

The three injured passengers were seated in the rear of the aeroplane. They stated that they had been sleeping in the aeroplane since takeoff at Cannes and had no memory of the accident.

1.3 Damage to Aircraft

The aeroplane was destroyed.

1.4 Other Damage

Some trees were damaged.

1.5 Information on the Pilot

The pilot, aged 63, was the holder of a Belgian private pilot's PPL (A) licence issued in July 1988. He obtained the TBM700 SET class rating in May 2006. The last extension of this rating occurred on 30 May 2014. This rating was restricted to visual flight[3].

[3]The pilot had no instrument rating on his private pilot's licence issued in Belgium.

In 1993, the pilot had converted his Belgian PPL licence to an American PPL licence. In 1995, he obtained his instrument flight rating in the United States on a PA46 Malibu. The US regulation classifies the TBM700 in the category of "*single-engine land*". It requires neither TBM700 class rating nor type rating.

In the United States, to extend one's licence, a pilot must perform a check flight with an instructor every 24 months. These flights are only entered into the flight logbook and are not recorded by the FAA. The validity of instruments flight rating is subject to conditions of either at least six months recent experience or an in-flight check. In addition, the American Federal Regulation[4] requires that pilots of aeroplanes like the TBM700 must have taken the following training courses, to be noted in the logbook:

- a complex aeroplane training course (retractable gear, variable pitch propeller, in particular);
- a high-performance aeroplane training course (aeroplane equipped with an engine over 200 HP);
- a training course on pressurised aircraft capable of flying at high altitude.

Only an US logbook opened in August 2003 was found. Based on the information in this logbook, it was not possible to determine if the pilot's instrument rating was valid at the time of the accident. No check flight with an instructor was mentioned in this logbook. The pilot's US licence was not in the format in force at the time of the accident[5]. The conversion to a licence in the new format had not been done.

The pilot had a class 2 medical certificate issued by the FAA, renewed for the last time in September 2013. During this renewal, the pilot had declared about 3,000 flying hours.

He had a total of about 700 flying hours on TBM700, virtually all of it on the N129AG, of which 88 performed in 2014 and 92 in 2013.

On the day of the accident, the pilot got up at 5 h 00 to perform a first flight between Courtrai and Cannes. He had taken off from Courtrai at 7 h 17 with the three passengers who were seated in the rear seats during the accident flight. He had landed at Cannes at 9 h 34.

1.6 Aircraft Information

1.6.1 Airframe

Manufacturer	Daher-Socata
Type	TBM700 (version B)
Serial number	N129AG
Registration	171
Year of manufacture	2000
Airworthiness certificate	N° DART111002EA on 20/12/2007 issued by the FAA
Airworthiness Review Certificate	29/08/2013 valid until 31/08/2016
Total utilisation	1,385 flight hours and 1,219 cycles

[4] FAR 61.31.

[5] The format of the licence found has not been in force since 2010.

The TBM700 is a single- turboprop single-pilot aeroplane manufactured by Daher-Socata. It has six seats, including that of the pilot. Its maximum certified takeoff weight is 2,984 kg (for versions A and B).

Its VMO is 266 KIAS. Exceeding this speed in flight triggers an aural warning in the cockpit and a recording in the engine's maintenance computer, called the ''*Shadin ETM*''.

The weight of the aeroplane at the time of the accident was about 2,500 kg. The stall speed of the aeroplane at this weight, with the wings flat in clean configuration is 70 kt.

The weight and balance of the aeroplane were within the limits defined by the manufacturer.

Two control wheels, placed in front of each front seat in the cabin, allow the pitch and roll of the aeroplane to be controlled. These two wheels are linked mechanically and each has an autopilot disconnection button. It is also possible to disconnect the autopilot by exerting force on the control column of 36 lbs in pitch or 26 lbs in roll.

The autopilot control system installed in the N129AG is of the Bendix King[6] "*KFC325 Flight Control System with EFS40/50*" type. The inputs commanded by the autopilot are transmitted to the flight control surfaces through four servo-controls (pitch, roll, yaw and elevator trim).

[6]Now Honeywell.

The aircraft's attitude information is measured by several computers, including ''*KVG350 vertical gyro*'' which supplies the precise information on pitch and roll. This computer checks the integrity of the speeds of the gyroscope and of the exit signals. It supplies a validity signal to the autopilot computer. If this signal indicates invalid information, the autopilot disconnects automatically. The autopilot also monitors the speeds of the KVG350 gyroscopes in order to disconnect if the speeds of pitch and roll variations exceed 5°/s and 10°/s respectively.

1.6.2 Engine and propeller

Manufacturer	Pratt & Whitney
Type	PT6A-64
Serial number	PCR-PM0049
Engine run time	1 385
Propeller	MT-Propeller MTV-37-1-E-C-F-R(P)/CFR225-55f
Propeller serial number	140231
Propeller run time	99

1.6.3 Maintenance

The last maintenance operation was undertaken at 1,286 flight hours (TSN 1286), in April 2014. It involved installation by Air Alliance GmbH of the MT Propeller 5 blades, new, in accordance with the supplemental type certificate (STC) n°SA02958NY.

In July 2014, an invoice was issued by Air Alliance GmbH concerning the planned replacement of the three oxygen generators. The operation was being planned.

The last programmed maintenance operation took place at TSN 1276 in February 2014 and included:

- an ''*A-check*'' - annual maintenance (100 h) of the aeroplane, and
- a 600 h overhaul of the engine.

In August 2004, the manufacturer Socata had issued Honeywell service bulletin SB KDC222-4 by service letter SL 70-036 22. This service bulletin deals with an evolution in the autopilot air parameter computer (KDC 222) which was aimed at reducing AP disconnection in light turbulence conditions (for vertical accelerations of the order of 1.6 g). This service bulletin was recommended in case of untimely AP disconnections. It applied to N129AG, but no modification had been requested by the owner.

1.7 Meteorological Information

At the time of the accident, an active disturbance was passing near Saint-Jean-les-Deux-Jumeaux. The rain was intense. The forecast chart for wind and temperatures at 10 h 00 forecast, at FL240, a wind coming from the west/southwest at 40 kt and a temperature of -26°C.

A study of the meteorological situation made by Météo France shows:

- a covered cloud base between 1,000 and 2,000 ft and a top between FL300 and FL340, with the greatly reduced oblique and horizontal visibility;
- a moderate risk of icing between FL120 and FL210;
- a high risk of icing between FL140 and FL180;
- a low risk of icing at FL240.

The observations[7] made at 12 h 00 and 12 h 30 at Roissy-Charles of Gaulle (LFPG) Airport, 35 km away, indicated rain, a cloud base at 1,600 ft, a temperature of 17°C to 18°C and visibility between five and seven kilometres.

[7] METAR LFPG 061000Z VRB11G25KT 5000 -RA FEW016 BKN050 BKN083 18/15 Q1015 NOSIG= METAR LFPG 061030Z 17012G22KT 120V180 7000 RA FEW016 BKN040 BKN083 17/15 Q1015 NOSIG=

1.8 Aids to Navigation

Not applicable.

1.9 Communications

The recording of the communications with ATC show that the pilot of the N129AG was in contact with Paris ATC from 11 h 37 min 09, announcing flight level FL240. Several routine communications on the turning points on the flight path and on changes of frequency were then recorded. The radio communications with N129AG from 12 h 19 min 12 were:

Time	Speaker	Messages
12 h 19 min 12	N129AG	We're overhead Charlie Lima Mike and request for a direct to Charlie Mike Bravo if possible.
12 h 19 min 18	Paris control	I'll call you back
12 h 19 min 22	Paris control	November one two nine Alpha Golf, heu for the direct contact heu Reims…, Paris one three five decimal five five zero bye bye
12 h 19 min 30	N129AG	Three five, five five zero
12 h 19 min 51	N129AG	One two nine Alpha Golf, overhead Charlie Lima Mike for direct to Charlie Mike Bravo?
12 h 21 min 07	Paris control	November Alpha Golf?
12 h 21 min 09	N129AG	(*)
12 h 21 min 11	Paris control	November Alpha Golf, bonjour, what are you doing?
12 h 21 min 15	N129AG	We have a problem (*)
12 h 21 min 17	Paris control	November Alpha Golf, call me back with your intentions
12 h 21 min 22	N129AG	(*)
12 h 22 min 14	Paris control	November one two nine Alpha Golf, Paris?

(*): Word or group of words not understood

All of the messages transmitted from N129AG came from one person only.

1.10 Aerodrome Information

Not applicable.

1.11 Flight Recorders

The aeroplane was not equipped with flight recorders. The regulation in force does not make it mandatory for aeroplanes with MMDC of less than 5,700 kg, like the TBM700.

It should be noted that, since 1st January 2016, TBM700s from serial number 1106 are equipped with flight recorders[8].

[8] L-3 Communications LDR1000 type.

1.12 Wreckage and Impact Information

The wreckage site was located at the bottom of a garden in the commune of Saint-Jean-Les-Deux-Jumeaux (77). All of the aeroplane's parts were grouped together at the site of the accident, which excludes an in-flight breakup.

The trees that were around the wreckage were about a dozen metres high. There was little damage to the vegetation. A tree was cut off at the left rear of the aircraft, about a dozen metres from the ground, another at right rear of the aircraft, at 7 metres from the ground (*see figure 2*).

Figure 2 : aerial view of the accident site, with positions of the damaged trees

The fuselage was damaged by bending along the longitudinal axis. The main rupture was in front of the main door, a second being more aft, on the tail fin root.

Figure 3 : view of the fuselage, left side

These distortions on the wreckage and the damage to the trees at the accident site showed that the aeroplane collided flat with the ground, along a flight path having an angle of about 30° in relation to the vertical.

1.13 Medical and Pathological Information

The occupants of the cockpit suffered fatal injuries on impact, the injuries being located on the upper part of the bodies.

An examination of the pilot's injuries showed that he was sitting in the left front seat.

The passenger sitting in the right front seat was a man aged 62. He was found in a bent over position, with his chest on his thighs, the head and shoulder line being under the instrument panel. His injuries were consistent with such a position and with vertically-oriented impact forces.

The three passengers seated in the rear seats survived the accident and mainly suffered traumatic brain injuries and fractures.

1.14 Fire

Not applicable.

1.15 Survival Aspects

The two occupants seated at the front were only wearing the lap safety belt at the time of the collision with the ground. The inertia reel belts that pass diagonally across the length of the torso were not used.

1.16 Tests and Research

1.16.1 Video

All of the witnesses stated that they saw the aeroplane come out of the clouds between 1,000 and 2,000 ft, turning flat towards the left.

A witness recorded the aeroplane's final flight path on his mobile phone for about five seconds. The images that made up this video sequence were exported by the BEA then adjusted to the same scale by taking into account the movements of the camera and the zooms used. These images were then superimposed to make the following picture:

Figure 4 : superimposed video images showing N129AG's flat spin

This picture shows the aeroplane falling in a flat spin, along a virtually vertical flight path. The altitude of the aeroplane on the first video image is about 1,000 ft. The average speed of rotation around the yaw axis during the sequence is about 60 °/s. The vertical speed was about -5 000 ft/min. Analysis of the images on which the aeroplane is seen in profile indicates a left roll angle of the order of 10° and a nose-down attitude of about 10°. On the last images, the roll angle decreased by about 5° and the pitch was between 0° and 5° nose down.

1.16.2 Wreckage examination

The examination of the propeller and of the engine showed that the latter was providing power at the time of the collision with the ground.

The examination of all of the flight controls showed that they were continuous.

The roll, rudder and pitch control surfaces were in the neutral position at the time of the collision with the ground.

The examinations of the autopilot servo-controls and their pulleys did not bring to light any malfunction likely to alter their operation.

The "*crash lever*", which allows the aeroplane's electrical generation to be cut off, was found in the down position (electrical generation cut off).

Figure 5 : crash lever

The control switches for the airframe de-ice system and of the inertial separator[9] were found on the OFF position at the site of the accident. However, the propeller de-ice system control switch was found in the ON position[10].

Figure 6 : icing control panel

The examination of the warning panel and of the autopilot mode selector did not make it possible to conclude whether the lights were on or off.

The ''*Shadin ETM*'' computer was found at the site of the accident. Its memory card, read out at the BEA, contained a VMO exceedance dated on 6 August 2014 at 12 h 20 min 50 s, at an altitude of 18,710 ft and a maximum indicated speed reached of 303 kt.

The examination of the pressurization system did not bring to light any malfunction likely to cause any cabin pressurization problem.

[9] The inertial separator is a system that allows the engine air inlet to be protected against the ingestion of ice, water and sand particles.

[10] This combination does not correspond to a procedure described in the manufacturer's manual: in case of icing, all of the de-ice systems must be in the ON position.

1.16.3 ATM data

The radar data from the CRNA Sud-Est and the CRNA Nord contained the accident flight. It made it possible to reconstitute the flight path in *figure 1* and to calculate the ground speeds and the vertical speeds.

The radar data recorded on the day of the accident show the presence of ten aeroplanes between 12 h 10 and 12 h 25 less than 20 NM from point ❷ on the flight path in figure 1 between FL200 and FL280. None of the crews of these aeroplanes reported any icing or turbulence in this zone. The separation between the flight paths of these aeroplanes makes it unlikely that there was any wake turbulence that might affect N129AG during the accident flight.

Spectral analyses were carried out on the last messages transmitted by the pilot. The low noise sensitivity of the headset microphones on board N129AG made it impossible to identify the engine rotation speed.

1.16.4 Flight and simulator tests

Some tests were carried out on a TBM700 training simulator to determine if control inputs could reproduce the flight path based on the radar data, as represented in *figure 1*.

The following sequence of inputs made in the flight simulator allowed the characteristics of the radar trajectory[(11)] to be reproduced, in terms of:

- ❒ turn radii;
- ❒ descent time between points ❷ and ❸;
- ❒ climb time between points ❸ and ❺.The moment passing point ❷ on figure 1 is noted as t0.

Time	Corresponding position on figure 1	Observations and inputs on simulator
t0-47 s	point ❶	Initial simulator conditions: FL240 stable in cruise, indicated airspeed 190 kt, wind 240° / 40kt
t0	point ❷	Inputs on the control column to set and maintain: ❒ a nose-down pitch of 20° and ❒ a right roll between 60° and 75°
t0+27 s		Altitude 19,500 ft Appearance of VMO warning Reduction in engine thrust towards IDLE
t0+47 s	point ❸	Altitude 15,000 ft Pull out by maintaining the roll and holding the control wheel with both hands
t0+50 s		Set of the maximum engine thrust Inputs on the control column to set and maintain: ❒ wings level ❒ nose-up pitch between 45° and 50°

[(11)] This is a sequence determined during tests; it is not necessarily the only sequence allowing the characteristics of the radar trajectory to be reproduced.

t0+65 s		Altitude 19,000 ft Appearance of stall warning
t0+70 s	point ❺	Climb stops (exit from the simulator's operational use)

The tests undertaken without reducing the engine power during the descent at the appearance of the VMO warning between points ❷ and ❸ or without adding power in the climb between points ❸ and ❺ did not make it possible to reproduce the radar flight path.

A test was made with one person seated in the right seat in the simulator cockpit who slumped onto the right side of the control wheel. This led to the autopilot disconnection button to be pushed and resulted in the beginning of a flight path similar to that of the accident.

In addition, the tests performed in the flight simulator cabin, which had the same dimensions as that of the aeroplane showed that:

- it is impossible for a person of weight and size similar to that of the passenger seated in the front seat during the accident flight to pass under the control wheel and the instrument panel by simply leaning straight towards, since the chest comes into contact with the control wheel, even with the seat completely back;
- it is possible but difficult to do, by passing the head between the pedestal console and the control wheel. In this case the control wheel very quickly blocks on the neck. With a person thus positioned, it is not possible to pull out with an amplitude of that of the accident.

In addition, real in-flight tests were performed in a TBM700 of the same type as that of the accident in order to observe the aeroplane's behaviour on disconnection of the autopilot without touching the control column with various flight control surface positions.

These tests showed that:

- if the roll trim and the rudder trim are set in neutral position, the aeroplane remains stable;
- if the roll trim is set to the left or right, then the aeroplane goes into an accelerated sharp turn dive in a few seconds towards the side the trim was moved;
- if the rudder trim is set to the takeoff position, the aeroplane goes into a turn to the right, but less rapidly than with the roll trim not in neutral.

1.17 Organisational and Management Information

1.17.1 Owner and operator of the aeroplane

The owner and operator of the aeroplane was Allan Thomsen and Co SA. The aeroplane was purchased in May 2006 by this company with registration D-FBOY. In October 2007 it was registered N129AG by an American company.

The passenger who was seated in the front right seat on the day of the accident was the Managing Director of the company. The pilot was the only pilot of the aeroplane. He was not working for Allan Thomsen and Co SA and was not paid to perform these flights.

1.17.2 Regulations on carrying flight recorders

The European regulation makes it mandatory to carry flight recorders on board aircraft used in Public Transport with an MCTOW above 5,700 kg.

For aeroplanes operated in general aviation, it is recommended by Annex 6 to the Convention on International Civil Aviation to carry flight recorders on board turboprop aeroplanes with MCTOW equal to or below 5,700 kg, whose number of the passenger seats is over five and whose first individual certificate of airworthiness was issued after 1st January 2016.

The European regulation does not make mandatory carrying flight recorders on board aeroplanes that are not « complex motor-powered aircraft » in non-commercial operations.

Note: A "complex motor-powered aircraft» is an aeroplane:

- *with a MCTOW over 5,700 kg, or*
- *certified for a maximum passenger seats configuration of more than nineteen, or*
- *certified to be operated by a minimum crew of at least two pilots, or*
- *equipped with one or more turbojets or more than one turboprop.*

The TBM is thus not a « complex motor-powered aircraft".

The subject of carrying flight recorders on board light aeroplanes (weight below 5,700 kg) is being studied by EASA through regulatory task RMT.0271 (In-flight recording for light aircraft). This task began in 2013 and is scheduled to come to fruition in 2016. The terms of reference of this regulatory task include eight safety recommendations already issued by European Safety Investigation authorities (including the BEA) aimed at introducing carrying flight recorders on board light aeroplanes.

1.18 Additional Information

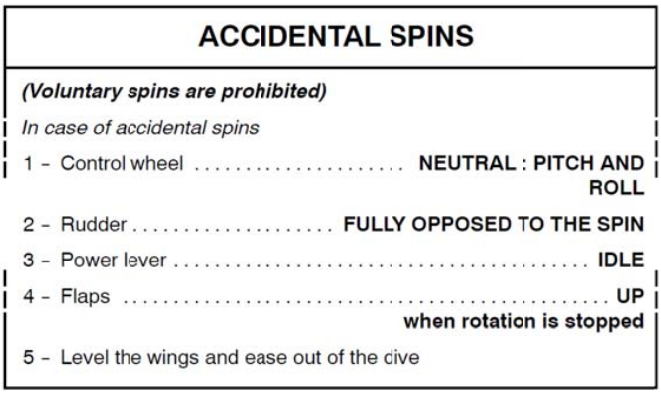
1.18.1 The accelerated sharp turn dive and the spin

The accelerated sharp turn dive is a turn during which the pitch evolves nose-down while the angle of attack increases. The speed then increases rapidly and the aeroplane descends in a spiral. The load factor is often near to 1 in this manœuvre. The recovery manœuvre consists of reducing the power, cancelling out the bank and pulling out smoothly. Recovering from an accelerated sharp turn dive spin is part of the training programme for a private pilot's licence.

The spin results from an angle of attack close to that of stall and an asymmetry. If the stall angle of attack is exceeded and the asymmetry maintained, then the aeroplane falls following a spiral flight path, slip and the angular speeds around the three axes can be high. Inadvertent entry into a spin can occur if visual references are degraded, during a flight in IMC for example.

No practical training for the spin is required to obtain a PPL, though theoretical training is planned.

The emergency procedure in the manufacturer's manual to stop a spin is as follows:



ACCIDENTAL SPINS

(Voluntary spins are prohibited)

In case of accidental spins

1 - Control wheel ..... **NEUTRAL : PITCH AND ROLL**

2 - Rudder ..... **FULLY OPPOSED TO THE SPIN**

3 - Power lever ..... **IDLE**

4 - Flaps ..... **UP when rotation is stopped**

5 - Level the wings and ease out of the dive

(Source : Daher-Socata)

Figure 7 : extract from the TBM 700 Operations Manual

A roll input against the bank during a spin, which can seem to be the natural instinctive reaction of a pilot not trained in spins, can maintain the spin.

If, during a spin, the pilot pulls back on the control column and maintains the pitch-up input and tries to counter the perceived rotation by using the ailerons against this rotation, the pitch increases, the yaw rate increases, then the spin flattens.

1.18.2 Accidents on high performance aeroplanes

In 2013, the BEA published a study on loss of control on fast single–engine aeroplanes[(12)]. The conclusion of this study underlined the need to highlight:

- training on the use of aeroplane with low speeds and during power variations (with and without external visual references);
- pilot awareness of the deterioration of the level of performance at the end of flight;
- pilot awareness of managing of his personal resources.

The 2014[(13)] aviation safety report published by the DGAC contains an article, written in collaboration with the BEA, on the accidents to high performance aeroplanes. This article identified eight fatal accidents that occurred in France between 2011 and 2014 to aeroplanes classified by EASA as high performance aeroplanes (HPA), including N129AG. The BEA initiated a safety investigation for each of them:

[(12)] See: https://www.bea.aero/uploads/tx_scalaetudessecurite/loss.of.control.on.fast.single.engine.turboprop.aircraft.en_04.pdf

[(13)] See: http://www.developpement-durable.gouv.fr/IMG/pdf/rapport_securite_2014.pdf

Date	Type	Reg.	Nb. fatalities	Phase of flight	Category	Circumstances
28/10/2011	PA31T	OE-FKG	4	Approach	LOC-I (*)	During the final ILS approach, which was started in IMC, to Toulouse Blagnac (31) Airport, the pilot lost control after saying that he had a problem at a height of about 900 ft.
09/11/2011	TBM700	N228CX	1	Go-around	LOC-I	During the arrival at Lyon-Bron (69) Airport (LOC-DME approach), the pilot started the final descent in the cloud layer well after passing the published final descent fix. During the missed approach, he lost control of the aeroplane.
28/08/2012	PC12	HB-FPZ	4	Cruise	LOC-I	While the aeroplane was beginning its descent at FL260 in unfavourable meteorological conditions (icing, cumulonimbus) and in IMC, the pilot lost control of the aeroplane, which broke up in flight.
04/03/2013	RA390	VP-CAZ	2	Takeoff	ICE/LOC-I	The aeroplane stalled due to the presence of frozen contaminants on the surface of the wings just after takeoff from Annemasse (74).
08/08/2013	TBM850	N850GC	3	Go-around	LOC-I	The pilot did not manage to stabilise his approach on the ILS axis at Clermont-Ferrand (63) in IMC conditions. He decided to make an approach. He lost control of the aeroplane.
24/09/2013	C421	N556MB	4	Takeoff	LOC-I	Witnesses stated that the aeroplane took off before it was halfway down the runway at Lyon-Bron (69), then that it climbed with a shallow slope up to about 200 ft in VMC conditions. The pilot lost control of the aeroplane, which collided with the ground.
19/11/2013	TBM850	N115KC	6	Cruise	LOC-I	In cruise at flight level 180, the crew was cleared to descend to flight level 120 en route for Toussus-le-Noble (78). The pilot lost control of the aeroplane in IMC and the radar data showed that the aeroplane had descended below the clearance level, then disappeared. The wreckage was found in a field.
06/08/2014	TBM700	N129AG	2	Cruise	LOC-I	The aeroplane was in cruise at FL240 in IMC, then descended suddenly in a right turn to FL150, climbed to FL200, before re-descending rapidly. The aeroplane struck the ground in a flat spin.

A ninth accident could be added to this list, which occurred on 22 March 2014 au TBM700 registered N702H in the Colorado (United States), which led to fatal injuries to the pilot and the four passengers. The preliminary report[14] published by the NTSB indicates that the aeroplane was on approach[15] to Montrose airport when the pilot informed the ATC controller that the aeroplane was in a spin and that he was trying to regain control. The aeroplane then crashed onto the surface of an artificial lake and sank.

All of these accidents were the losses of control in flight on single-pilot aeroplanes, and occurred in IFR. The majority of them occurred in IMC conditions. In total, 31 people were fatally injured during these nine accidents. Apart from the RA 390 registered VP-CAZ, none of these accident aeroplanes was equipped with a flight recorder. The investigations carried out into five of these accidents[16] showed that the absence of a flight recorder meant that it was not possible to determine with any degree of certainty the circumstances of these in-flight losses of control.

[14] See : http://www.ntsb.gov/_layouts/ntsb.aviation/brief.aspx?ev_id=20140322X03239&key=1

[15] N702H was likely in IMC during the loss of control, but it is also possible that it was between two cloud layers.

[16] N228CX on 09/11/2011, HB-FPZ on 28/08/2012, N850GC on 08/08/2013 (investigation ongoing), N556MB on 24/09/2013 (investigation ongoing), and N115KC on 19/11/2013 (investigation ongoing).

2 - ANALYSIS

2.1 Scenario

On the morning of the accident, the pilot got up early, at about 5 h 00, and made a flight with three passengers between Courtai and Cannes. The flight lasted about 2 h 30 min. After a stopover of about an hour in Cannes, the pilot took off, under an IFR flight plan, to return to Courtrai with four passengers: the three from the outbound flight and a man aged 62 who sat in the right front seat. This passenger did not have a pilot's licence.

The aeroplane climbed to flight level FL240. Cruise was performed at this altitude in a thick cloud layer, with a route towards the north-west. The aeroplane's flight path was stable in terms of speed, route and altitude until a point located about 25 NM east of Paris (point❷ on figure 1). This indicates that the flight was then likely performed on autopilot. Flight level FL240 presented a risk of light icing and the speed recorded on the radar during cruise was constant. This makes it unlikely that an icing problem occurred in cruise. In addition, the radio communications between the pilot and ATC recorded during cruise were normal and coherent, making unlikely a hypothesis of hypoxia problems on board the aeroplane.

After about 1 h 40 min of flight, the aeroplane descended suddenly, in a turn to the right. During this descent, the speed increased greatly and the VMO was triggered. Examinations undertaken on the flight controls and on parts of the autopilot did not bring to light any malfunction likely to affect their functioning. In-flight simulator tests also showed that a reduction in engine power at the triggering of VMO warning made it possible to reproduce the flight path of the accident flight as recorded on the radar. It is possible that the pilot did this, since he was the only person on board who knew how to fly and thus likely the only one able to identify this warning. He was thus probably conscious at that moment.

About forty-five seconds after the beginning of the fast descent, the aeroplane climbed back up to FL201, reaching a vertical climb speed of over 10,000 ft/min. The simulator tests showed that such a climb is possible by progressively applying pitch-up inputs of about 45° nose-up, by putting the wings level and by increasing engine power. Without these actions, the aeroplane would have continued to descend to the ground. These actions were likely taken by the pilot, since:

- he was the only person on board who knew how to pilot an aeroplane, and
- he was conscious at that moment. In fact, he transmitted two radio messages with a six second interval during the climb, one of which contains the phrase ''*We have a problem*''.

These actions were only possible if the occupant of the right seat in the cockpit did not interfere with the controls, and especially if he was not bent over under the control wheel and the instrument panel. If not, it is not possible to pull back on the control column to climb out with the same amplitude as that recorded on radar.

The speed fell during the climb until it reached the stall speed at around FL201, while the aeroplane was still in IMC conditions. The aeroplane then went into a spin, which flattened out during the descent. When the aeroplane came out of the clouds at an altitude between 1,000 and 2,000 ft, established in a flat spin, the height was insufficient to allow the pilot to take the necessary the actions to recover control of the aeroplane.

A short time before the collision with the ground, the crash lever was probably lowered, indicating that the pilot was preparing for the impact with the ground. In addition, the occupant of the right seat in the cockpit may possibly have bent forward with the intention of adopting a safety position.

2.2 Loss of Control in flight

After about 1 h 40 min of flying, while the aeroplane was in cruise at FL240 and in IMC, it descended suddenly, in a right turn. In the absence of any flight recorders, the investigation was unable to determine with certainty the reasons for this change of flight path. The following explanations are possible:

- One of the hypotheses, which the medical examinations could not exclude, was that the occupant of the right seat in the cockpit lurched on to the right part of the control wheel due to feeling unwell or drowsiness[17]. Such a lurch, made possible by not wearing the diagonal inertia reel belt across the torso, could have led to the disconnection of the autopilot, either by the head resting on the disconnection button, or due to the weight of the upper body on the control wheel which would exceed the effort necessary to disconnect the autopilot. Some tests on the flight simulator showed that the inputs on one of the control columns to set and maintain nose-down pitch of 20° and a bank of 60° for about 45 seconds generated a flight path similar to that recorded by the radar.
- An involuntary disconnection of the autopilot, for example following turbulence, with the roll trim set to the right and/or the rudder trim set to the take-off position. Flight tests have indeed shown that in this case, if the pilot does not touch the control column, the generated flight path would be similar at the beginning of the descent to the one noted on the accident flight radar trajectory. This scenario is unlikely since it implies that the trims were set at neutral before the collision with the ground, since the examination of the wreckage showed that this was their position at the time of impact.

[17] The three passengers at the rear stated that they were asleep during the flight.

A final hypothesis, highly unlikely due to the internal check logic of the input data in the autopilot system, would mean a flight path commanded by the autopilot, which would receive false attitude measurements and which would lead to the beginning of the descent in a right turn. The same erroneous information would then have been displayed on the instruments and the pilot would then have retaken control of the aeroplane to pull out at FL149.

During the climb after the pull-out, the aeroplane was flying at a rapidly-decreasing speed in a cloud layer that posed a risk of severe icing. The pilot had probably not activated the airframe de-ice system. It is not possible to determine if the aeroplane's wings were then contaminated by frost or ice, which would have increased the aeroplane's stall speed. Nevertheless, the high vertical speed of the aeroplane reduced the exposure time in this cloud layer, which makes it unlikely that there was significant ice contamination.

The aeroplane then stalled. This stall occurred in IMC conditions and thus without the pilot having any external visual references. It is thus possible that he had some difficulty in understanding the situation and identifying the aeroplane's unusual attitudes. The difficulty in identifying this may have been exacerbated by:

- the pilot's fatigue, who had got up early and who had already accumulated more than four flying hours during the day, and/or
- the stress generated by this situation which he had probably never encountered before.

The actions to perform to recover from a stall, if it is correctly identified mean levelling the wings, pushing the control column forward to reduce the angle of attack and regaining speed.

The aeroplane's flight path in a flat spin to the left in the last seconds of the flight is an established fact. However, to end up in a flat spin to the left, the aeroplane must previously have been in a spin to the left. This spin was probably the result of low speed, near to that of a stall, pulling back the control column to the rear and an input to the rudder to the left.

The actions to recover from this spin, that is to say with the control wheel in neutral, rudder to the right stop, reduced power and flaps retracted, depend initially on the fact that the pilot identifies the spin, and the direction of the spin. No practical training on spins is required to obtain a PPL. It is thus difficult for an untrained pilot to identify an involuntary spin. Identifying this with no external references is even more difficult, perhaps impossible, even for test pilots trained in this manoeuvre.

The pilot's actions in IMC during the descent down to 1,000 or 2,000 ft made it impossible to recover from the flat spin. Once out of the clouds, the remaining height was insufficient to regain control of the aeroplane and prevent the collision with the ground.

The investigation was not able to determine precisely the sequence of actions that led to the stall, the spin and the actions that the pilot may have made to recover from it. The presence of flight recorders would perhaps have made it possible to determine these actions.

2.3 Single-pilot flights in high performance aeroplanes in IMC

Note: the information in this section is taken from the 2014 aviation safety report published by the DGAC.

The use of high performance aeroplanes such as the TBM700 requires great thoroughness and structured work methods. Undertaking single-pilot flights, often in IMC and on complex aeroplanes leads pilots, even in a normal situation, to be faced with a high work load. In case of a failure or even not understanding an automated system, this work load increases rapidly and can quickly exceed the pilots' capacities.

Even if these uses are within the regulations, they are not necessarily safe. Experience, skills, fatigue and other factors can in fact alter a pilot's operational level.

To manage these constraints, crews in public transport generally include two pilots trained to fly together, one taking care of flight management and the other monitoring. This redundancy is a guarantee of safety, in particular in case of incapacity of one of them. They also usually benefit from a context and procedures defined by the operator which help them not to exceed their limits. In a context of private flights pilots' judgement, as well as knowledge of the limits of their skills, are essential so that instrument flights with a single-pilot HPA aeroplane occur safely.

3 - CONCLUSION

3.1 Findings

- The aeroplane had a valid certificate of airworthiness; it was maintained in accordance with the regulations.
- The aeroplane was within the weight and balance limits defined by the manufacturer.
- The pilot held a Belgian private pilot's licence issued in July 1988, and converted into an US private pilot's licence in 1993.
- The US private pilot's licence was not in the format in force at the time of the accident.
- The pilot had obtained his instrument flight rating in the United States in 1995.
- The pilot had obtained a SET TBM700 class rating in May 2006.
- The pilot held a valid class 2 medical certificate issued by the FAA.
- The pilot, accompanied by four passengers, took off from Cannes on 6 August 2014 at about 10 h 40 bound for Courtrai, under an IFR flight plan.
- Cruise was performed at FL240 in a thick cloud layer.
- After 1 h 40 of flight, the aeroplane descended, in IMC, in a right turn down to FL149. During this descent the VMO warning was triggered.
- Forty-five seconds after the beginning of descent, the aeroplane climbed, in IMC, up to FL201. During this climb, the pilot transmitted two radio messages, one of which contained the phrase ''*We have a problem*''.
- The aeroplane stalled near FL201, in IMC.
- The aeroplane descended again and entered a spin in IMC.
- The aeroplane was in a flat spin to the left in the last seconds of the flight, then collided with the ground in a virtually vertical flight path.
- The passenger seated in the right front seat was bent over with his chest on his thighs at the time of the collision with the ground.

3.2 Causes

During cruise in IMC, the aeroplane suddenly descended in a turn to the right for undetermined reasons. Inputs on the control column likely made it possible for the pilot to command the aeroplane to climb rapidly. The aeroplane then stalled and inappropriate actions of the pilot, probably intending to recover control of the aeroplane, led to a spin, then a flat spin.

The difficulty in identifying the spin and applying the appropriate inputs to recover from a spin, when there are no external visual references, made it impossible for the pilot to regain control of the aeroplane and to avoid the collision with the ground.

In the absence of flight recorders, the investigation was not able to establish the circumstances and causes of the accident with any certainty.

4 - 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 report to the authority in charge of safety investigations that have issued them, on the measures taken or being studied for their implementation, as provided for in Article 18 of the aforementioned regulation.

Carrying flight recorders on light aeroplanes

The aeroplane was not equipped with flight recorders. The European regulation in force does not require it for aeroplanes with a maximum certified takeoff weight of less than 5,700 kg, like the TBM700[(18)]. However, the presence of an image recorder, or otherwise a sound and parameter recorder would probably have made it possible to establish more precisely the circumstances of the accident, in particular the reasons for the sudden descent in cruise, the pilot's possible actions before and after the loss of control in flight and the state of the aeroplane's systems. In the absence of flight recorders, the causes of the loss of control in flight remain undetermined and the lessons learned from this accident remain limited.

[(18)]Even though the regulations do not yet make it mandatory, all TBM700s manufactured since 1st January 2016 have been delivered equipped with flight recorders.

For aeroplanes operated in general aviation, carrying on board flight recorders on turboprop aeroplanes with MCTOW equal to or below 5,700 kg, whose number of passenger seats is over five and whose first individual certificate of airworthiness was issued after 1st January 2016 is recommended by Annex 6 to the convention on international civil aviation on operation of aircraft.

The subject of carrying flight recorders on board light aeroplanes (weight below 5,700 kg) is being studied by EASA through regulatory task RMT.0271 (In-flight recording for light aircraft). This task began in 2013 and is scheduled to come to fruition in 2016. The terms of reference of this regulatory task include eight safety recommendations already issued by European Safety Investigation authorities (including the BEA) aimed at introducing carrying flight recorders on board light aeroplanes.

The investigation identified nine accidents between 2011 and 2014 involving high performance aeroplanes in which 31 people were fatally injured. The Safety Investigations carried out into five of these accidents, in addition to that of N129AG, showed that the absence of a flight recorder made it impossible to determine the circumstances and the causes of the accident with any certainty.

Consequently the BEA recommends that:

- **EASA add this accident to the TBM700 registered N129AG on 6 August 2014 at Saint-Jean-les-Deux-Jumeaux in the terms of reference for regulatory task RMT.0271. [Recommendation FRAN-2016-045]**

- **EASA require or promote the installation of on-board recorders on aeroplanes categorised as high performance aircraft (HPA), in accordance with the type of aircraft operation. [Recommendation FRAN-2016-046]**

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