MINISTRY FOR
INNOVATION AND TECHNOLOGY
TRANSPORTATION SAFETY BUREAU

FINAL REPORT

2016-082-4
accident

outside Valkó
25 March 2016

Tecnam P2002 JF
HA-VOE

The sole objective of the safety investigation is to reveal the causes and circumstances of aviation accidents or incidents and to initiate the necessary technical measures and make recommendations in order to prevent similar cases in the future. It is not the purpose of this activity to investigate or apportion blame or liability.

General information

This investigation has been carried out by Transportation Safety Bureau on the basis of

- 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 and repealing Directive 94/56/EC,
- Act XCVII of 1995 on aviation,
- Annex 13 identified in the Appendix of Act XLVI. of 2007 on the declaration of the annexes to the Convention on International Civil Aviation signed in Chicago on 7th December 1944,
- Act CLXXXIV of 2005 on the safety investigation of aviation, railway and marine accidents and incidents (hereinafter referred to as Kbvt.),
- GKM Regulation 123/2005. (XII. 29.) of the Ministry of Economy and Transport on the rules of safety investigation of aviation accidents and incidents and other occurrences
- NFM Regulation 70/2015 (XII.1) on safety investigation of aviation accidents and incidents, as well as on detailed investigation for operators,
- In absence of other relevant regulation in the Kbvt., in accordance with Act CXL of 2004 on the general rules of administrative authority procedure and service, and, as of 1 January 2018, in accordance with Act CL on General Public Administration Procedures.

The competence of the Transportation Safety Bureau of Hungary is based on Government Regulation 278/2006 (XII. 23.), and, as from 01 September 2016, on Government Regulation № 230/2016. (VII.29.) on the assignment of a transportation safety body and on the dissolution of Transportation Safety Bureau with legal succession.

Pursuant to the aforesaid laws,

- Transportation Safety Bureau Hungary shall investigate aviation accidents and serious incidents.
- Transportation Safety Bureau Hungary may investigate aviation and incidents which – in its judgement – could have led to more accidents with more serious consequences in other circumstances.
- Transportation Safety Bureau Hungary is independent of any person or entity which may have interests conflicting with the tasks of the investigating body.
- In addition to the aforementioned laws, the ICAO Doc 9756 and the ICAO DOC 6920 Manual of Aircraft Accident Investigation are also applicable.
- This Report shall not be binding, nor shall an appeal be lodged against it.
- The original of this report was written in the Hungarian language.

Incompatibility did not stand against the members of the IC. The persons participating in the safety investigation did not act as experts in other procedures concerning the same case and shall not do so in the future.

The IC shall safekeep the data having come to their knowledge in the course of the safety investigation. Furthermore, the IC shall not be obliged to make the data – regarding which the owner of the data could have refused its disclosure pursuant to the relevant act – available for other authorities.

This Final Report

was based on the draft report prepared by the IC and sent to all affected parties (as specified by the relevant regulation) for comments.

TSB Hungary organised a closing meeting on 5 December 2019, where the representatives of the following organisations attended:

- Aviation Risk Assessment Department, Ministry for Innovation and Technology
- CAVOK Aviation Training Ltd.

Copyright Notice

Translation

This document is the translation of the Hungarian version of the Final Report. Although efforts have been made to translate it as accurately as possible, discrepancies may occur. In this case, the Hungarian is the authentic, official version.

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Definitions and abbreviations

aerodrome	*Means a defined area (including any buildings, installations and equipment) on land or water or on a fixed, fixed off-shore or floating structure intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft*
AIAS	*Autoritatea de Investigații și Analiză pentru Siguranța Aviației Civile (AIAS) (from 29th August 2018) / Romanian Safety Investigation Agency*
ANSV	*Agenzia Nazionale per la Sicurezza del Volo / Italian Safety Investigation Agency*
ARP	*Airport Reference Point*
ATO	*Approved Training Organisation*
ATSB	*Australian Transport Safety Bureau*
CAMO	*Continuing Airworthiness Management Organisation*
CB	*Circuit Breaker*
CIAS	*Centrul de Investigații și Analiză pentru Siguranța Aviației Civile (till 29th August 2018)*
EASA	*European Union Aviation Safety Agency*
ELT	*Emergency Locator Transmitter*
GKM	*Ministry of Economy and Transport (Hungary)*
HDF	*Hungarian Defense Forces*
IC	*Investigating Committee*
ICAO	*International Civil Aviation Organization*
Kbvt.	*Act CLXXXIV of 2005 on the safety investigation of aviation, railway and marine accidents and incidents and other transportation occurrences*
LAPL	*Light Aircraft Pilot Licence*
LT	*Local Time*
MIT	*Ministry for Innovation and Technology*
MTOM	*Maximum Take-Off Mass*
NFM	*Ministry of National Development*
NTA AA	*National Transport Authority Aviation Authority, Hungary (till 31 December 2016)*

organisation	*An entity which operates the aircraft involved in an occurrence or provides its airworthiness on a continuous basis or provides training for its crew.*
PKBWL	*Paitstwowa Komisja Badqnia Wypadków Lotniczych / Polish Safety Investigation Agency*
PLB	*Personal Locator Beacon*
PPL(A)	*Private Pilot License (Aeroplane)*
pre-flight inspection[1]	*The inspection carried out before flight to ensure that the aircraft is fit for the intended flight*
QNH	*local atmospheric pressure adjusted for mean sea level*
RNSA	*Rannsóknarnefnd samgönguslysa / Icelandic Safety Investigation Agency*
SEP (land)	*Single Engine Piston Airplane (land)*
TSB	*Transportation Safety Bureau*
useful load[2]	*The total mass of fuel on-board, passengers, baggage, cargo and carry-on specialist equipment*
UTC	*Coordinated Universal Time*
VFR	*Visual Flight Rules*

[1] According to Article 2, section j) of Commission Regulation (EU) No 1321/2014
[2] JAA ATPL Training – Mass and Balance, Jeppesen Sanderson Inc., 2004

Summary of the occurrence

Occurrence class		accident
Aircraft	Manufacturer	Construzioni Aeronautiche TECNAM S.r.l
	Type	Tecnam P2002-JF
	Registration	HA-VOE
	Operator	CAVOK Aviation Training Ltd.
Occurrence	Date and time	25 March 2016, 17:00 LT
	Location	Outside Valkó (Figure 1)
Fatalities related to the occurrence:		2 persons
Extent of damage to the aircraft involved:		Destroyed

Each time indicated in this Report is local time (LT). At the time of the occurrence: LT= UTC+1 hours.

All geographical coordinates in this Report are according to the WGS-84 survey.

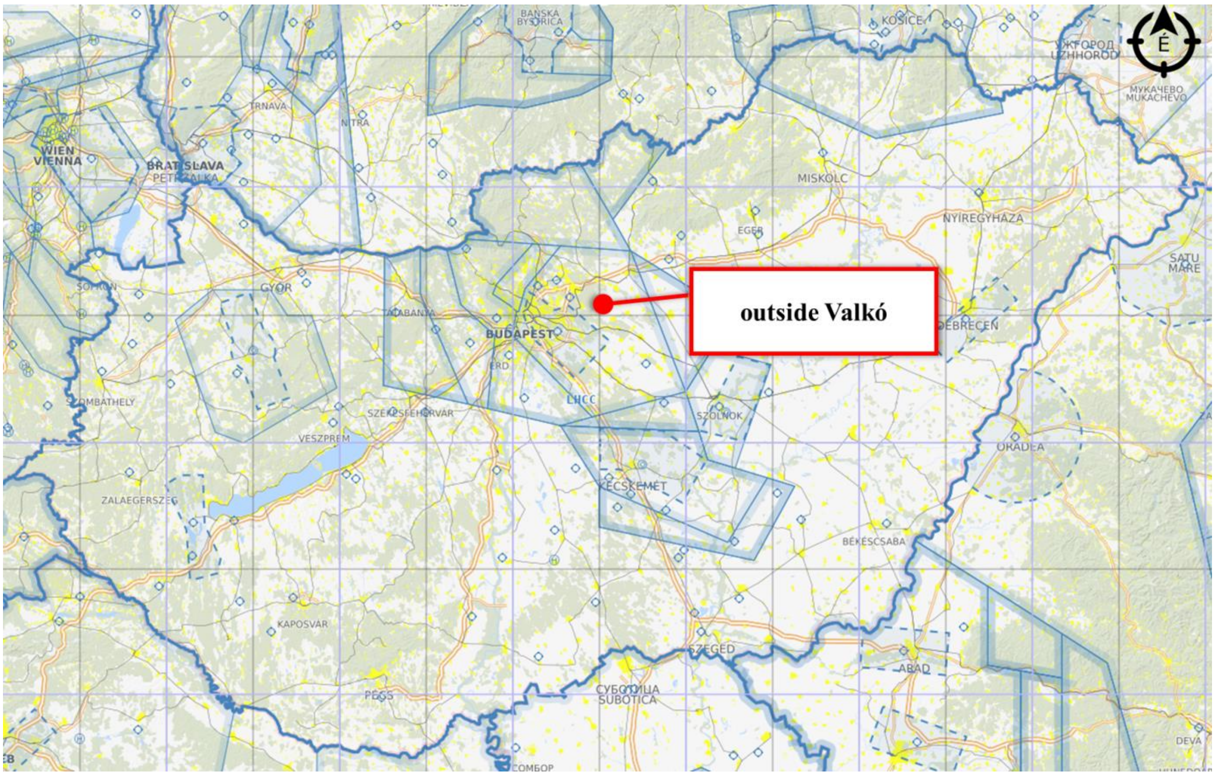


Figure 1: Location of the occurrence in Hungary

Reports and notifications

The occurrence was reported to the duty service of TSB on 25 March 2016, at 19:28, by a staff member of Gödöllő Aerodrome. The aircraft was found outside Valkó village on 26 March 2016, around 7 o'clock am.

TSB Hungary notified:

- the investigating organisation (ANSV) of the state of the designer, on 27 March 2016
- the investigating organisation (CIAS) of the state of the manufacturer, on 27 March 2016
- European Aviation Safety Agency, on 10 May 2016.

After the notification, the following notified foreign organizations assigned and authorised representatives for the investigation:

- Italian investigating organisation - Agenzia Nazionale per la Sicurezza del Volo (ANSV)
- Romanian investigating organisation (CIAS)

Investigation Committee

The Head of TSB assigned the following investigating committee (hereinafter referred to as IC) to the investigation of the case:

Investigator-in-charge	**Zsigmond Nagy**	Investigator
Member	**Ferenc Kamasz**	Investigator

Overview of the investigation process

During the investigation, the IC:

- viewed the scene of the occurrence on 26 March 2016;
- TSB seized the wreck and had it carried to its hangar in Tököl;
- viewed the wreck of the aircraft again at the hangar of TSB in Tököl on 1 April 2016;
- obtained the radar image relating to the presumed period of the flight of the HA-VOE aircraft from the competent air traffic management service;
- requested and received the autopsy report;
- viewed the wreck of the aircraft again at the hangar of TSB in Tököl in a joint effort with ANSV on 18 May 2016;
- on 7 June 2016, in Rome, Italy, had a meeting, organized by ANSV, with representatives of the manufacturer of the aircraft and representatives of the Polish and Icelandic investigating bodies, focussed on earlier accidents involving the aircraft type Tecnam P2002-JF;
- requested the manufacturer of the aircraft to perform a flight test with the type Tecnam P2002-JF aircraft, and used the test results for the investigation;
- participated in a discussion relating to the type Tecnam P2002-JF aircraft with EASA and RNSA in June 2018;
- performed detailed inspection of the fuel cock and the rpm meter found on the spot, and used the results for the report;
- received, in writing, the modifications made in the procedures of the operator of the aircraft following the occurrence, on 25 February 2019;
- co-operated with the investigating bodies of Poland and Iceland;
- performed a survey at the site at Gödöllő Airfield of the operating organisation of the aircraft involved in the accident, on 19 November 2019.

Short summary of the occurrence

On 25 March 2016, soon after half past four pm, a pilot and a passenger took off in the type Tecnam P2002-JF aircraft with reg. № HA-VOE (Figure 2) from Gödöllő airfield. After the first turn of the left traffic circle following the take-off, the transponder signal of the aircraft disappeared from the radar screen of the competent air traffic management service.

As the aircraft still had not returned to the aerodrome by shortly before sunset, the operator notified the police of a potential aviation incident. The lost aircraft, with the two casualties in it, was identified by a search & rescue helicopter of the Hungarian Defence Forces between Dány and Valkó villages in the morning on 26 March 2016, the day after.

The IC attributes the cause of the accident to the pilot's loss of control over the aircraft. The problems originating in the organisational and safety culture identified with the organisation operating the aircraft directly contributed to the occurrence.

Taking into account the actions taken by the operator of the aircraft involved in the accident, the IC proposes no safety recommendation.

Figure 2: The reg. HA-VOE aircraft prior to the accident (source: internet)

1. Factual information

1.1. History of the flight

On 25 March 2016, six flight tasks were scheduled for the Type Tecnam P2002-JF reg. HA-VOE aircraft by the organisation involved in the occurrence. After those flights ended, the tanks of the aircraft were refuelled, full up, according to the entry in the fuel refill log.

Subsequently, the pilot took off for a private flight, with a passenger on board, in the reg. HA-VOE aircraft. Before takeoff, the pilod told one of the people staying at the airfield that "*they would go just around here*". According to the on-board flight log entry, the pilot flying the aircraft last before the take-off ending up in accident transferred the aircraft with the engine hour counter displaying 929.7. The pilot involved in the accident made no entry in the on-board flight logbook (including CG calculation) prior to take-off.

Following the take-off from Runway 31 Gödöllő airfield, the transponder signal of the aircraft appeared on the radar screen of the competent air traffic management service at 16:43:49, and disappeared from the screen 32 seconds later, at 16:44:21. In that moment, the flight altitude was 1400 feet (427 metres) (Figure 3).

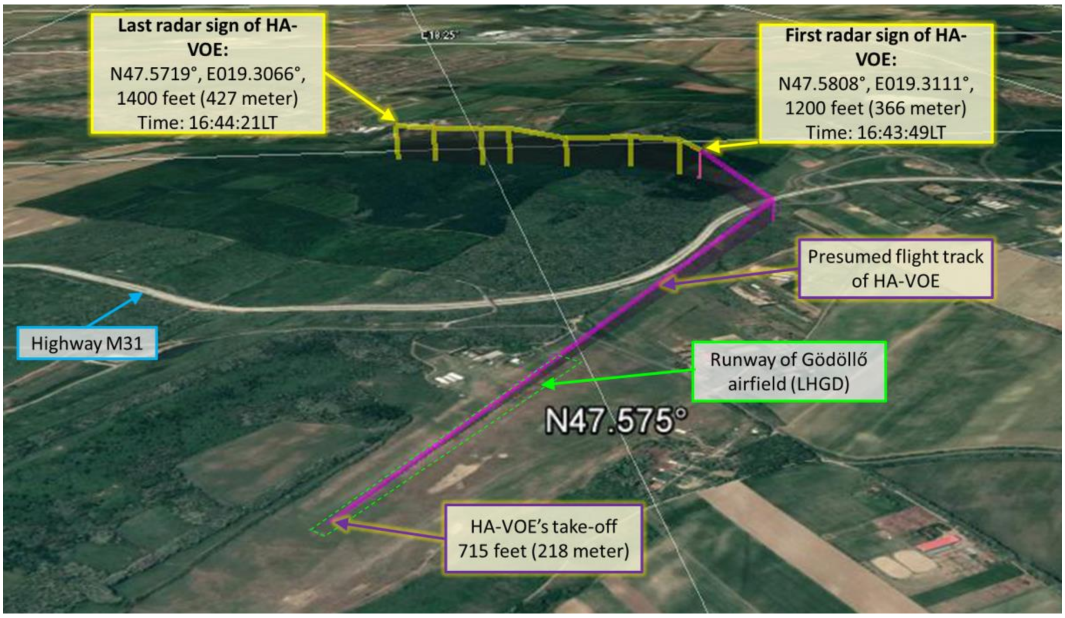


Figure 3: The flight path of the reg. HA-VOE aircraft as recorded by the radar (source of map: Google Earth)

Shortly before sunset, the operator of Gödöllő airfield and the operator of the aircraft realised that the aircraft still had not returned to the airfield. After failed efforts to establish contact by radio and mobile telephone, the operator of the aircraft and the personnel of the airfield notified the police of disappearance of the aircraft.

The search & rescue units identified the wreck of the missing aircraft on 26 March 2016 at about 7 am. The scene of the accident was in a direction of 107° and ca. 15 km of the last radar signal recorded, ca. 13 km of Gödöllő airfield. (Figure 4).

In absence of flight data, the IC had no chance to fully reconstruct the flight path of the aircraft following its disappearance from the radar. Based on data in the engine hour counter found at the scene and data in the on-board logbook of the aircraft, the engine of the aircraft ran 0.3 to 0.4 hours (18 to 24 minutes) during the flight involved.

Inspection of the wreck suggests that, at the moment of ground impact, the attitude of the aircraft showed a steep angle to the ground, and a slight left bank.

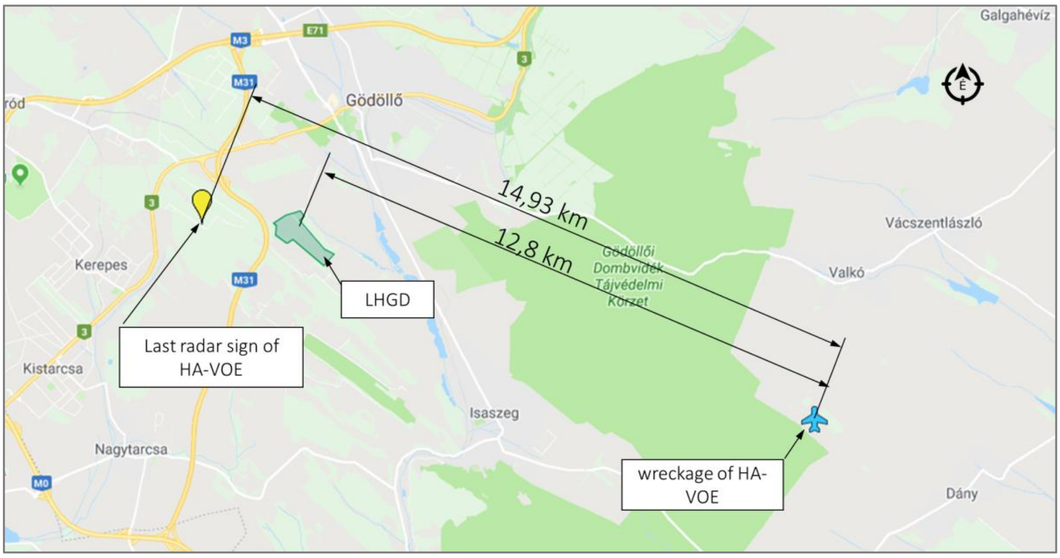


Figure 4: The last radar signal position and the location of the wreck

1.2. Injuries to persons

Injuries	Crew		Passengers	Others
	Pilot	Cabin		
Fatal	1		1	
Serious				
Minor				
None				

1.3. Damage to aircraft

The aircraft was destroyed in the accident. Upon ground impact, the nose part of the fuselage crumpled up as far as the seats.

Figure 5: Damage to the airframe

The main landing gears were found almost intact, fastened to the fuselage. The fuselage buckled behind the trailing edge of the wings and right in front of the stabilisers. The stabilizers suffered minor damage but stayed in place (Figure 5); the flap broke off the left wing and collided hit the horizontal stabilizer. The frame of the canopy separated from the fuselage and fell over the right wing tip. Each major structural element and spoiler of the aircraft was found in the vicinity of the impact.

During the on-site inspection, the IC found no sign of erroneous assembling in the controls of the aerodynamic control surfaces, all of them were properly fitted fastened and secured. Such controls were damaged as a consequence of ground impact.

The left wing of the aircraft broke into two, and a significant part of the leading edge (from the wing tip towards the fuselage) showed the marks of ground impact. The right wing was damaged all along its leading edge, and it was moved forward slightly (Figure 6).

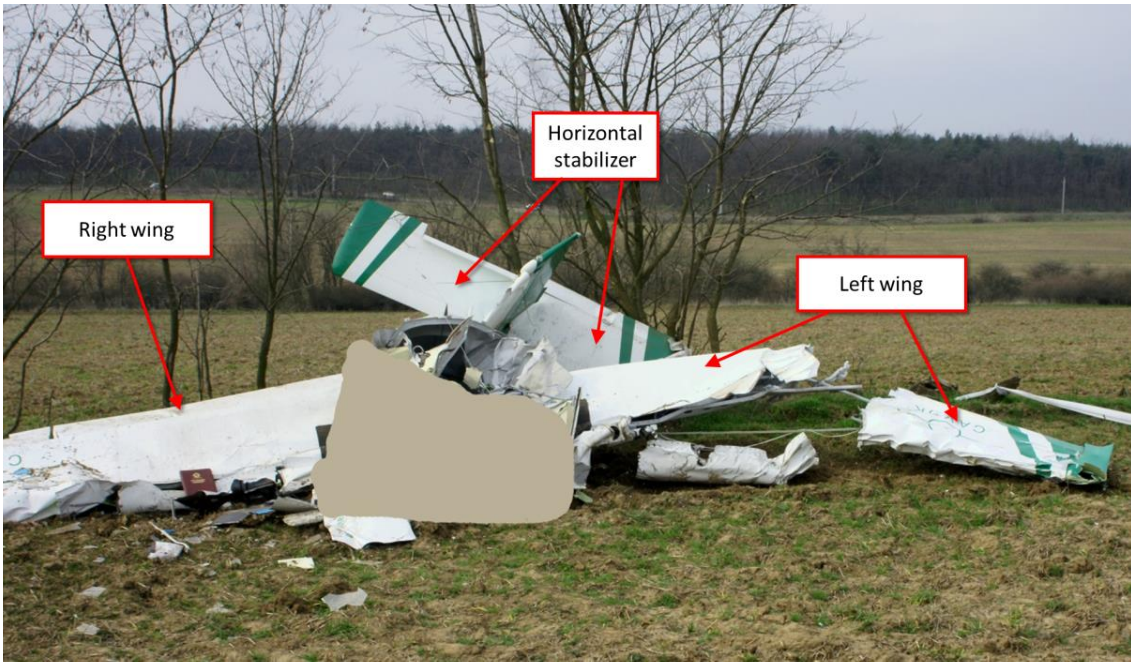


Figure 6: Damage to the wings

The aileron and the flap were separated from the left wing; the joints of these control surfaces remained intact on the right wing. The connections between the two wings and the aircraft were intact. The flaps were retracted at the moment of ground impact.

The engine and the propeller got stuck into the ground to a depth of 60 to 70 cm. One of the rotor blades broke into smaller pieces, while the other broke off the hub and remained almost whole (Figure 7). The nose landing gear broke off due to the impact, and gut trapped under the fuselage.

Figure 7: Damage to the propeller

The marks suggest that all the damages of the aircraft occurred during ground impact.

The IC found the panels of the automatic circuit breakers (CB) of the aircraft, but the components installed in them broke out during the crash (Figure 8). Due to the damage caused to the panels by ground impact, it was impossible to check the pre-crash positions of the circuit breakers.

Figure 8: The damaged CB panel

The IC found no proof of any malfunction of the structure or any system of the aircraft prior to ground impact.

1.4. Other damage

The IC had got no information on other damage by the completion of the investigation.

1.5. Personnel information

1.5.1. Data of the pilot in command

Age, nationality, gender		18 years, Hungarian, male
Licence data	type	PPL(A)
	professional valid until	30th November 2017
	ratings	SEP (land)
Certificates		private pilot
Medical class and valid until		Class 1: 29 June 2016 Class 2 and LAPL: 29 June 2020
Flying hours/take-offs	in the previous 24 hours	42 minutes / 1 take-off
	in the previous 7 days	11 hours 52 minutes / 43 take-offs
	in the previous 90 days	25 hours 58 minutes / 85 take-offs
	total:	86 hours 13 minutes / 405 take-offs
Aircraft types flown:		P2002-JF, AT-3, Cessna C-172

Information on the pilot's flight experience:

- The pilot performed his training and flights exclusively in type Tecnam P2002 aircraft from 14 June 2015 to 14 November 2015.
- The pilot acquired his PPL(A) licence on 14 November 2015.
- The pilot performed his flights exclusively in type AT-3 aircraft between 25 November 2015 and 03 December 2015.
- The pilot performed his flights exclusively in type Tecnam between 18 February 2016 and 13 March 2016.
- Between 19 March 2016 and 21 March 2016, the pilot flew a type Cessna C-172 aircraft on 8 occasions, 7 hours and 04 minutes in total (36 take-offs.)
- On 24 March 2016 (the day preceding the day of the accident), the pilot performed one take-off in a type AT-3 aircraft; the flight lasted 42 minutes.
- In summary, it may be concluded that the pilot performed many of his flights in type Tecnam P2002 aircraft.
- However, the pilot was engaged in conversion training on the week preceding the accident, so he performed almost all his flights in a type Cessna C-172 aircraft.
- The pilot had a flight experience of 9 months at the time of the accident.

1.6. Aircraft information

1.6.1. General information

Class	Fixed wing aircraft (MTOM<5700kg)
Manufacturer	Construzioni Aeronautiche TECNAM S.r.l.
Model	Tecnam P2002-JF
Year of manufacture	2007
Serial number	070
Nationality and registration marks	HA-VOE
State of registry	Hungary
Date of registry	09 March 2015
Name of the owner	CAVOK Aviation Training Ltd.
Name of the operator	CAVOK Aviation Training Ltd.

	Flight hours	Take-offs
Total	3181	unknown
Since last inspection[3]	22.3	108

[3] 50 hours inspection carried out on 20 March 2016

1.6.2. Airworthiness Certificate

Airworthiness Certificate	Number	FD/LD/NS/A/627/2/2015
	Date of issue	09 March 2015
	Valid until	Until withdrawal
	Restrictions	None

Airworthiness Review Certificate	Number	FD/LD/NS/A/1891/1/2015
	Date of issue	12 May 2015
	Valid until	16 May 2016
	Date of latest review	12 May 2015

1.6.3. Engines

Category	4-cylinder piston engine with opposed cylinders, with integrated gearbox and torque damper
Engine manufacturer	Bombardier Rotax GmbH.
Type	Rotax 912 S2
Serial number	4.923.782
Hours / cycles flown	
Total	1578 hours (during the maintanance on 20/03/2016)
Since last inspection	22.3 hours

1.6.4. Data of propellers installed on the engine

Category	fixed pitch, wooden propellers
Engine manufacturer	Hoffmann Propeller
Type	HO17GHM A 174 177 C
Number of blades	2
Propeller diameter	1740 mm

Propeller data did not influence the course of events, so it needs no detailed discussion.

1.6.5. Aircraft loading data

In order to determine the mass and centre of gravity (CoG) of the aircraft at the time of the occurrence, the IC:

- used the record of the last centre of gravity inspection of the HA-VOE aircraft,
- obtained earlier fuel refill logs of the aircraft,
- computed fuel consumption, taking into account data in the flight manual as well as earlier refuelling and flight data,
- determined the running time of the engine during the flight ending up in accident on the basis of the final reading of the engine counter at the end of the last uneventful flight as recorded in the flight logbook and the reading displayed at the time of the accident (Chapter **Hiba! A hivatkozási forrás nem található.**),
- took into account the body weights of the victims on the basis of data in the autopsy report relating to the pilot and the passenger (Chapter **Hiba! A hivatkozási forrás nem alálható.**),

– regarded the time that had elapsed between actual engine start and the take-off as 0.1 hours (6 minutes).

Empty mass	368 kg
Maximum useful load	212 kg
Pilot, passengers and other load[4]	115kg + 124kg + 5kg = 244 kg
Centre of gravity at the time of the occurrence	within limit (Figure 9)
Permissible position of the centre of gravity	26% - 32,5%
Type of fuel	gasoline 95
Total capacity and mass of fuel tanks	100 litres, 72 kg
Fuel consumption	18 litres/hour
Fuel on board at take-off	98.2 litres, 70.7 kg
Aircraft mass at engine start-up	676.8 kg
Fuel on board at the time of the occurrence	appr. 94.6 litres, 68.1 kg
Aircraft mass at the time of the occurrence	appr. 680 kg
Maximum take-off mass (MTOM)	580 kg

At the time of the engine start before the flight ending up in accident, the mass of the HA-VOE aircraft exceeded the maximum limit by 104 kg; its centre of gravity was within the specified limits. In order to determine the mass and centre of gravity at the time of the accident, the IC calculated the centre of gravity according to the flight manual of the HA-VOE aircraft (Figure 9). The calculation results show that that the centre of gravity was within the specified limits, and the total mass of the aircraft exceeded the specified upper limit by 100 kg. The IC did not find any document, neither on-board nor at the airport of take-off, which would have proven that the pilot had performed pre-flight checks of the aircraft or calculations of the mass and CoG.

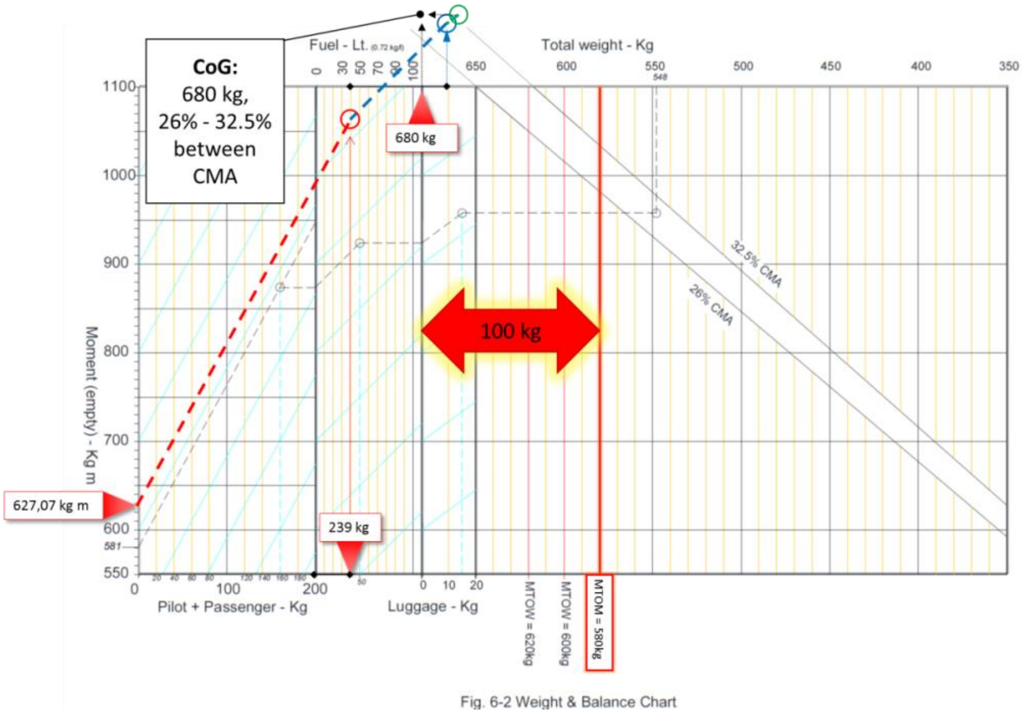


Figure 9: calculation of the mass and CoG at the time of the accident

[4] according to chapter 1.13

1.6.6. Description and data of malfunctioned system or equipment

No information emerged during the investigation on malfunction of the structure or any system of the aircraft prior to the occurrence, thus contributing to the occurrence or influencing the course of events.

1.7. Meteorological information

At the time of the occurrence, there was a long weather front system reaching from Scandinavia to the Carpathian Basin, with a lot of clouds and scattered rains along it. The weather in the Carpathian Basin was determined by a cold drop.

On 25 March 2016, cloudiness increased first in the Western Transdanubian region, and then in more and more areas. Rain occurred only near the western border of Hungary until the evening. Peak temperatures varied between 9°C and 13°C. At night, the sky was very cloudy or overcast all over the country, with scattered rain, except for the Great Plain. The air cooled to values between 0°C and 7°C by the next dawn.

According to the meteorological telegram issued at Budapest Liszt Ferenc International Airport, the weather was as follows (*METAR LHBP 251600Z 23008KT CAVOK 10/M02 Q1014 NOSIG=*):

- wind: from 230°, at a speed of 8 knots;
- visibility: ≥10 km;
- cloud base: above 1500m;
- air temperature: 10°C; dew point: -2°C;
- QNH value: 1014hPa.

1.8. Aids to navigation

The equipment items specified in the airworthiness certificate were installed on the aircraft, and the IC made or received no comment relating to irregularity of their operation.

The navigation equipment did not influence the course of events, so it needs no detailed discussion.

1.9. Communications

The equipment items specified in the airworthiness certificate were installed on the aircraft, and the IC made or received no comment relating to irregularity of their operation.

During the flight, the pilot of the aircraft did not establish contact with the competent air traffic management service. The pilot filed no flight plan before the flight.

The communication equipment did not influence the course of events, so it needs no detailed discussion.

1.10. Aerodrome information

The aerodromes involved in the occurrence had valid operation licences.

Name of aerodrome	Gödöllő Airfield
Location indicator	LHGD
Airport operator	Sky Escort Hungary Aero Club
Reference point (ARP)	47°34’25”N 19°19’57”E
Elevation	715 feet (218 m)
Runway identification	13/31

Runway length	1350x60m
Runway surface	grass
Type of traffic permitted	VFR – Day

The accident took place outside of the aerodrome and urban areas, in an agricultural land. The parameters of the aerodromes did not influence the course of events, so they need no detailed discussion.

1.11. Flight recorders

No data recorder was installed in the aircraft; it is not required for the aircraft type affected.

During the investigation, the IC obtained recorded radar data from the air traffic management service; such data shows that the transponder signal of the HA-VOE aircraft appeared on the screen at 16:43:49 and disappeared 32 seconds later, at 16:44:21 (Annex 2). The transponder signals issued by the aircraft were not available to the radar for the rest of its flight.

The radar data recorded indicates a primary radar signal at 17:07:45 at the location with coordinates N47°31’40” E019°34’39”; it was detected for 12 seconds, and disappeared at the location with coordinates N47°32’27” E019°35’11”. The radar processing system of the air traffic management service associated a ground speed of 44 knots to such primary radar signal (Figure 10).

The nearest ground-based radar (used by the competent air traffic management service) located to the scene of the accident is at Liszt Ferenc International Airport. The highest point of the Gödöllő Hills between the ground-based radar and the spot of disappearance (N47°34’19”, E019°18’24”, 427 metres) of the transponder signal is 310 metres, i.e. the radar had direct line of sight on the aircraft.

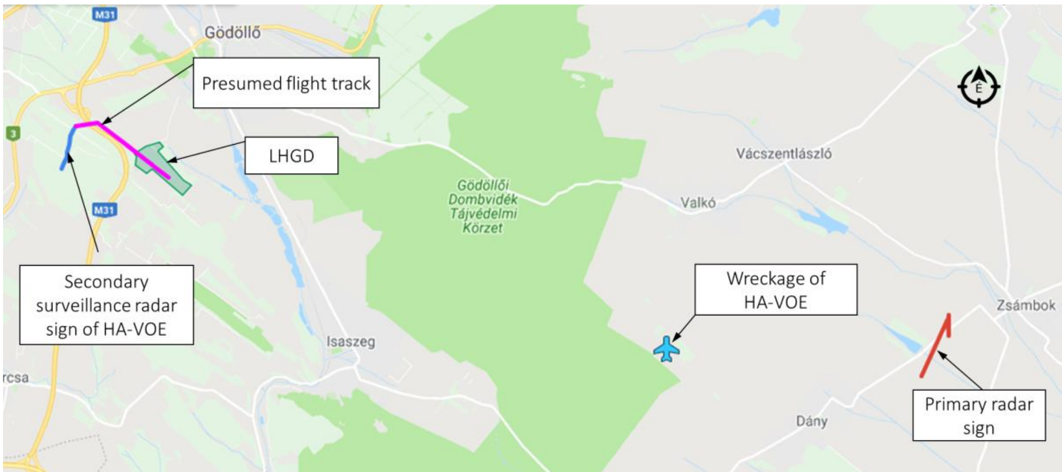


Figure 10: Sections of the flight path recorded on the basis of primary and secondary radar signals (source of map: Google Maps)

1.12. Wreckage and impact information

Damages to the aircraft are described in detail in Chapter 1.3. The wreck was found (geographical coordinates: N47°32'2.40", E19°29'49.44") next to a small clump of trees in the middle of a slightly sloped arable land parcel sized cca. 1180 x 210 metres.

On the basis of the damages to the aircraft, the on-board instruments, the impact marks and the fractures of the tree branches, the IC concluded that the aircraft had impacted the ground from a steep fall, along a path with an angle of 65° to 85° to the ground, in a steep tilt angle (with its nose pointing downward) (Figure 11).

Figure 11: Determining the angle of impact

Due to the impact, the airspeed indicator of the aircraft suffered damages such extent that its indicator preserved the value displayed at the moment if the impact (Figure 12). The instrument reading was 90 knots (*166.68 km/h*).

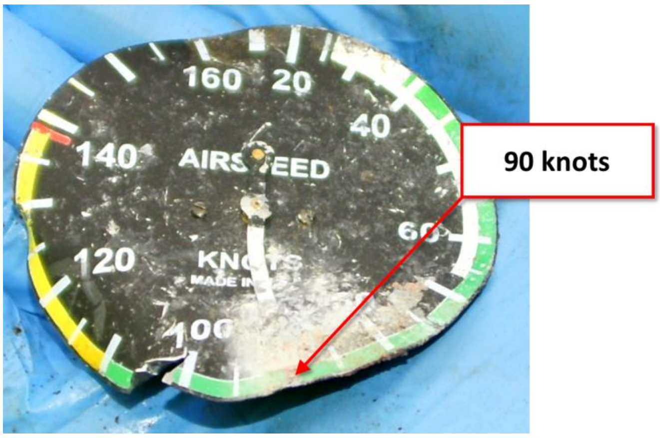


Figure 12: The airspeed indicator with its hand fixed

On the basis of the damages of the wreck and the impact marks seen in the ground, the IC concluded that the aircraft had not slid on the ground, i.e. the horizontal speed of the aircraft must have been insignificant, but the impact speed had almost been of vertical direction. After the propeller and engine of the aircraft stabbed into the ground and the fuselage decelerated, the wings went on forward due to inertial forces, and crashed to the ground with their leading edges. Upon impact of the aircraft, the tail also cracked in two places, due to inertia of the stabilisers. The stabilisers were not displaced in lateral direction significantly on the cracked tail. The objects fallen out of the flight cabin were found right of the fuselage; the frame of the canopy separated from the fuselage and was projected over the right wing tip. On the basis of the impact marks, the IC concludes that the aircraft was rotating to the left around both its vertical and longitudinal axes.

1.13. Medical and pathological information

According to the forensic toxicologist's report, chemical testing of the pilot's blood sample indicated no sign of any drug or psychotropic substance. Based on measurement on not uncertified weighing scales, the pilot's body weight was 115 kg, and the passenger weighed 124 kg. The pilot's quantitative mean carbon dioxide haemoglobin value was 9.7 rel. %.

There was no evidence that physiological factors or other impediments had affected the legal capacity of the personnel concerned.

The cause of death of both occupants of the aircraft was traumatic shock caused by multiple bone fractures and soft tissue injuries – which affected several parts of the body and had unsurvivable combined effect – suffered during the accident.

1.14. Fire

There was no fire in connection with the occurrence.

1.15. Survival aspects

According to the police report available to the IC, the police forces arrived at the airfield in Gödöllő at 19:50 o'clock. Upon arrival, the police unit was given the information by the operator of the aircraft that the outgoing call to the pilot's mobile phone got no ringing tone anymore, but the passenger's mobile phone was still available.

According to data from Operations Centre Veszprém, Air Command and Control Centre HDF, the aircraft was flying in southwest direction after its take-off, and it emitted the last transponder signal at the coordinates N47°34′29″ and E19°18′26″. On the basis of the information received, the police directed research activity to that location.

At about 10 o'clock pm, ground-based search was completed with a helicopter of the Rapid Response and Special Police Service which searched forest areas using infrared camera. At about 11 pm, the commander of the police helicopter reported they had found no crashed aircraft in the area searched. In the meantime, the police contacted mobile telephone service providers in order to obtain cell data of the mobile phones of the missing persons. The data they received showed that, in addition to the mobile phone relay stations in Gödöllő, the missing persons' phones had been connectable through relay stations in Tápiószecső and Kóka on several occasions (Figure 13). After evaluation of such data, the police expanded the search area to areas southeast of the aerodrome. Rescue activity was temporarily suspended at 00:30 am.

Figure 13: Wreck of the HA-VOE and locations of mobile phone relay stations

Soon after sunrise in the morning of the day after the day of disappearance of the aircraft, several civil aircraft took off from Gödöllő Airport in order to find the missing aircraft. The police continued their search activity involving also a search & rescue helicopter of Szolnok Helicopter Base № 86, HDF. After taking off in Szolnok, the search & rescue helicopter started search in the district of Tápiószecső and Kóka villages on the basis of the clues given by the mobile phone service providers. Before reaching the target area, the search & rescue helicopter received a call through the relevant air traffic information frequency according to which a powered aircraft that had taken off from Gödöllő had probably found the wreck of the missing aircraft 5 km northwest of Dány village. The search & rescue helicopter found the aircraft and the missing people in the specified area at 7 am. Upon arrival, the medical professional of the search & rescue team could not do more than establish the fact of their death.

The scene of the accident was in a direction of 107° and ca. 15 km of the last radar signal recorded, and ca. 13 km of Gödöllő airfield.

In order to evaluate survivability of the ground impact, the IC determined the deceleration forces acting at the moment of the ground impact. Based on such calculations, the people on board suffered a deceleration of ca. 600 m/s^2 during the impact. Comparing the results of the calculations of the IC to the results published in a study[5] of the US investigation organisation[6], it may be stated that the impact was not survivable. Both occupants of the aircraft suffered fatal injuries upon impact. The lives of the pilot and passenger of the aircraft could not have been saved even by immediate medical intervention.

During posterior inspection, the IC found an emergency locator transponder (ELT) remote control integrated into the dashboard, but neither ELT nor personal locator beacon (PLB) was found at the scene or during subsequent inspections. According to its radio licence, the HA-VOE was not equipped with ELT device.

1.16. Tests and research

1.16.1. Inspection of controllability of the aircraft

In order to understand the flight characteristics of the aircraft type Tecnam P2002-JF during flight with high angle of attack, the IC requested the manufacturer of the aircraft to perform a test flight including near-stall-angle conditions. The test result received from the manufacturer showed that, if within the weight limit, the aircraft carrying two occupants was not prone to stall during flight with a near-critical angle of attack, and it remained controllable along each of its axes.

The Polish investigating organisation (PKBWL) performed further test flights with the type Tecnam P2002-JF aircraft, with various performance parameters, in order to map critical flight characteristics of the model. According to the position of PKBWL, when stall is performed with low engine performance, the aircraft can be manoeuvred easily, and the critical flight situation can be resolved by applying appropriate steering manoeuvres. However, when stall is performed with high engine performance, the aircraft may fall into a spin, in connection which PKBWL intends to issue a safety recommendation, according to information available to the IC at the time of issuing this Final Report.

1.16.2. Detailed inspection of the aircraft and the gearbox of the propeller

On 01 April 2016, the IC performed a posterior inspection of the wreck in the hangar of TSB in Tököl with the help of the operator’s personnel, in presence of representatives from the competent police headquarters and the forensic expert appointed by the police. The structure of the aircraft, the steering control systems, and the engine and its subsystems were inspected, and the propeller gearbox was opened for further inspection (Figures 14 and 15).

Prior to opening the propeller gearbox, the spark plugs were removed from the engine cylinders for inspection, but the plugs showed no sign of abnormity. Also prior to opening the propeller

[5] NTSB Safety Report, NTSB/SR-85/02, 04 Sep1985

[6] National Transportation Safety Board (NTSB)

gearbox, participants of the inspection attempted to rotate the propeller shaft, but they had to conclude that manual effort was insufficient for that.

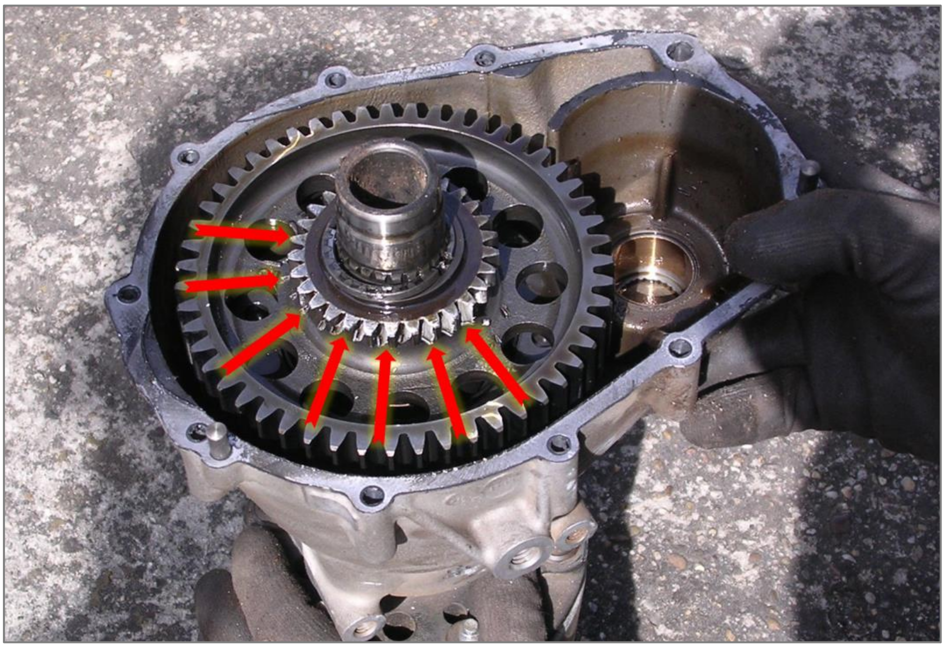


Figure 14: The propeller shaft with the cogwheels installed on it

During ground impact with the nose in front, the gearbox of the propeller got deformed, as a consequence of which the cogwheel of the propeller deeply scratched the surface of the gearbox at the engine side.

The red arrows in Figure 14 point to aluminium chips scratched out of the propeller gear house by the cogwheel of the propeller shaft.

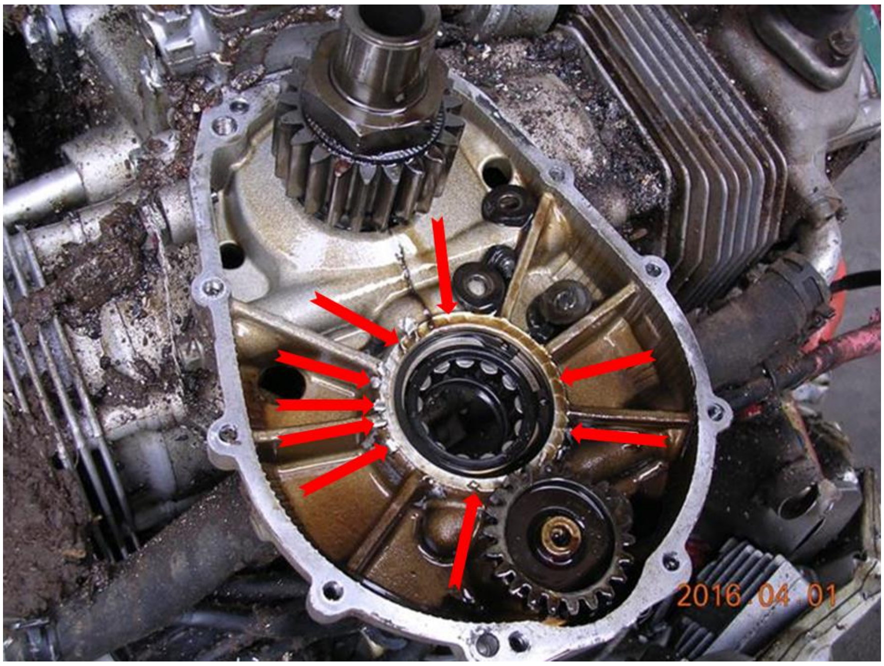


Figure 15: The cogwheel of the crankshaft of the engine and the engine-side surface of the propeller gearbox

The red arrows in Figure 15 show the points where the cogwheel of the propeller shaft contacted the engine-side surface of the gearbox.

Multiple fracture of one of the propeller blades and damages to the gearbox suggest that the engine and the propeller were rotating at the moment of ground impact, and then, after the gearbox was deformed, the cogwheel of the propeller shaft got pushed to the engine-side surface of the gearbox, and both the engine crankshaft and the propeller shaft stopped rotating.

Posterior inspection revealed no proof of any defect or malfunction of the structure or any system of the aircraft or the engine or any subsystem of it prior to the occurrence.

1.16.3. Detailed inspection of the ball valve of the fuel system

The three-way ball valve of the fuelling system provides three positions: left tank, right tank and OFF. Two of the three connections of the ball valve are connected to the wing tanks, and thee one in the middle is connected to the engine (Figure 16).

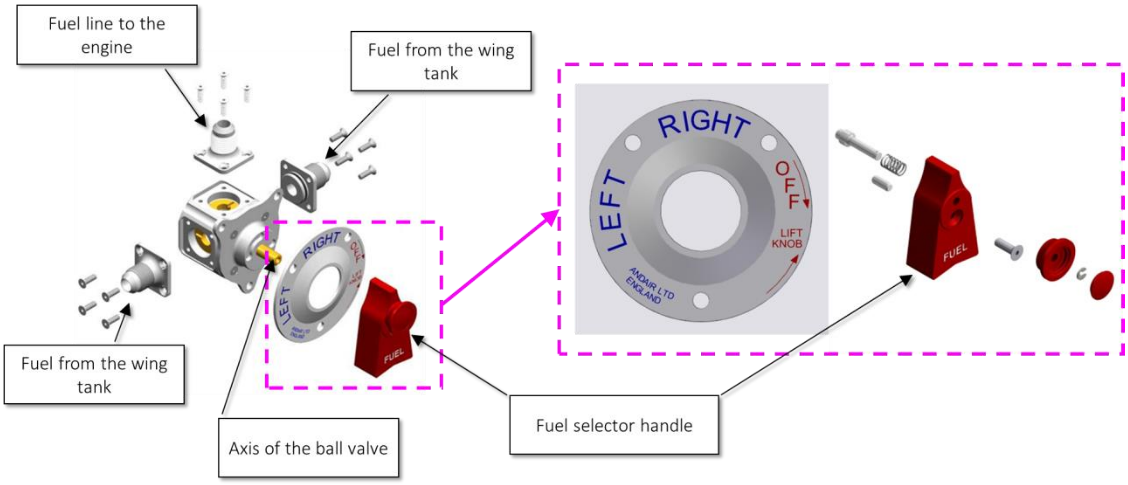


Figure 16: ball valve of the fuel system (source of figure: www.andair.co.uk)

The flow direction inside the valve is regulated by a ball (Figure 16 – in yellow colour), which contains two bores arranged perpendicular to each other, in such manner that both bores reach the centre of the ball. When the (red) lever of the valve is set in the LEFT position, fuel can flow freely between the left-hand side connection and the central connection. Setting the lever to the RIGHT position will block the flow between the left-hand side connection and the central connection, and give free way to the fuel to flow between the right hand-side connection and the central connection.

After lifting the lockout button, the knob can be turned to OFF position, when fuel cannot flow to the engine, neither from the left nor the right tank.

The setting mechanism of the fuel ball valve broke and the cover of the valve housing was significantly deformed due to the forces generated by the impact.

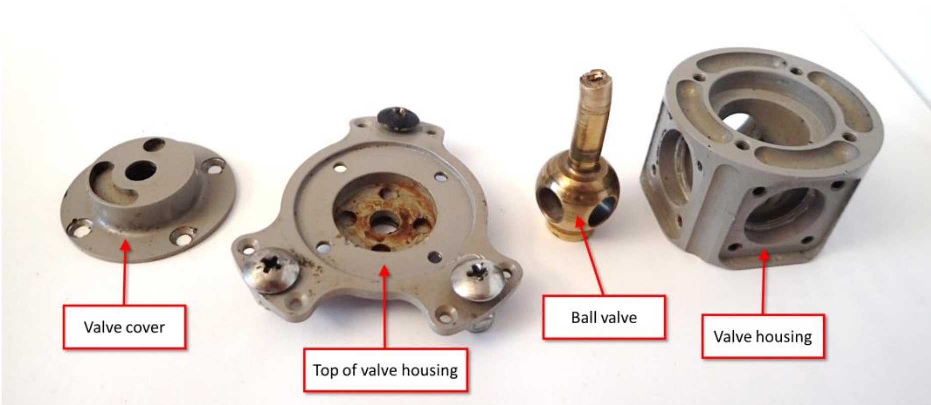


Figure 17: Parts of the damaged fuel ball valve

On 18 May 2016, the IC, ANSV and experts from Tecnam viewed the wreck in a joint effort. The engineer of Tecnam found the damaged fuel ball valve in OFF position.

The IC inspected the fuel ball valve in detail in order to determine its position at the moment of the ground impact (Figure 17). The opinion of the IC is that the deformations of the shaft of the ball valve (Figure 18) and of the valve housing (Figure 19) were consequences of the forces generated by the ground impact. The IC assembled the ball valve, taking into account the direction of the force and the deformations caused. On the basis of the inspection, it may be stated that the fuel ball valve was in open position at the moment of the ground impact, in such manner that the fuel system supplied the engine from the left hand side tank.

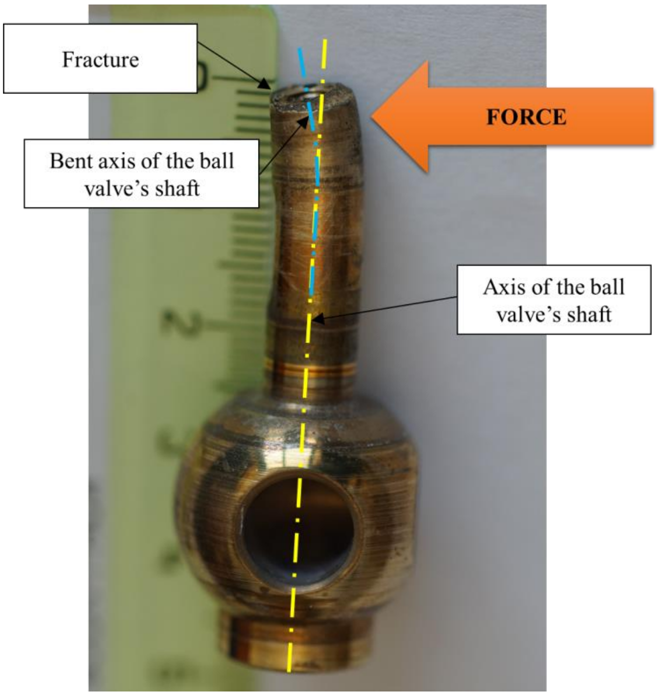


Figure 18: The damaged ball valve

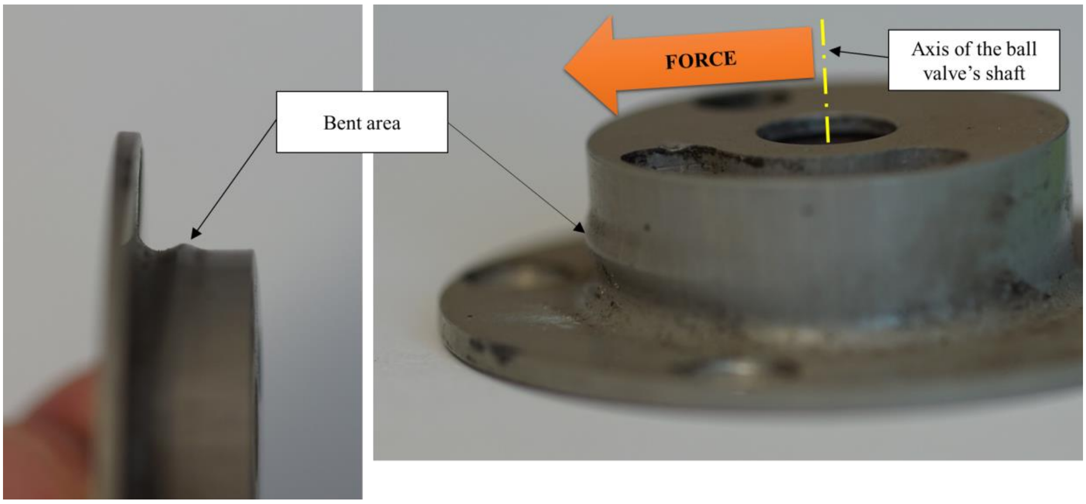


Figure 19: Deformation of the cover of the fuel ball valve

1.16.4. Inspection of the engine counter and engine RPM

The IC dismounted the propeller revolution meter from the wreck, and subjected it to further inspection. Prior to opening of the instrument, its glass cover had been found in broken state (Figure 20). The dial was dusty and showed signs of scratches as well. The IC found no signs of a punch mark caused by the hand of the instrument hitting the dial, which would have showed the RPM value at the moment of the ground impact.

At the time of the inspection, the hand showed 0 RPM and it moved freely within the range from it baseline position and the 800 RPM value (which was at the ridge of the bent dial). After removal of the hand and the dial, the rest of the instrument was found intact.

It may be concluded from the shape of the bent dial of the instrument that if the hand of the instrument had been in a position exceeding the 800 RPM value at the moment of the ground impact then the hand would have got into resting position at the other side of the ridge of the dial, somewhere around 900 RPM.

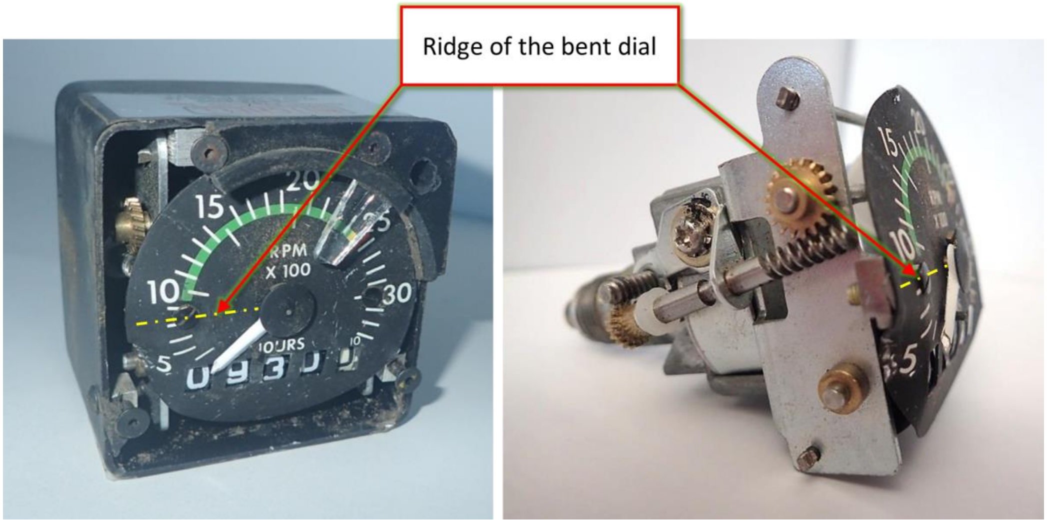


Figure 20: Damages to the dial and hand of the revolution meter of the propeller

Based on damages to the dial and hand of the revolution meter of the propeller, the IC concluded that the hand of the instrument had been in the 0 to 800 RPM range at the moment of the ground impact. The transmission ratio between the engine and the propeller is 2.4286 (according to data in page 1-9, AFM), on the basis of which, the IC gives the engine rpm values associated to the given propeller rpm values in the following table:

	Propeller RPM	**Engine RPM**
Maximum at take-off	2388	5800
Maximum continuous	2265	5500
Maximum value of the damaged RPM indicator Possible maximum value on the damaged instrument	800	1943
Idle	576	1400

In the case of a possible engine stall, the apparent wind cannot rotate the propeller (due to the propeller gear) at normal cruising speed, so the crankshaft of the engine would also stop. During inspection of the gearbox of the propeller, the IC found that that the propeller shaft had been rotating at the moment of the ground impact. The idle RPM value of the engine is 1400 rpm.

Based on those above, it may be concluded that the speed of the propeller was somewhere within the range of 576 to 800 RPM, and the engine was running at 1400 to1943 RPM at the moment of the ground impact.

1.17. Organizational and management information

The aircraft involved in the accident was owned by a legal person (hereinafter: the Organisation) which performed training activity using the reg. HA-VOE aircraft, performed supervision of the aircraft from the aspect of continuous airworthiness according to legislation in effect at the time of the accident, and was its operator as well.

According to the Training Manual in effect at the time of the accident, the Organisation performed its training flights relying on 57 contracted flight instructors and 15 aircraft.

1.17.1. Requirements for fuel quantity

According to Operation Manual Part B[7], the fuel policy of the organisation is based on fuel demand (which is based on consumption data given in the Flight Manual), and on providing sufficient quantity for the statutory reserve. Operational Manual Part A 1.5 specifies the weight of the standard crew member as 85 kg (including hand baggage as well) for precalculation of the mass and centre of gravity. According to the chapter of Operational Manual Part B[8] relating to Tecnam P2002-JF aircraft, the mass of a passenger should be taken into account on the basis of their oral statement, plus 5 kg added to include clothing and hand baggage.

Pursuant to the Operation Manual and relevant legislation[9], the fuel quantity to be filled into the aircraft for a ‘local flight’ is the quantity required for the planned flight plus a quantity sufficient for 30 minutes of flight.

1.17.2. Fuel refill procedure of the Organisation

According to information available to the IC, the Organisation used the affected aircraft primarily for training purposes. During the site investigations performed in 2016, the IC was by emplyees of the Organisation that when therewas no more booking for an aircraft for the current day then they fully refilled the fuel tanks of such aircraft. That procedure was confirmed by the fuel refill records used with the organisation and obtained by the IC, as well as the entries in the aircraft logbooks. Using such data, the IC was able to reconstruct the flights directly poreceding the accident; Figure 21 shows the flight times and related fuel quantities of such flights. The chart shows that prior to the first scheduled flight the fuel quantity was 100 litres, and after the last scheduled flight, the fuel tanks of the aircraft were fully refilled again. Later on, the pilot involved in the accident started his flight in an aircraft fully refilled (Figure 21 – the section depicting the flight ending up in accident).

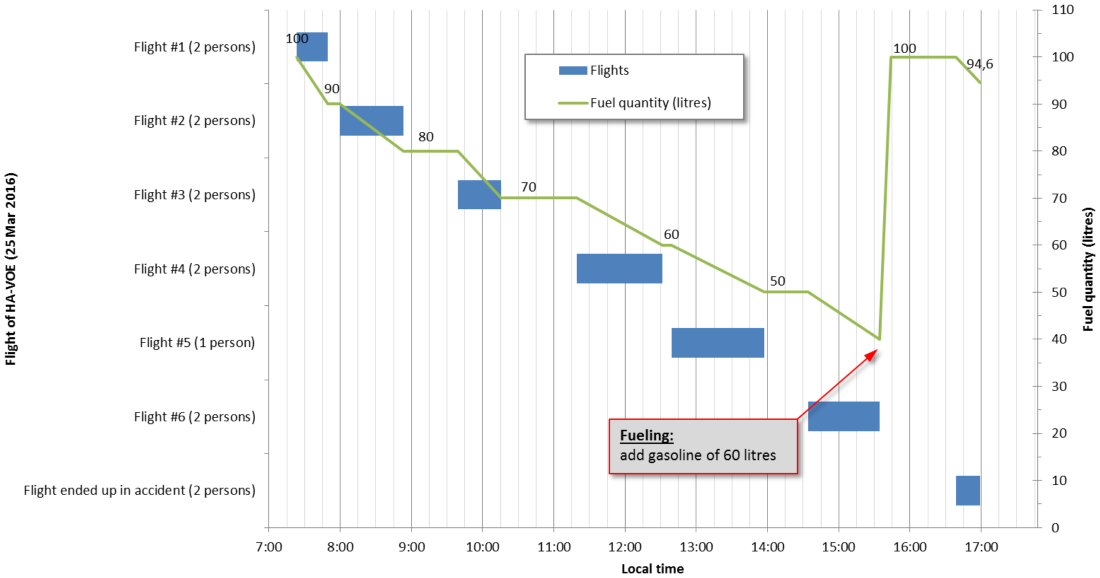


Figure 21: Flights and fuel quantities of the reg. HA-VOE aircraft on the day of the accident, according to entries in the flight logbook

[7] OM Part B / section 4 / chapter 7 / 3. Fuel planning (Rev 0, 01 January 2015)
[8] OM Part B / section 4 / chapter 8 / 4. Mass values for passengers (Rev 0, 01 January 2015)
[9] NCO.OP.125, Commission Regulation (EU) No 800/2013

1.17.3. Earlier aviation occurrences involving the Organisation

The aviation accidents which took place with the Organisation between 21 June 2015 and 26 March 2016:

Date	Aircraft type and registration	Number of fatal / serious injuries:	Short description of the occurrence
21/06/2015	AT-3, HA-VOA	0 / 0	During landing after a training flight, the aircraft had a hard landing at Gödöllő airfield, which caused damage to the nose landing gear, the propeller, and the nose casing of the aircraft. No one was injured.
18/10/2015	Cessna C-150, HA-VOF	0 / 0	During a touch-and-go performed in the course of a night-time IFR training flight, the aircraft crashed to ground at Jakabszállás airfield. No one was injured.
28/02/2016	Cessna C-152, HA-VOK	1 / 1	The aircraft, with two occupants on board, crashed to the mountain in the Gerecse Mountains, just 1 kilometre of Vértestolna village. One of the occupants died on the spot, and the other was carried to hospital with serious injuries by ambulance helicopter. The wreck of the aircraft and the occupants were found by a search & rescue helicopter.

The Organisation had not taken or drafted risk-reducing actions in connection with the above occurrences by the time of issue of this Draft Report.

On 1 February 2016, the aviation safety section of the Organisation sent TSB the aviation safety report of 2015 of the Organisation, pursuant to relevant regulations. Such report indicates that the aircraft operated by the Organisation flew 5962.24 hours after 22036 take-offs.

According to the aviation safety report of 2015 of the Organisation:

> *"There were 2 aviation accidents and 1 incident during which no one was injured. In comparison with the number of hours flown, however, the aviation safety situation is satisfactory."*

1.18. Additional information

1.18.1. Storage of aircraft

The IC found no law or regulation which would require that the aircraft may only be stored in the hangar with its fuel tanks filled up.

1.18.2. Aircraft booking system

At the time of the accident, the Organisation had in place an electronic system for booking aircraft. Based on interviewing a witness working for the Organisation, the IC knows that booking was not a condition of flight. If there was an "*available*" aircraft, like in the case of the flight ending up in accident, then a pilot having the appropriate certificate was allowed to take the aircraft for a flight without booking in advance.

1.18.3. Aircraft Flight Manual

The Flight Manual of the aircraft does not allow aerobatic manoeuvres (including intentional spin) to be performed.

According to the Flight Manual of the aircraft, if the aircraft gets into an unintended spin, the accelerator must be set to basic position, the rudder must be moved opposite the direction of the rotation (until rotation stops), and, at the same time, the control stick must be set to neutral position. The aircraft may only be manoeuvred out of the fall and use the accelerator again only after rotation has stopped.

According to Section 5, Chapter 5 of the Flight Manual, with a take-off weight of 580 kg and with its flaps retracted, the aircraft Tecnam P2002-JF will stall:

- with horizontal wings: at a speed of 40 knots according to the instrument,
- in a turn with a bank of 45 degrees: at a speed of 55 knots according to the instrument.

1.18.4. Centre of gravity calculation

The pilot-in-charge should plan the flight keeping in mind that the combined mass of the empty aircraft, fuel, the occupants and the luggage on board should not exceed the maximum take-off weight. During flight, the empty mass of the aircraft and the combined mass of occupants are given, so the quantity of fuel should be determined in such manner that it should be sufficient for the flight task plus the mandatory reserve, and that the total mass of the refuelled aircraft should not exceed the maximum take-off mass.

According to Chapter 2 Annex IV to Regulation (EU) № 216/2008 in effect at the time of the accident, *“A flight must not be commenced unless [...] the mass of the aircraft and centre of gravity location are such that the flight can be conducted within limits prescribed in the airworthiness documentation.”* The relevant requirement of the organisation involved in the accident observes this regulation regarding the calculation of mass and location of the gravity centre, saying that the pilot-in-charge should perform such load calculations before take-off, on the basis of the aircraft flight manual.

Chapter 6 of the Flight Manual prescribes that the pilot should fly the aircraft within the load limits.

Operation Manual Part ANot [10] indicates that the Organisation allows training-, test-, working- and private flights. According the the Operation Manual[11], calculations of the mass and centre of gravity must be performed, on a so-called Load Sheet, prior to starting a flight of any kind of those mentioned above, and such calculaations must be retained fo 3 months following the flight.

During the investigation of the scene, the IC found no *Load Sheet* (as defined by the Organisation) on-board the aircraft, and the IC received no such document from the Operator during the site investigations when requesting all documentation related to the aircraft.

1.18.5. Usage of the transponder device

Pursuant to *Annex H* to Decree № 14/2000. (XI. 14.) of the Minister of Transport and Water Management on the Rules of the Air within the Airspace and the Aerodromes of the Republic of Hungary, in effect at the time of the occurrence:

> *“1. Transponders with a setting mode ‘C’ shall in each case be operated in that mode unless ordered expressly otherwise by the competent ATS unit.”*
>
> *“2. Unless specified otherwise for the given aerodrome, the transponder – following the setting up of its mode/code – may only be turned on right before take-off. After landing, the device shall be turned off or standby without waiting for any instruction.”*
>
> *...*

[10] OM Part A / section 8 / chapter 7 / 1. General (Rev 1, 25 April 2013)
[11] OM Part A / section2 / chapter 1 / 10. Document storage periods (Rev 1, 25 April 2013)

"4. If the ATS did not instruct the pilot if the aircraft to apply an individual code, then the following codes shall be set up:

In case of moving in a controlled airspace: A/C 2000.

In case of moving outside a controlled airspace (according to the category of the given aircraft):"

Aircraft category	*SSR code*
aeroplanes	*A/C 7000*
helicopters	*A/C 7001*
sailplanes	*A/C 7002*
lighter-than-air aircraft	*A/C 7003*

1.18.6. Transponder device

According to the manual published by the manufacturer of the transponder type Garmin GTX 327 transponder (Figure 22), the device has the following modes of operation:

- Press the ON button (Mode A turned on): the device will respond to ground-based equipment but will not give altitude signal.
- Press the ALT button (Mode C turned on): the device will respond to ground-based equipment and give altitude information as well.
- Press the STBY button: the device will switch to standby. In this mode, the device is on but emits no response.
- Keep the OFF button depressed for a few seconds: the device will turn off.

When the device is off, it can be turned on by pressing any of the ON, ALT, STBY buttons.

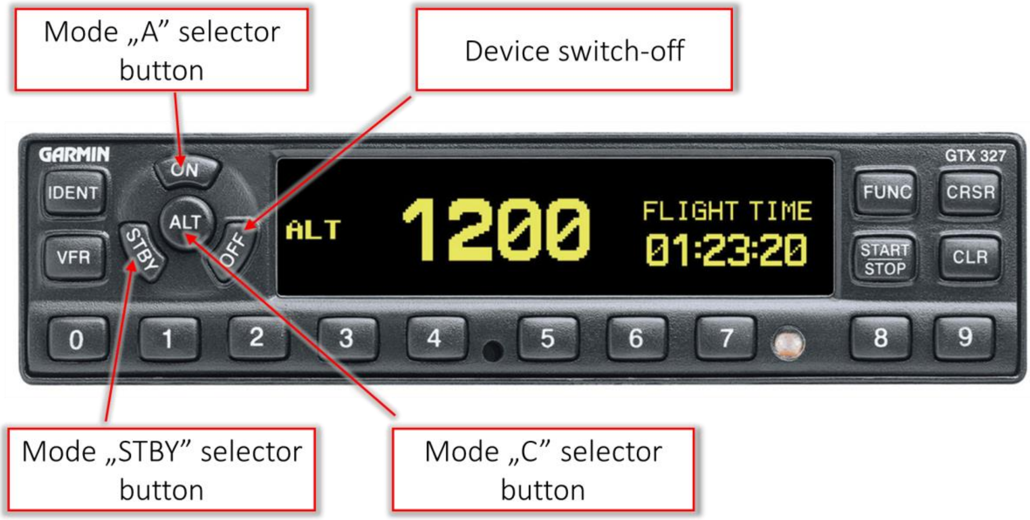


Figure 22: Control panel of the Garmin GTX327 transponder

In the opinion of the IC, the signals emitted by a transponder may disappear from the radar screen of the air traffic management service for the following reasons:

- malfunction of the transponder or its power supply;
- the signals emitted by the transponder do not get to the processing unit due to geographical circumstances (shielding or too long distance);
- the device was turned off or switched to standby (STBY) mode.

1.18.7. Emergency Locator Transmitter device

Pursuant to Chapter NCO.IDE.A.170 Emergency locator transmitter (ELT) of the Commission Regulation (EU) № 800/2013 of 14 August 2013 amending Regulation (EU) № 965/2012 laying down technical requirements and administrative procedures related to air operations pursuant to Regulation (EU) № 2016/2008 of the European Parliament and of the Council:

"(a) Areoplanes shall be equipped with:

(1) an ELT of any type, when first issued with an individual CofA on or before 1 July 2008;

(2) an automatic ELT, when first issued with an individual CofA after 1 July 2008; or

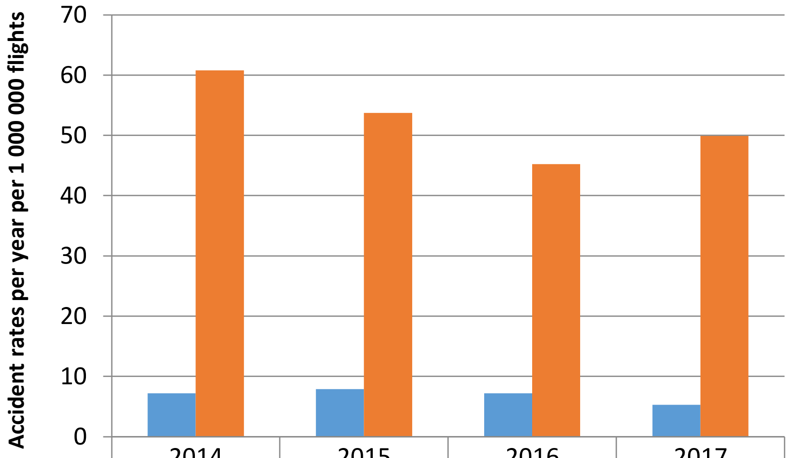
(3) a survival ELT (ELT(S)) or a personal locator beacon (PLB), carried by a crew member or a passenger, when certified for a maximum passenger seating configuration of six or less.

b) ELTs of any type and PLBs shall be capable of transmitting simultaneously on 121.5 MHz and 406 MHz."

The above Regulation allowed the Member States to postpone implementation of NCO.IDE.A.170 relating to non-commercial operations till 25 August 2016, and Hungary took the opportunity. Accordingly, the installation of an ELT in the reg. HA-VOE aircraft was not mandatory at the time of the accident.

1.18.8. Flight safety data of the EASA

According to the aviation safety report[12] of EASA, the rate of non-fatal accidents was 53.7, and the rate of fatal accidents was 7.9 per 100,000 flights in non-commercial aviation (small aircraft) in 2015 (Diagram 1).



	2014	2015	2016	2017
Fatal Accident Rate	7,2	7,9	7,2	5,3
Non-fatal Accident Rate	60,8	53,7	45,2	49,9

Diagram 1: Accident rates of non-commercial aircraft, 2014-2017

[12] Annual Safety Review 2018, European Aviation Safety Agency

1.18.9. Inspection visit to the Organisation following the dissemination of the Draft Report

The Draft Report of this investigation was sent by TSB to the Orgnisation as well, on 10 July 2019. Subsequently, on 22 August 2019, the Organisation submitted an opinion in which there were some statements contradicting the information in the Draft Report, and the IC was not able to resolve such contradictions (see Appendix 1 for details). In order to clarify the facts, the IC paid a visit, without announcing it in advance, to the site of the Organisation on 19 November 2019. During such visit, it was found that:

- the Organisation has an operations logbook system in which pilots must enter, among others, current fuel quantity as well as current takeoff mass;
- the keys and on-board documents of the aircraft are only be obtained through the instructor-on-duty;
- aircraft are stored with their tanks not fully refuelled; and during refill, the fuel tanks are refilled according to instruction from the pilot-in-command;
- The organisation does not lend aircraft. Every flight (including "*flight time building*" flights as well) takes place within the framework of some training activity, where an instructor-on-duty supervises or sometimes inspects if pilots are prepared for the planned flight;
- Only the ATO OM manual was in use instead of the ATO OM and and OM manuals effective at the time of the accident;
- No personal scale is available for the calculations of mass and centre of gravity, so the mass of pilots and passengers is determined on the basis of oral statements;
- According to the ATO OM, the calculation of mass and gravity of centre must be performed according to the flight manual of the given aircraft, and the ATO OM does not require the use of load sheets.

1.19. Useful or effective investigation techniques

During the investigation, the IC cooperated with the Polish (PKBWL) and Icelandic (RNSA) investigating organisations. The sharing of information, facts and experiences significantly helped the IC understand the course of events of the accident.

Cooperation was necessitated by the following two occurrences:

- On 01 April 2016, after taking off from Warszawa-Babice (EPBC) aerodrome for a training task, a type Tecnam P2002-JF aircraft crashed to ground almost vertically at high speed in the 48th minute of its flight. The purpose of the flight was to practice flight at low speed and stall. Two people died in the accident.
- On 12 November 2015, two persons with trainer licence took off for a training flight from Reykjavik aerodrome (BIRK), Iceland, in a type Tecnam P2002-JF aircraft with reg. TF-IFC. According to radar data, the aircraft crashed to the ground south of the departure aerodrome after 30 minutes of flight. Both of its occupants died in the accident.

In order to better understand the interrelations of the accident and to address the chain of causation, the IC used a method of analysis developed by the Australian Transport Safety Bureau (ATSB Model) (Appendix 4).

2. Analysis

2.1. Operation of the engine

Multiple fracture of one of the propeller blades and the damage to the gearbox suggest that both the engine and the propeller were rotating at the moment of the ground impact (Chapter 1.16.2). Upon impact, and after the deformation of the gearbox, the cogwheel of the propeller shaft was pushed to the engine-side surface of the gearbox, and both the engine crankshaft and the propeller shaft stopped rotating. On the basis of damages to the dial and hand of the revolution counter of the propeller, the IC concluded that the hand had been in the rev./min range of 0-800 RPM at the moment of the ground impact (Chapter 1.16.4). The damage to the gearbox of the propeller shows that the engine was running at the moment of the ground impact (Chapter 1.16.2), which fact suggests, in the opinion of the IC, that the propeller RPM was ca. 576 to 800 RPM at the moment of the ground impact, i.e. the engine was running at a speed of 1400 to 1943 RPM (Chapter 1.16.4). Accordingly, the IC supposes that the engine was running until the aircraft crashed to the ground. No proof of any malfunction of the engine or any of its subsystems existing prior to the accident was revealed during the investigation (Chapter 1.16.2). The position of the IC is that the operation of the engine did not contribute to the occurrence, neither directly not indirectly.

2.2. Course of the flight

The IC was not able to determine the whole flight path of the aircraft from take-off to ground impact. The IC had no objective data of the flight path following the interruption of the transponder signals.

On the basis of the evidence collected (Chapters **Hiba! A hivatkozási forrás nem található.**, REF _Ref2092427 \r \h * MERGEFORMAT **Hiba! A hivatkozási forrás nem található.** and **Hiba! A hivatkozási forrás nem található.**), the IC has concluded that the aircraft impacted the ground in a steep angle, rotating counterclockwise, which corresponds to a spin situation. In absence of any proof, the IC found no explanation of the cause of fall of the aircraft into a spin. The most frequent cause of an unintended spin is (except for technical malfunction) that the pilot loses control over the aircraft, which leads to a catastrophe in most of the cases[13].

For the calculation made in order to determine the exact time of the accident and certain points of time of the phases of the flight, the IC:

1. used the times of the transponder signal (see chapter **Hiba! A hivatkozási forrás nem alálható.**. for details) as reference;
2. regarded the (assumed) length of the phase of takeoff as 2.65 km, during which the aircraft travelled at an average ground speed of 60 kts (Figure 3), therefore the duration of this phase was 1 minute and 26 seconds;
3. established, on the basis of those above, that the aircraft had started takeoff at 16:42:23[14] ;
4. established (on the basis of an assumed operation time of 0.1 hours (6 minutes)) that the pilot had started the the engine at about 16:36;
5. the duration of the signal emitted by the transponder was 32 seconds (Chapter **Hiba! A ivatkozási forrás nem található.**.), which suggests that:
    a. in the case of a total operation time of 0.3 hours, the aircraft flew 10 minutes and 2 seconds after the radar signal disappeared;

[13] International Air Transport Association (IATA), Loss of Control In-Flight Accident Analysis Report 2010-2014
[14] the period of time determined as the difference between the appearance of the radar signal and the duration of the assumed phase of the takeoff.

b. in the case of a total operation time of 0.4 hours, the aircraft flew 16 minutes and 2 seconds after the radar signal disappeared;

According to calculations made by the IC, the accident took place between 16:54:23 and 17:00:23. Figure 23 shows the timeline of the accident.

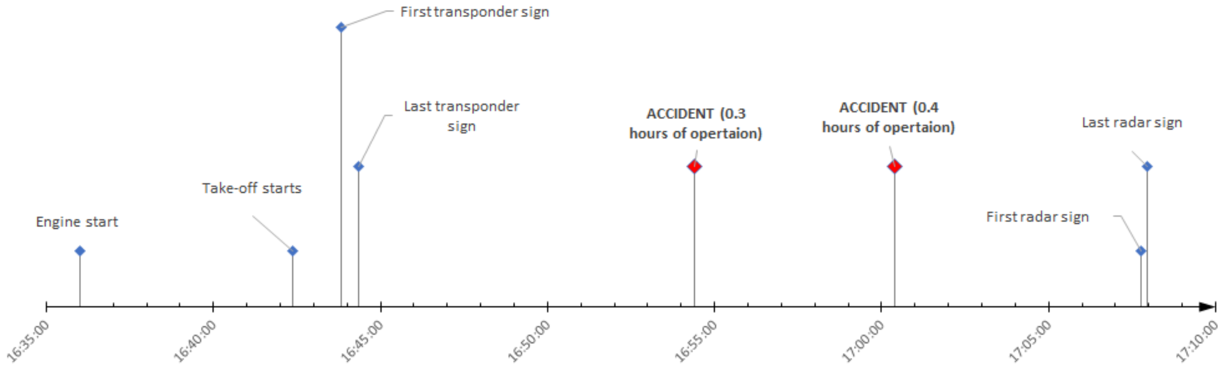


Figure 23: timeline of HA-VOE's flight

Based on data collected, the IC excludes that the primary radar signal (Figure 24) (described in Chapter 1.1) which was visible for 12 seconds could be the radar signal of the HA-VOE aircraft, because it appeared on the radar screen of the air traffic anagement 7 seconds after the time of the accident of HA-VOE (Figure 23).

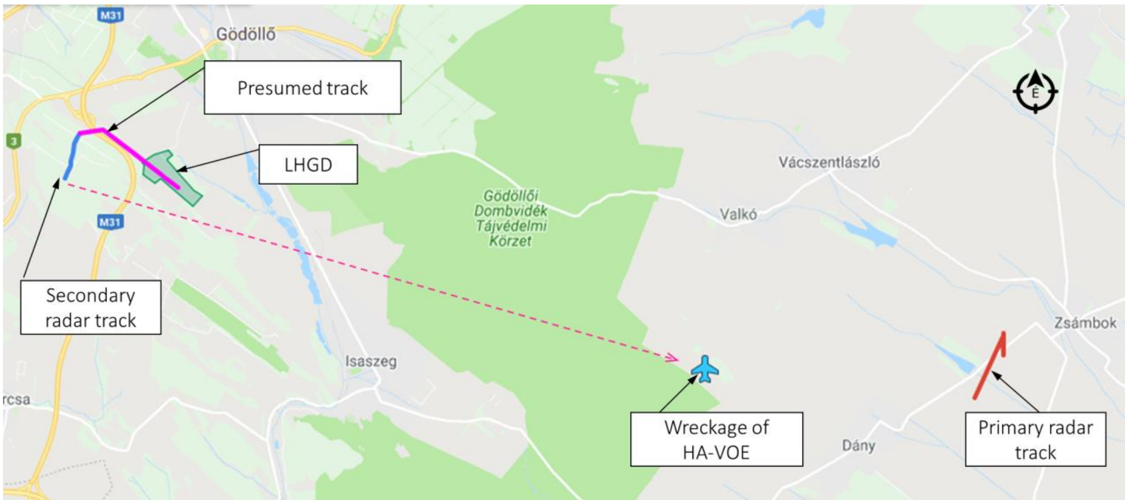


Figure 24: Possible flight path of the reg. HA-VOE aircraft (source of map: Google Maps)

2.3. Actions taken by pilot

Relying on witness statements and data from the air traffic management service, the IC was able to partly reconstruct the pilot's pre-flight activity, namely that he had stated that he and his passenger were off for a local flight. He had filed no flight plan. During the investigation, the IC found no document to prove preparation for the planned flight – not even calculations of the mass and gravity of centre location or an entry in the on-board flight logbook of the aircraft to confirm receipt of the aircraft.

The position of the IC is that, after engine start and before loss of the transponder signal, the pilot pushed the ALT button of the transponder device at least once, because the Mode C signal of the aircraft appeared with the code number 7000 on the radar of the competent air traffic management service.

The IC found no clear evidence of the reason why the radar signal in the first short leg around the Runway 31 of the Gödöllő airfield had disappeared. Shielding by the terrain as one of the possible causes described in Chapter 1.18.5 is excluded by the IC, because the aircraft was at least 110 metres above the Gödöllő Hills, when the radar signal disappeared (Chapters 1.1 and 1.11). The radar in use at Budapest Liszt Ferenc International Airport had direct view on the aircraft when it was in that position. The IC also excludes the possibility that either the pilot or the passenger switched the transponder off or to standby mode by an unintended touch. This opinion is based on the following:

- you need to keep the OFF button pressed for a few seconds to turn the device off;
- the pilot had filed no flight plan and had not contacted the competent air traffic management service prior to the flight, so he did not have to set up a new transponder code during which he could have switched the device off or to standby mode by mistake.

The IC does not exclude in-flight malfunction of the transponder device as the cause of stopping of the radar signal, but finds it implausible, based on own experience. The IC supposes that the cause of stopping of the transponder signal from the aircraft reg. HA-VOE was the turning off or switching to standby (STBY) of the device.

In the opinion of the IC, the location of the gravity of centre of the aircraft did not influence manoeuvrability of the aircraft to such extent that it would have led to the accident directly. In general, it may be stated that increasing the loading of the aircraft will increase the stalling speed[15] of the aircraft. Accordingly, the stalling characteristics of an aircraft with its mass significantly exceeding the limit may be significantly different than usual. Taking into account the pilot's flight experience and his flights preceding the accident (Chapter 1.5.1), the IC does not exclude the possibility that the pilot had not paid due attention to the changed stall characteristics of the aircraft (originating in the excess weight) during the manoeuvres performed.

Based on the foregoing, the IC supposes that the total mass of the aircraft exceeding the limit contributed indirectly to the loss of control of the aircraft.

2.4. Safety culture in the organisation

According to the practice mentioned in Chapter 1.17, the fuel tanks of the aircraft are refilled fully after arrival. The Organisation uses its aircraft mainly for training purposes, so the aircraft fly with two occupants in most of the cases. With its fuel tanks full of motor spirit (petrol), the reg. HA-VOE aircraft allowed 134.5 kg total mass for two occupants and their luggage. Taking the requirements of the Organisation into account, namely that a crew member's weight is taken as 85 kg (Chapter 1.17.1), and the mass data of the aircraft, in the opinion of the IC it may occur in the everyday practice of the Organisation that, using a fully refuelled aircraft, a training task can be performed only at the cost of exceeding the relevant take-off mass limit.

The IC received no "*load sheet*" documents specified by the Organization for itself (Chapter 1.18.4).

In March 2016, several types of aircraft were used for training by the Organisation, and actually the pilot involved in the accident had flown 3 different types in 9 months (Chapter 1.5.1). According to the IC, the training staff and the size of the aircraft fleet assume a large number of trainee and tenant pilots. An adequate level of management and monitoring of aircraft and persons-related data shall only be carried out with an effective IT background and/or human resources, which the system described in Chapter 1.18.2 did not fully comply with, according to the IC. Due to the size of the Organisation and the number of persons involved, the reservation system used did not allow for an adequate level of professional supervision, which, according to the IC, posed a high safety risk.

[15] JAA ATPL theoretical training book, Jeppesen Sanderson Inc., 2004, ISBN 0-88487-358-7

According to experience gained during the investigation, it seems that deviation from the requirements in the flight manual and from relevant regulation occurs as a common mistake during everyday activity within the Organisation, i.e. deviation from the rules has become daily routine. With time, such deviation is reinforced by the fact that the people acting within the Organisation experience no anomaly due to such deviation in most of the cases. Accordingly, the environment develops a flight safety culture in which the mandatory nature of rules becomes relative. As a consequence, such common mistakes infiltrate also into the attitudes/actions (Chapters 1.6.5 and 2.3) as well as decision making mechanisms of people with less experience, which may even lead to tragedies.

Within the aviation industry and within the aviation community, an organisation which acts with the generally expected responsibility views every aviation incident (regardless of its consequences) as an important learning opportunity. After several incidents or after a series of incidents with more and more serious consequences, the organisations and managements of organisations acting with due diligence do their best to investigate such incidents thoroughly and to take appropriate action to reduce risk with no delay. The position of the IC is that the Organisation involved in the occurrence did not meet this expectation, because:

1. In its report on the year 2015, the Organisation evaluated its flight safety situation as suitable, despite the fact that there had been 2 aviation accidents within the Organisation in the year under review (Chapter 1.17.3). For that period, the accident rate per 1 million flights of the organisation was 90.76, which value is almost double of the European average (Chapter 1.18.8). The Organisation did not introduce or draft risk-reducing actions in connection with the occurrences (Chapter 1.17.3).
2. It has not taken effective steps in time to reduce the safety risks identified in the fatal accident of Cessna C-152 with registration HA-VOK on 11 February 2008 (chapters 1.17.3 and 1.18.2).

Search & rescue operation following the accident was hindered by the fact that neither the operator of the aircraft, nor the competent air traffic management service had no accurate information on the planned or actual route of the aircraft (Chapters 1.15 and 1.18.7). The position of the IC is that, although the accident was not survivable, search & rescue was significantly hindered by the lack of any emergency locator transmitter device (Chapter 1.15).

The flight safety culture of the organisation contributed significantly to the occurrence.

3. Conclusions

3.1. Findings

The pilot had the appropriate licences and ratings at the time of the occurrence. The pilot had low level of flight experience (Chapter 1.5.1).

The aircraft was found airworthy prior to the take-off.

The aircraft had a valid airworthiness certificate (Chapter 1.6.2).

The aircraft was not equipped with any emergency locator transmitter device (Chapters 1.15 and 1.18.7).

Due to postponement of the introduction of the Commission Regulation (EU) № 800/2013 to 25 August 2016, ELT was not mandatory for aircraft involved in non-commercial operations (Chapter 1.18.7).

There was 100 litres of fuel in the fuel tanks of the aircraft at the time of engine start. At the same time, the total mass of the aircraft exceeded the limit value significantly (by 104 kg) (Chapter 1.6.5).

The IC did not find any evidence which would have proven that the pilot had performed pre-flight calculations of the mass and CoG calculation (Chapter 2.3).

The pilot made no entry in the on-board flight logbook before flight (Chapters 1.1 and 2.3).

The IC supposes that the time of take-off of the aircraft from Runway 31, Gödöllő Airfield is 16:42:23 (Chapter 2.2).

Following the take-off, the transponder signal of the HA-VOE appeared on the radar screen of the air traffic management service at 16:43:49 and disappeared from there at 16:44:21 (Chapter 1.1).

The flight took place at daytime, in good visibility conditions (Chapter 1.7).

The pilot filed no flight plan before the flight (Chapter 1.9). The pilot did not contact the competent air traffic management service during his flight.

No information emerged on the activity of the air traffic management service or the characteristics of the airfield which could be associated with the occurrence. (Chapters 1.9 and 1.10).

No information emerged during the investigation on malfunction of the structure or any system of the aircraft prior to the occurrence, thus contributing to the occurrence or influencing the course of events (Chapter 1.6.6).

At the moment of the ground impact, the propeller speed was within the range of 576 to 800 RPM, and the engine was running at 1400 to 1943 RPM (Chapters 1.16.2, 1.16.4 and 2.1).

Ground impact of the aircraft took place between 16:54:23 and 17:00:23 (Chapter 2.2)

The aircraft impacted the ground after a steep fall in an angle of 65° to 85°, in a steep pitch angle (with the nose pointing downward), and in a left spin around the longitudinal axis, while the speedometer indicated a speed of 90 knots (166,68 km/h) (Chapters 1.1, 1.3, 1.12 and 2.2). The impact was not survivable (Chapters 1.13 and 1.15).

The IC supposes that the cause of disappearing of the transponder signal of HA-VOE is that the device was turned off or switched to standby (STBY) mode (Chapter 2.3).

During its daily operations, the organisation deviated from the procedure of calculation of mass and gravity of centre specified in its OM (Chapter 2.4).

3.2. Causes

During the investigation, the IC concluded that the cause of the occurrence was that the pilot had lost control of the aircraft (Chapter 2.2). The fact that the total mass of the aircraft significantly exceeded the relevant limit might have contributed to the occurrence indirectly (Chapter 2.3).

The problems originating in the flight safety culture of the Organisation contributed to the occurrence directly (Chapter 2.4).

4. Safety recommendations

4.1. Actions taken by the operator/authority during the investigation

According to statement (of 25/02/2019) from the Organisation affected by the accident, they introduced the measures indicated in Appendix 3 after the accident.

Following an unannounced audit, the supervisory authority suspended the CAMO and ATO licences of the Organisation affected by the accident, on 5 April 2016. Subsequently, such licences were given back to the Organisation after they took corrective actions approved by the supervisory authority.

4.2. Safety recommendation(s) issued during the investigation

The Investigating Committee of TSB identified no circumstance which would warrant issuance of an immediate safety recommendation.

4.3. Safety recommendation(s) issued on completion of the investigation

With regard to the actions taken by the organisation involved in the accident and to existing regulations, the IC proposes no safety recommendation.

Budapest, 30 December 2019

Zsigmond Nagy Investigator-in-charge	Ferenc Kamasz Member of IC

APPENDICES

Appendix 1: Differing opinions

After receipt of the Draft Report, the Organisation expressed opinions differing from those of the IC, and invited a court expert to form an opinion on such Draft Report. Taking the received opinions into account, the IC made changes to the text of the Final Report, but disagrees with the following comments:

Opinions from the Organisation:

"When addressing issues beyond the expert's competence, the contents were evaluated in a joint effort with lawyers; according to our lawyers, you seriously endanger the reputation of our Company through your unfounded opinions full of contradictions implied in the report, as, although the intended purpose of the report is to gain experience in general and to communicate advice, actually the name of our Company can be identified exatly. The content of the last but one paragraph in page 34 is incomprehensible, as it had been impossible to determine the quantity of the of the fuel filled into the aircraft, so the remark relating to fully refilled aircraft + the mass of the pilots and overweight should be omitted fully. The contents of the last line are not founded in any way therefore that remark is also capable of damaging the repuration of our Company, which may raise the issue of your legal liability in the event that such remark is left unchanged in the final report."

"According to Chapter 4.2, [the IC] *proposes no safety recommendation, but they repeat it in Chapter 4.3 and then close the report by adding a general piece of advice."*

"With regard to those above, we do not agree with the report sent to us in draft form, neither technicaly, nor legally, therefore we request you to rewrite it according to the facts and substantiated events, in accordance with what you write in the introduction of the report."

Based on information obtained during the investigation, the IC maintains its opinion.

Findings of the expert opinion obtained by the Organisation:

"According to the report, the pilot of the aircraft turned the on-board transponder off deliberately, while Chapter 1.18.5 of the investigation document contains an analysis of the secondary transponder equipment, but the possibility of technical malfunction of such equipment is excluded in Chapter 2.3 of the report without any documentation of laboratory investigation attached."

"That statement or presumption is immensely important from the aspect of posterior judgement of liability, therefore my position is that the exclusion of technical malfunction without instrumental examination of the transponder equipment in a laboratory cannot stand."

As regards those above, the IC maintains its opinion, on grounds that the opinion of the IC in the Draft Report was worded in accordance with the probability scale used in forensic linguistics, as follows: "*The IC does not exclude in-flight malfunction of the transponder device as the cause of stopping of the radar signal, but finds it implausible, based on own experience*".

"The alleged overloading of the aircraft is solely based by the Investigating Committee on unsupported information in Chapter 1.17.1. cited above[16]. "The Draft Report contains no reference to any record of interviewing people in this subject, nor any documentation relating to refuelling prior to the flight task involved, which could easily have been been

[16] Chapter number in the Draft Report of TSB

checked against the consumption logbook of the filling station owned by the Company and could have been used to substantiate the allegation concerned, notwithstanding the lack of on-board documentation."

The IC maintains its opinion relating to those above, based on the contents of Chapter 1.17.2.

"Both the first instance Decision № LH/RB/195/25/2016 of NDA cited above and the final second instance Decision № EH/MD/NS/A/3/1/2017 of MND modifying such first instance Decision discuss in detail the determination of the mass of the pilot and the passenger at the time of the accident, with the addition that the latter refers specifically to the Autopsy Reports (made at Department of Forensic and Insurance Medicine, Faculty of Medicine, Semmelweis Uiversity on 26/06/2016 and 04/08/2016) which indicate that the measurements were performed on non-calibrated measuring instruments."

…

"Mesurements having legal effect may exclusively be performed using a calibrated measuring instrument."

…

"The same applies to the exact determination of the post-event mass of the wrecks of the aircraft."

"In absence of these, the aforesaid comments and statements cannot be judged or qualified by means available to of forensice experts."

The IC maintains its opinion relating to those above, based on Chapters 1.6.5, 1.13, Hiba! hivatkozási forrás nem található.**, 1.17.2,** Hiba! A hivatkozási forrás nem található.**, 1.18.9 and 2.4.**

"2.4 Organisational culture:

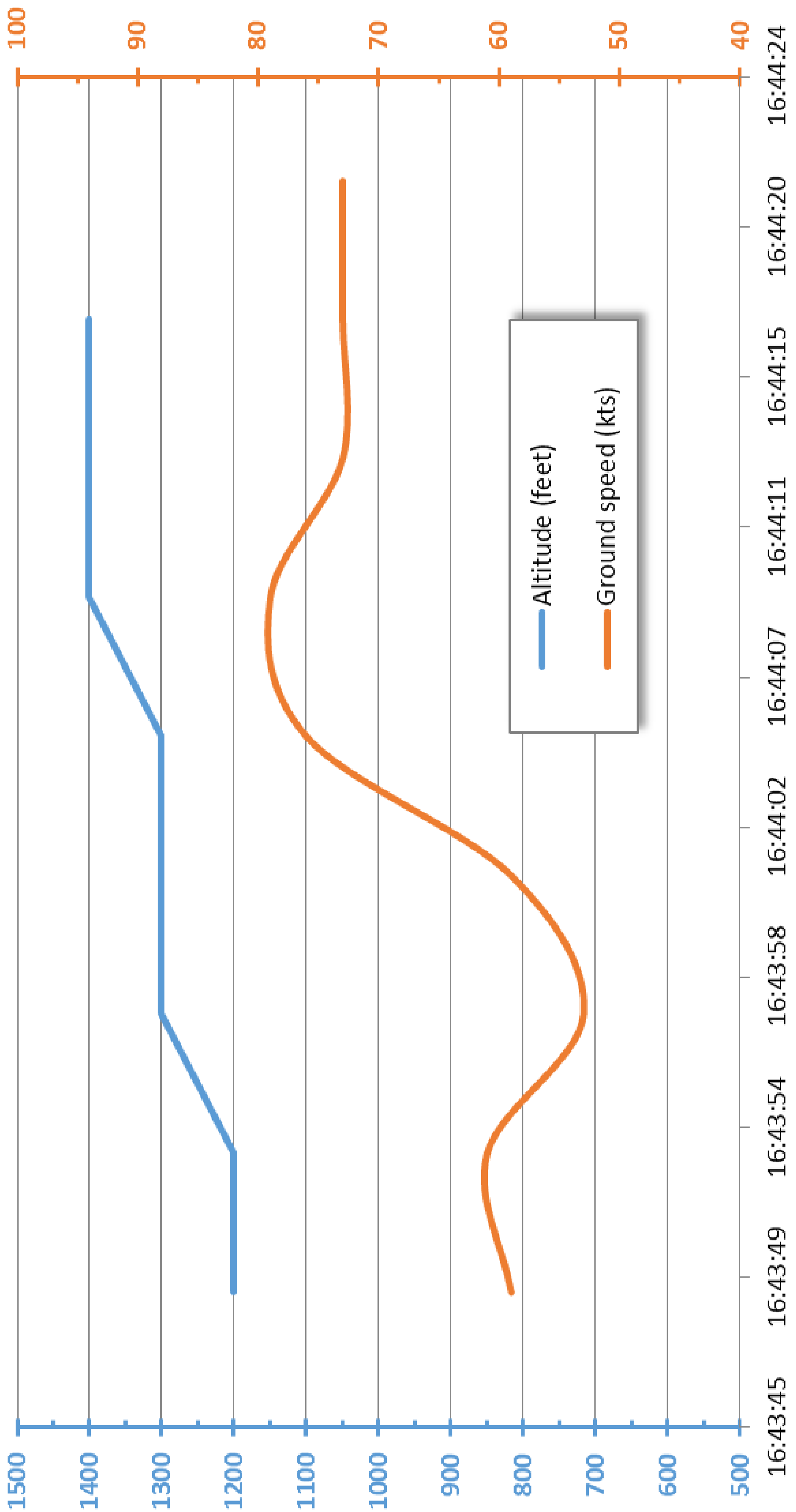
This part of the Draft Report contradicts, in any event, to the following sentence included in the Chapter 4.2. Safety recommendation(s) issued during the investigation of the same Draft Report: "*The Investigating Committee of TSB identified no circumstance which would warrant issuance of an immediate safety recommendation."*

The forensic expert cannot resolve such contradiction relying on the means available to them.

Due to the contradiction found in the Draft report, a comment should be added relating to affected statements in of the Final Report, and alteration thereof should be requested."

Based on information obtained during the investigation, the IC maintains its opinion.

Appendix 2: flight data from secondary surveillance radar



Appendix 3: Actions taken by the Organisation

"Since the accident of 25/03/2016, our Company has taken the following actions which increase safety of our operation:

1. *On the basis of a pre-prepared duty schedule, we provide an instructor-on-duty for every day when training flights are performed. A so-called dayly instructor-on-duty position has been introduced and is staffed with our full-time instructors.*

   Responsibilities of the instructor-on-duty:

   - *Check if a given student pilot is prepared for their flight task and, in the case of cross-country flight, the planned route of the flight and the airspaces affected.*
   - *Check weather minima and the state of the airfield.*
   - *Answer the student pilot's questions if any.*

2. *Prior to flight, every pilot and student pilot shall enter into a so-called operations logbook such details of their flight as the quantity of fuel and motor oil available, number and personal details of the persons to be carried, the type of flight, etc.*

3. *The booking calendar has been upgraded in such manner that now it checks both the aircraft and the crew.*

   - *Validity of aircraft documents.*
   - *Time left till next maintenance.*
   - *Validity of flight instructors'/student pilots' certificates, ratings, medical certificates and other documents.*
   - *The system blocks the release of an aircraft for use if any of the above validity dates has expired.*
   - *The use of the booking calendar is mandatory, i.e. no authorisation to takeoff in the given aircraft is given without it.*

4. *The keys and flight logs of aircraft are kept in a container in a lockable place. Only authorised people with valid booking have access to such items."*

Appendix 4: ATSB model