DUTCH
SAFETY BOARD

Stalled during take-off

Hilversum aerodrome, 15 December 2018

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The Hague, January 2022

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The Dutch Safety Board

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Dutch Safety Board

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N.B:
In addition to this English report a Dutch summary exists. If there is a difference in interpretation between the Dutch summary and the English report, the English report will prevail.

CONTENT

SUMMARY

On 15 December 2018 the pilot – being the only occupant – took off from Hilversum aerodrome for a local pleasure flight. The home-built single engine tail wheel aircraft, type Europa Aviation Limited Europa, registered as PH-BGV, demonstrated a steep climb angle during the initial climb and stalled at low height with a wing drop. The crash was fatal and the aircraft was destroyed.

The investigation revealed that the tailplane trim was not set in the take-off position, but in the full aircraft nose-down position. The cause of the full aircraft nose-down trim position could not be determined with certainty, but a technical anomaly in the trim indicator (shifted needle position over the scale) or a human factor (procedure slip or a reading error) are the most likely explanations.

During the ground roll, the incorrect trim position caused an abnormal nose-down effect. An uncommon backward stick position with a significant stick force would have been required to counteract this nose-down tendency. When applying such force, it is difficult to set the correct pitch attitude. Due to the unnatural control feel and given the risk of a ground strike of the propeller, the pilot presumably pulled the stick abruptly backwards, unintentionally initiating an early over-rotation followed by a steep climb at low airspeed. The gusty wind may have contributed to an early lift-off and the degree of rotation. Furthermore, the design of the aircraft is prone to become airborne at low speeds. As maximum take-off power at low airspeed possibly required up to full right rudder, this increased the susceptibility to slip and wing drop.

When the aircraft got airborne, the situation became critical because of the low height and low speed in combination with the still-occurring unnatural control feel, substantially required rudder input and chance of rapidly varying windspeed. This made it difficult to set the correct pitch attitude and maintain a coordinated flight (no slip). Even if the pilot would have instantly assessed the situation correctly, margins to safely remedy this critical situation were small.

ABBREVIATIONS

AD	Aerodrome
AND	Aircraft nose down
ANU	Aircraft nose up
APS	Aircraft prepared for service
BEM	Aircraft basic empty mass
CAA	Civil Aviation Authority
CofA	Certificate of Airworthiness
CG	Centre of gravity
EHAL	Ameland aerodrome
EHHV	Hilversum aerodrome
ft	Feet
GPS	Global Positioning System
ICAO	International Civil Aviation Organization
KNMI	Royal Netherlands Meteorological Institute
kg	Kilogram
kt(s)	Knot(s)
LAA	Light Aircraft Association
LAPL	Light Aircraft Pilot Licence
MTOM	Maximum take-off mass
NFI	Netherlands Forensic Institute
OM	Owner Manual
RPM	Rounds per minute
SEP	Single engine piston
TCU	Turbo control unit
TODA	Take-off distance available
TORA	Take-off run available

UDP	Uniform daylight period
UTC	Universal time coordinated
ZFM	Zero fuel mass

Identification number:	2018125
Classification:	Accident
Date, time of occurrence:	15 December 2018, 15.59 hours[1]
Location of occurrence:	Hilversum aerodrome (EHHV)
Registration:	PH-BGV
Aircraft type:	Europa Aviation Limited Europa
Aircraft category:	Fixed wing, single engine piston
Type of flight:	Pleasure flight
Phase of operation:	Take-off
Damage to aircraft:	Destroyed
Flight crew:	One
Passengers:	None
Fatalities/ Injuries:	Pilot, fatally injured
Other damage:	None
Light conditions:	Daylight

1 All times in this report are local times (UTC+1 hour), unless otherwise specified.

1 INTRODUCTION

On 15 December 2018 the pilot – being the only occupant – took off from its home base Hilversum aerodrome for a local pleasure flight with the type Europa Aviation Limited Europa. The Europa is a single engine two seat high performance homebuilt aircraft, which is not subject to the international standard of airworthiness requirements. The aircraft was Dutch registered as PH-BGV and the pilot was one of the two owners. Approximately 300 to 350 Europa aircraft are in use globally.

As far as known, nobody witnessed the ground roll during take-off, but eyewitnesses saw the aircraft in the air when it demonstrated – just airborne and at low height - a steep climb angle when it rolled to the left before it crashed. The crash was fatal and the aircraft was destroyed.

Initial information indicated that the aircraft aerodynamically stalled shortly after it became airborne. The purpose of this investigation was to determine the cause of the stall at low height and the operational and technical contributing factors.

Based upon legislation, the investigation is mandatory and has been conducted in line with the principles as laid down in annex 13 of ICAO. The Air Accident Investigation Branch (AAIB) of the United Kingdom and its technical advisors and the Austrian Civil Aviation Safety Investigation Authority of the Federal Ministry of Austria and its technical advisors participated in the investigation. The results have been included in this final investigation report.

2 FACTUAL INFORMATION

2.1 History of flight

2.1.1 Flight preparation

On the morning of 15 December 2018, the pilot decided to make a local flight in the afternoon with his aircraft, registered as PH-BGV. Due to the cold weather, he expected the engine to have starting problems. Anticipating these problems, the pilot contacted a mechanic who sometimes assisted in maintaining PH-BGV to arrange an external battery for engine start.

In the early afternoon, the pilot contacted the Royal Netherlands Meteorological Institute (KNMI) to check the weather for his flight. Just before his flight, the pilot made a phone call to the on duty operational manager of Hilversum aerodrome (EHHV) to request a non-standard taxi route, namely directly from the hangar[2] to Runway 13, to spare a long route over the grass field. The operational manager approved the request, because there were no other activities on the field.

2.1.2 Conduct of flight

After the mechanic had helped the pilot with starting the engine by connecting and disconnecting an external battery, the pilot taxied towards Runway 13. Either prior to or during taxiing, the pilot contacted the operational manager by radio requesting a radio check, which was acknowledged with a "readability 5". As there was no immediate response from the pilot, the operations manager asked "Did you copy?", which in return was confirmed by the pilot.

PH-BGV took off from Runway 13 at 15.59 hours. As far as known, nobody witnessed the take-off roll. The operational manager had just temporarily left the operating room, and two eyewitnesses stated that they only observed PH-BGV after it had become airborne. They stated that the aircraft demonstrated a steep climb angle and then rolled to the left. One of them described the nose-up attitude as if it 'stood upright in the air'. He estimated the aircraft reached a height of approximately 15 to 20 meters. His impression was that the aircraft was making a go-around before it crashed a few seconds later at the location where Runways 13/31 and 07/25 join.

2 The official parking stands and most hangars are on the southeast side of the field and only from there published taxi routes exist to each runway. A direct route to the runway would save some time and avoid a longer route with possible roughness of the terrain, see also the caution as indicated in the Aeronautical Information Publication, EHHV, AD 2.23.

The operational manager stated that he did not hear any radio communication on his handheld radio during the time he temporarily left the operating room. One of the mentioned witnesses phoned to tell him that an aircraft had just crashed. An airport rescue car was deployed by the operational manager and the driver found the destroyed aircraft in an inverted attitude with the pilot still inside the aircraft. The pilot was taken out of the aircraft and appeared to be fatally injured.

Figure 1: The crashed aircraft. (Source: Dutch Aviation Police)

2.2 Meteorological information

The wind was gusty, varying between 15 and 23 knots. The freezing level was at 300 ft height with moderate icing conditions in clouds. The uniform daylight period (UDP)[3] for 15 December 2018 ended at 16.44 hours.

Height (feet)	Wind direction (degrees)	Wind speed (knots)	Temperature (°C)	Dewpoint (°C)
ground	140	15 gusting 23	+1	-5
500	150	23	-1	-7
1.000	150	25	-2	-7

Table 1: Weather at EHHV on 15 December 2018 at 15.59 hours[4].

3 Except for some night VFR-training flights, in the period of the accident flight VFR flights in the Netherlands were only allowed during uniform daylight period (UDP).
4 Source: Royal Netherlands Weather Institute (KNMI).

2.3 Aerodrome and crash site information

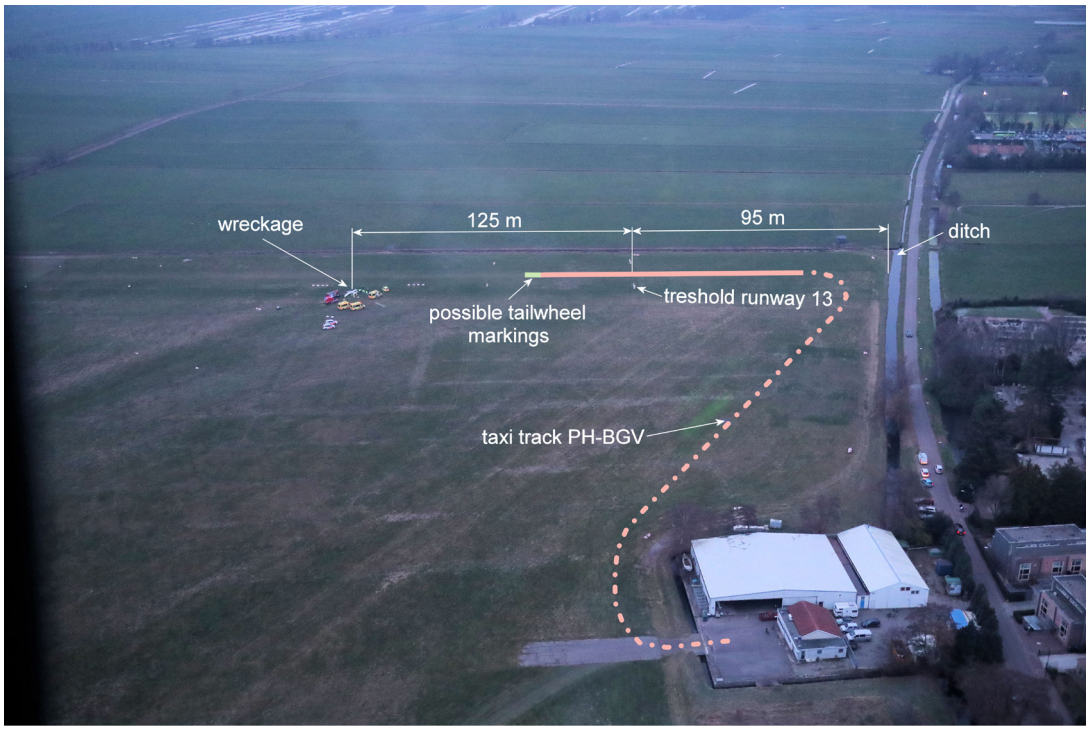

Figure 2: Overview of taxi route and take-off dimensions. (Source picture: Dutch Aviation Police)

Hilversum aerodrome (EHHV) is available for domestic and international flights. It has three grass runways: Runway 18/36, Runway 07/25 and Runway 13/31. Due to the wind from the southeast, Runway 13 was in use on the day of the accident. Runway conditions did not permit touch-and-go manoeuvres. The published take-off distance available (TODA) and take-off roll available (TORA) of Runway 13 are both 660 meters.

The threshold of Runway 13 is located approximately 95 meters from a ditch and is marked with triple red-white markers on each side of the runway. PH-BGV crashed at approximately 125 meters from the threshold, just north of the runway, see Figure 2.

When the crash site investigation started, it was dark and overnight snow had covered the runway and crash site, which hampered runway and debris field[5] observations the next day. On the second day after the accident, when the snow had disappeared, the airport authority found a trace in the grass on Runway 13 at about 45 meters from the runway threshold. This trace was approximately 5–10 meters long and possibly made by the tailwheel of PH-BGV during its take-off. No other marks, like propeller strikes, were found in the grass.

5 The traces and debris field of the canopy doors and engine cowlings may have been disturbed by rescue actions, which include movements of ambulances and rotor wash from a helicopter.

2.4 Pilot information

2.4.1 License and experience

The pilot held a valid Light Aircraft Pilot License (LAPL) issued on 23 February 2017 with class single engine piston (SEP) and an aerobatic (A) rating. His last refresher training had been on 19 October 2017 and the license had remained valid as sufficient flight hours were made. His medical certificate class 2/LAPL was issued on 10 December 2014 and was valid until 10 December 2019.

The pilot's latest logbook showed 290.5 hours as pilot in command (PIC), including his last flight prior to the accident flight on 1 December 2018. By far most of the hours were recorded for flights made with PH-BGV and all hours in this logbook were recorded as single engine and as single pilot time. The last logbook did not contain his 'total flight hours'.[6]

The pilot frequently made local flights and cross-country flights. Local flights mostly lasted around 30 minutes and he often flew over his house since he lived nearby. The airport authority stated that after take-off the pilot would occasionally first stay at low height above the runway after which he would make a steep climb. These manoeuvers are unusual for general aviation aircraft at Hilversum aerodrome.

2.4.2 Autopsy

The Netherlands Forensic Institute (NFI) carried out an autopsy on the pilot. It showed no indications of carbon monoxide intoxication, nor the presence of any other toxic substances (alcohol, medicines, drugs) that could have affected the pilot's behaviour or consciousness in relation to the accident. No diseased deviations were found. The pilot died as a result of the aircraft impacting the ground.

2.5 Aircraft information

2.5.1 General

The Europa Aviation Limited Europa is a single engine two seat high performance homebuilt aircraft. Approximately 300 to 350 Europa aircraft are in use globally.[7] The older version is the Europa Classic and the next version is the Europa XS, which has a modified wing design in order to improve stall characteristics.

PH-BGV was originally built as an Europa Classic with a monowheel with outriggers and a tailwheel. Later, the configuration changed into a fixed main landing gear with a tailwheel. The stall behaviour of Europa Classic aircraft could be improved by fitting stall strips on the leading edges of the wings, which was the case for PH-BGV.

6 The pilot's logbook shows that 94 hours and 10 minutes were recorded in one or more previous logbooks.
7 Based upon an estimate by the Europa club, these aircraft have or recently had a valid certificate of airworthiness. Probably another 150 aircraft were built but are no longer in use or have never been used (mothballed).

PH-BGV was equipped with a Rotax 914F piston engine. Its first flight (a test flight) was made on 16 September 1999. The last Certificate of Registration of PH-BGV was issued on 28 July 2016 and its validity was unlimited.

PH-BGV was classified as amateur-built.[8] Amateur-built aircraft are not subject to airworthiness requirements from the International Civil Aviation Organization (ICAO) or the European Union (EU).[9] Instead, amateur-built aircraft have to meet only a few requirements in national legislation[10], in that they have to be maintained and operated within the pertinent operating limitations in order to receive a Special Certificate of Airworthiness. When the accident occurred, PH-BGV held a valid Special Certificate of Airworthiness (valid from 26 October 2018 up to and including 13 September 2019).

Due to its classification as amateur-built, PH-BGV was not allowed to be used for commercial purposes, flight instruction or aerial work. Furthermore, not being compliant with the international airworthiness requirements, it was not allowed to fly above or within 100 meters from populated areas or crowds except when necessary for take-off and landing.

2.5.2 Owner's Manual and aircraft and engine log books

According to the Owner's Manual (OM), the builder or pilot is entirely responsible for maintenance, inspections and operations of the aircraft. The pilot of the accident flight shared the ownership of PH-BGV with another pilot[11].

The aircraft logbook (journal) had been updated until 1 December 2018, the last flight prior to the accident flight. Information in the aircraft maintenance logbook suggests the aircraft had accumulated 807.5 flight hours, as noted per 19 September 2017 upon completion of an annual inspection. A 100 hours inspection was recorded on 3 April 2018, without listing the total number of flight hours. Since then no more entries were made. The engine maintenance logbook also showed no recent flight hours.

According to the engine manufacturer, the Rotax 914 engine is supposed to be overhauled after 1,000 hours or after 10 years, whichever comes first. There was no evidence at Rotax nor in the engine logbook that an engine overhaul had been carried out since the engine was installed on PH-BGV nineteen years before the accident.

8 Source: Amendment to the Flight Manual of Civil Aviation Authority of the Netherlands (CAA-NL).
9 At that time European Regulation (EC) 216/2008 was in effect.
10 Regeling amateurbouwluchtvaartuigen.
11 The co-owner reported that a few weeks before the accident, the left canopy door had opened when flying at 1000 feet and accelerating. He and the pilot of the accident flight concluded that the rear shoot bolt had not been in its locked position. Dutch Safety Board adds that, combined with a high airspeed, chances increase that the canopy door opens due to the Venturi effect.

2.5.3 Mass and balance

According to the weight report, the aircraft prepared for service mass (APS, usually known as aircraft basic empty mass, BEM) was 419 kg, and the pilot mass (including clothing) was approximately 106 kg. The resulting zero fuel mass (ZFM) was 525 kg. Based on the fuel calculation (see Paragraph 2.6.1), the estimated take-off fuel was at most 11,2 kg.[12] The estimated take-off mass was at most 536 kg, which is within limits of the maximum take-off mass (MTOM) of 621 kg as described in the OM.

The forward centre of gravity (CG) limit is at 1473 mm (58 inch) and the aft limit is 1,588 mm (62,5 inch) aft of the datum line.[13] For the accident flight the calculated CG was within limits at 1,531 mm.

2.5.4 Take-off performance and technique

According to the OM, the estimated take-off ground roll is 490 feet (150 m) without further corrections for aircraft mass, runway conditions, aircraft configuration or meteorological conditions. Examination of the GPS navigation equipment memory revealed that no data was available to reconstruct the flight path for analyzing the take-off performance.

The OM[14] contains the following information about the take-off technique:

'Open the throttle smoothly and keep the aircraft tracking straight with rudder pedals. […] The control stick should be held just aft of neutral, there is no need for full aft stick. […] For normal operations ease the stick forward at approximately 30 kts so that the tail wheel is clear of the ground, take care not to lift the tail too high endangering the propeller – particularly in long grass. […] As the aircraft accelerates through 50 kts smoothly rotate to lift-off. Climb initially at 55 kts to clear any obstacles allowing the aircraft to accelerate to 60 kts before retracting flaps.'

The checklist of PH-BGV prescribes under the header *'Pre-take-off'* to set flaps for take-off. Under the header *'Take-off'*, the speed to lift the tail is 35-40 kts and to rotate is at 55 kts. The initial climb speed is 60 kts.

2.5.5 Aerodynamic characteristics

According to the OM for the Europa Classic[15], the aircraft stall speed is 44 kts at gross mass for gear and flaps down. The OM describes stall buffeting as an indicator that the airspeed is nearing the stall speed. The Light Aircraft Association (LAA)[16] of the United Kingdom notes that the stall speed with full power will be considerably lower. This would require up to full right rudder to maintain balance (slip ball in the middle).

12 Fuel mass = density * volume = 0,72 kg/liter * 15,5 liters = 11,2 kg.
13 The datum line is defined as 29.25" (743mm) forward of the joggle in the fuselage at the rear of the cowling, when a Rotax 912 or Rotax 914 engine is installed.
14 Section 5, Normal Operations: take-off and normal take-off procedure.
15 Section 12 Performance.
16 The Civil Aviation Authority (CAA) has approved the LAA to be responsible for the initial airworthiness and oversight of the continuing airworthiness of this type of aircraft in the UK.

The OM[17] contains a warning that during high speed taxi, the pilot and the aircraft should be ready for flight, since the aircraft can inadvertently become airborne. Taxiing should ideally be done in calm weather conditions, maximum wind 10 kts down the runway.

The described susceptibility of becoming airborne at low speed may have played a role in another fatal accident with an Europa aircraft.[18] The investigation report of that accident states that it was likely that the pilot of this aircraft had no intention to fly, but only wanted to fast taxi. The aircraft probably stalled at low altitude with the tailplane trim not in the take-off position.

2.6 Technical investigation

Two Europa pilots, who had built several Europa aircraft, participated in the investigation.

2.6.1 Fuel tank and take-off fuel

All fuel in the tank, which has a main compartment and a reserve compartment, had leaked out due to impact damage. When reconstructing the midsection of the fuselage, the fuel tank lever indicated that the main tank compartment had been selected prior to departure. The fuel pump switch was found in the ON position.

The take-off fuel for the accident flight could not be established from the wreckage. As far as known to the mechanic who runs the hangar in which PH-BGV was garaged, the pilot usually refueled PH-BGV at the regular fuel station at Hilversum aerodrome. For this flight, there was no evidence that the pilot had refueled the aircraft at the fuel station nor at the hangar by using a jerrycan. Refueling history showed that the last refueling (25 liters) prior to the crash occurred at Ameland aerodrome (EHAL) on 8 November 2018.

Assuming the fuel tank was full (70 liters, including 9 liters reserve fuel), and subtracting the estimated fuel consumption during the subsequent flights recorded in the aircraft logbook, the calculated take-off fuel[19] for the accident flight at Hilversum aerodrome was 15,5 liters. Due to the fuel tank configuration of the Europa, PH-BGV had 9 liters of fuel in the reserve fuel compartment and approximately 6,5 liters in the main fuel compartment.

2.6.2 Aircraft and damage assessment

All connections between the stick, rudder pedals and primary flight control surfaces were found broken or out of position. Damage demonstrated the tailplane (elevator) was in an aircraft nose-up (ANU) position at the moment of impact as seen in Figure 3.

Both tailplane anti-servo/trim tabs were found only connected to their hinges of the tailplane. Impact damage indicated that the trim tabs had been in a connected position during impact.

17 Section 9, Flight Testing Procedure.
18 AAIB Bulletin No: 9/2000, Ref: EW/C2000/03/06.
19 According the aircraft journal 4 flights were made with a total flying time of 2 hours and 20 minutes and trip fuel was assumed to be18 liters per flight hour. Taxi fuel was 2,5 liters per flight for 5 flights, including the accident flight.

After reconnecting the anti-servo/trim tabs, as seen in Figure 3 for the left one, they showed an aircraft nose-down (AND) trim position. Further examination of the trim servo motor demonstrated it was in the full AND position.

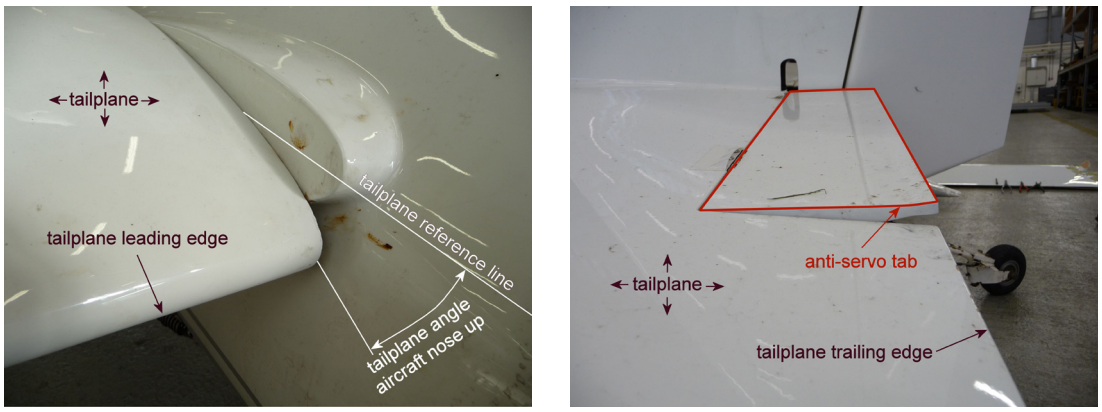

Figure 3: Left: tailplane in ANU position on impact. Right: the left anti-servo/trim tab in full AND position (Source: Dutch Safety Board).

The left flap was partly detached and the drive mechanism showed that flaps were in the 10 degrees take-off position. The detachable wings were out of their normal (attached) position. Engine control settings were found consistent for take-off. Impact broke the fuselage almost in two. The break was located behind the seats and fuel tank and did not extend to the bottom part.

As it was common to use a car to tow the aircraft across the field from the hangar to the fuel station (or vice versa), the seat belt of the passenger was used to secure the flight control stick in order to protect, in particular, the tailplane against damage. To check whether the flight controls were free, the seat belt of the passenger was found unbuckled and at a length that does not match with securing the tailplane.

The construction of both canopy doors[20] was severely damaged by ground impact. The shoot bolts of the right door latches of the canopy were found in the closed positions land locked in its bushing in the aircraft frame. The left door shoot bolts were found in the closed position. Rescue actions might have disturbed the evidence of the position of the left canopy door and its locking.

A limited inspection of the engine[21] and propeller system showed severe impact damage to the governor housing accompanied with traces of oil on the engine. Neither of the two carburetors contained any fuel, which had likely vaporised by the time the inspection took place. Both carburetors were internally free of contamination.

20 Rescue works may also have contributed to the found damage of the canopy. Crash site information gives the impression that the left canopy door and engine cowling had been (re)moved.

21 Cracks in the engine frame were found on other Europa aircraft. Inspection showed that the engine of PH-BGV had been in the correct (pitch) position during the accident flight as the engine frame showed no breaches due to corrosion.

2.6.3 Digitally recorded engine information

The Flydat[22] records samples of engine operation parameters. Data analysis of engine speed, the oil system, and temperatures of cylinder heads and exhaust gases did not reveal any anomalies. It was not possible to derive usable engine data out of the turbo control unit (TCU) memory chip due to damage.

2.6.4 Tailplane trim system

The format of the checklists found in the PH-BGV owners' documentation is not the standard for Europa aircraft. One of the items underneath the header *'Cockpit'* – where the items for preparing the cockpit prior to starting the engine are listed – indicates to set the trim 3 notches[23] down. This item is not listed in the standard format of the checklist of the manufacturer.

In the 'Pre-take-off checklist', the trim needs to be set for take-off. The OM does not specify the take-off position on the trim indicator. Amateur-built aircraft may differ from each other, and as such may have different take-off settings on the trim indicator.

Past pictures of the PH-BGV instrument panel show that the trim indicator in the cockpit used to have a small yellow pointer-shaped bug (placard), pointing at approximately the second unit below the middle position on the trim indicator scale. The co-owner of PH-BGV, who flew on PH-BGV regularly, confirmed the yellow bug indicated the trim position for take-off. The small yellow placard, as seen in Figure 4, was not found during the investigation and it is unknown whether the yellow bug was still attached to the trim indicator prior to the accident flight.
The tailplane trim switch, with a spring return mechanism, was found in its neutral position. The wiring of the trim system was intact, except for some breaches due to impact.

Figure 4: The trim indicator with yellow bug during flight a few years before the accident.
(Source: PH-BGV co-owner)

22 Flydat is an electronic device for indicating engine data during flight and storing data of the last 20 samples of each parameter for engine maintenance purposes.
23 The meaning of this item is not quite clear as 'Notch' is not used in the standard checklist of the Europa.

The electrical analogue trim indicator was pulled out backwards from the instrument panel during impact and showed a broken signal wire (orange/white). Metallurgical examination in a laboratory showed the signal wire failed due to overload. Examining the electrical trim servo motor revealed that the trim was in full aircraft nose down (AND) position.[24]

2.6.5 Testing the electrical elevator trim system

The electrical elevator trim system had sustained minor damage from the accident and it was possible to test the system post-accident.

The electrical trim servo motor worked properly in both directions over its full range when tested separately. The complete wiring including the trim switch and circuit breaker, was tested for signal continuity and found to be functioning properly.

The trim indicator was tested by setting the servo motor to various positions (middle position, full AND and full ANU) and using another – in this case digital – trim indicator for comparison. The position of the red needle on the trim indicator showed a systematic deviation of approximately three and a half units, which is one third of the total range on the trim indicator display. The testing could not reveal whether this condition existed prior the accident flight or that it was a result of the impact.
Aircraft logbook and interview information from the engineer, who regularly carried out inspections on PH-BGV, did not reveal evidence that the trim indicator had been removed from the instrument panel and re-installed, or that there had been any work done on the tailplane trim system.

2.7 Flying with full down trim

2.7.1 Reference flight for investigation

A flight with another Europa aircraft[25] was made. The goal of this flight for investigation was to experience the flight handling characteristics of the Europa aircraft in take-off with full AND trim position at low airspeed, as was the case with the accident flight. The flight handling characteristics in this configuration, under calm weather conditions provided insight into the extent to which PH-BGV was controllable during the accident flight. Just like PH-BGV, the aircraft used for this reference flight had stall strips installed on the wings.

Similar to the accident flight, the aircraft was configured with flaps 10˚, the propeller governor set for take-off and full take-off power was applied. During the reference flight, the atmosphere was stable and the ball of the slip indicator was kept in the middle to maintain a coordinated flight straight ahead (no slip).

24 In tenths of a second the extreme AND position was reached. As this difference is insignificant, for the readability the extreme or full AND position is used.
25 An Europa XS with a main landing gear and a nose landing gear (tri-gear) with two pilots on board.

2.7.2 Results of the reference flight

It was possible to maintain a climb speed, which was 5 knots above the stall speed of the aircraft used for this reference flight. Flying with this trim setting was demanding. Furthermore, the crew performing this reference was prepared and the unusual trim position was carefully realised in steps.

The crew experienced the following:

- The stick force was unusually high for the Europa aircraft, but acceptable in terms of muscle power required;
- The control stick was in an unusual backward position resulting in an unnatural feel of pitch control;
- Due to the unusually high stick force, it was difficult to adjust the amount of elevator input (i.e. less/more pressure on the stick) needed to maintain proper pitch and climb speed.

Overall, the reference flight showed that, with advance knowledge of the trim setting, preparation and focus, the aircraft was controllable, but it demanded specific attention. The difficulty in proportioning the amount of pitch causes a critical situation when airspeed is close to stall speed.

3 ANALYSIS

3.1 Initial findings

3.1.1 Stall at low height

The inverted attitude of the aircraft during impact and the impact marks on the ground indicate a loss of control that occurred immediately at, or shortly after lift-off. Furthermore, eye witnesses reported a steep pitch angle followed by a left roll at approximately 15 to 20 meters above the ground. Based upon these indications, it is concluded that the aircraft entered into a stall, causing a wing drop. The uncontrolled impact with the ground, with an inverted attitude of the aircraft, was not survivable.

3.1.2 Investigation topics

Aircraft impact damage, traces on the ground and information from eyewitnesses indicate a scenario of an aerodynamic stall at low height. Therefore, the investigation focused on factors which are directly linked to pitch effects, namely:

- Flight characteristics including take-off technique;
- The flight control system, in particular the elevator (tailplane) and its trim system. Settings of the trim system, as well as pilot input to the elevator, immediately affect the pitch behaviour of the aircraft in the air. Because PH-BGV was equipped with a tail wheel, pitch behaviour was also relevant during the ground roll for take-off;
- The position of the centre of gravity;
- The aircraft configuration for take-off. The flap system and the engine settings for take-off were assessed.

Both the condition of the aircraft and the pilot were also investigated, because these factors can contribute to stall accidents.

3.2 Excluded factors

3.2.1 Flight and fuel

The pilot often made short local flights with an average of approximately 30 minutes. Without hurry, a short flight could be done within the remaining uniform daylight period which ended 45 minutes after take-off time on 15 December 2018. As such, the accident flight of this pilot was not different from other flights.

Due to runway conditions, touch and go practicing was not allowed by the aerodrome authority. Hence, the pilot intended to temporarily leave the aerodrome circuit area, probably to fly to his home as he often did since he lived near the aerodrome.

Based upon the calculated fuel, the equivalent of 52 minutes of fuel remained for take-off. It is concluded that fuel starvation can be excluded.

3.2.2 Pilot and aircraft

The license of the pilot, his medical certificate and all aircraft certificates were valid. The pilot was in good health and autopsy showed no evidence that he had been exposed to toxic substances that would have affected his skills or behaviour.

A general assessment of the engine frame, engine controls and examination of the technical state of the flight control systems – in particular the pitch control (tailplane) and flap systems - did not reveal anomalies that would have been present prior to the accident. The state of the passenger seat belt indicated that the control sticks were free for flight.

Taking into account the wreckage and crash site information, no conclusions can be made whether the left canopy door opened during take-off. Yet, as the pilot knew the canopy opened during a recent flight made by the co-owner, he might have paid more than normal attention to the locking. Additionally, as the airspeed was low (little Venturi effect) during the take-off of the accident flight, it is less likely that the left door opened.

The centre of gravity (CG) was within limits of the flight envelope. Flap position and engine RPM had been properly set for take-off.

The engine maintenance did not meet the requirements for overhaul of the manufacturer Rotax, but this finding had no relation to the cause of the accident. Data analysis of the last stored samples in the Flydat did not indicate anomalies in the operation of the engine.

The short take-off distance and (steep) climb suggest that the engine produced significant power, but no data was available to confirm this.

3.3 Trim position

3.3.1 Incorrect trim setting

The trim position was found in the full AND position, which is not a normal setting for take-off as it creates unnatural control feel flight and the risk of a ground strike of the propeller.

A runaway trim is considered as unlikely, because technical investigation and testing of the trim system showed no failures in the trim driving and control switch system. Furthermore, aircraft maintenance history did not reveal that there had been any complaints or maintenance actions relating to the trim system. A post-crash runaway trim is excluded as no electrical power to the trim motor was available due to impact damage.

Occasionally, the pilot stayed low after lift-off to accelerate for a steep climb farther down the runway. To anticipate pitch up effects at higher airspeeds, it is not uncommon to set the trim more AND than for a normal take-off. However, this would not explain the extreme AND position (full AND).

3.3.2 Testing of the trim indicator

Testing of the trim indicator system revealed a deviation of at least 3 units (stripes on the scale). The testing could not establish whether this deviation of the trim indicator existed prior to flight when the trim was set (technical issue).

Otherwise the deviation of the trim needle position was caused by the impact, meaning that the incorrect trim position was the result of a human factor: either the pilot forgot to check and set the trim (procedure slip), or he made a reading error when he set the trim.

3.4 Effect incorrect trim setting on ground roll

3.4.1 The ground roll

As far as known, nobody witnessed the take-off ground roll. The wreckage was found at a distance of approximately 125 meters from the Runway 13 threshold marking. Taking into account PH-BGV reached a height of possibly 10-20 meters and the required 150 meters ground roll (uncorrected for operational conditions) as mentioned in the OM, it is unlikely the pilot initiated the take-off roll from the threshold of Runway 13.

Since it was approved to taxi from the hangar directly to Runway 13, the pilot must have commenced the take-off roll at or close to the ditch at the northwest side of the airfield, see Figure 2. This might also explain the trace in the grass at 45 meters from the threshold into the direction of Runway 13. This trace could be a print of the tailwheel of PH-BGV.

3.4.2 Effects extreme trim position and gusts on pitch behaviour

The prevailing headwind component (15 kts gusting 23 kts) and the relatively low take-off mass (85 kg below the maximum take-off mass) reduced the required take-off ground roll significantly. Consequently, airspeed and lift must have built up quickly.

As the aircraft accelerated during the take-off roll, its nose likely pitched down due to the effect of the full AND trim position setting. As revealed by the reference flight (see Paragraph 2.7.2), the control stick must be put in an unusual backward position in order to counteract this nose down tendency to avoid a propeller ground strike and to keep the correct aircraft attitude. In order to maintain that stick position, the pilot must have applied an uncommonly high stick force. It normally requires light control forces and a slightly aft-of-centre stick position to keep the correct attitude.

Furthermore, the reference flight showed that when applying high force, it is difficult to set the correct pitch attitude. Therefore, the aircraft could easily have been over-controlled.

It is concluded that in attempting to stop the nose-down tendency during the ground roll, the pilot presumably over-rotated the aircraft unintentionally due to the unnatural control feel, which led to an early steep climb and subsequent stall.

Due to the lack of recorded GPS data, the take-off (roll) – and in particular lift-off speed – could not be reconstructed. Considering the relatively short take-off distance (ground roll and flight path) and low height the aircraft reached, it is estimated that the aircraft became airborne close to the stall speed. According to the OM the stall speed of the type Europa is 44 kts, but under the effect of take-off power the stall speed could have been significantly lower.

Furthermore, as aerodynamic force increases to the second power with increasing airspeed, any gusts may have adversely affected the moment and degree of rotation contributing to a steep climb. Additionally, a positive gust instantly increases the lift produced by the wings. Combined with an abrupt correction (or over-rotation) by the pilot and the ground effect[26], a gusting wind may have further contributed to an early lift-off of PH-BGV.

This rapid increase and decrease of wind velocity is particularly dangerous when lift-off occurs close to the stall speed, where a short slip condition after lift-off due to slight crosswind from the right and an imbalance around the longitudinal axis (heavy pilot on left seat, right seat empty) may cause the left wing to drop. Additionally, as take-off power at low airspeed after lift-off possibly required up to full right rudder (see 2.5.5, note of LAA), this increased the susceptibility to slip and hence wing drop.

3.4.3 Effect of design

As indicated by a warning in the OM (see 2.5.5, Aerodynamic characteristics) and as seen in an accident report issued by the AAIB (*bulletin 9/2000*), this type of aircraft is prone to become airborne at low speed. Taking into account the pilot's action to counteract the nose-down tendency during the ground roll, it is concluded that the aerodynamic characteristics of the type Europa increased the risk of a lift-off close to the stall speed.

3.5 Effect incorrect trim setting when airborne

It is common knowledge for pilots to abruptly lower the nose of the aircraft when they stall or when they realize that a stall is imminent. Pilots are usually trained to do so, as it is the only option to immediately increase the margin to stall or to recover from it. As eyewitnesses reported a steep climb, the pilot of PH-BGV had no other option than to abruptly lower the nose. When stalling, loss of height is inevitable. The height the aircraft reached as observed by an eyewitness was too low for recovery.

26 When a wing is near the ground the presence of ground modifies the airflow around the wing, which is called the ground effect. It causes an increased lift which during take-off helps the aircraft to become airborne, but not to climb.

The full AND trim position would have facilitated in lowering the nose, but as seen in Figure 3 in Paragraph 2.6.2, the tailplane was in an ANU position at the moment of impact. The found ANU position of the tailplane can only be the result of pilot input. This might be the intuitive response of a pilot when being close to the ground.[27] This intuitive response would have opposed increasing the margin to stall or, when already in a stall, perpetuated the stall.

Due to its low airspeed and low height, the aircraft was still in a low energetic state while the pilot had to fly with an uncommonly backward stick position and uncommon steering forces after the ground roll. This all occurred in a short period of time.

Again, but now for an airborne situation, the unnatural feel and uncommon stick position would have made it difficult for the pilot to set the correct pitch attitude. The gusty wind would have also made it harder for the pilot to control the pitch as he would be required to make adjustments to counter the effect of the gusts. Even if the pilot would have been immediately aware of the low airspeed or (imminent) stall, the margins to safely remedy this critical situation were small.

27 Skybrary: Counter-intuitive responses - after much routine training emphasizing the recovery from the approach to the stall, which usually requires an increase in thrust and a relatively small reduction in pitch attitude, it may well be counter intuitive to use full down elevator control or to reduce thrust when recovering from a high angle of attack, especially at low altitudes.

4 CONCLUSIONS

The aircraft crashed because it stalled at low height as a result of an overly high pitch attitude, followed by a left wing drop. The aircraft was destroyed in the crash, which was not survivable for the pilot.

The physical condition of the pilot, the centre of gravity, the take-off configuration of the flaps, engine frame and engine settings, and the state of the flight control systems can all be excluded as factors that adversely affected pitch control.

The tailplane trim was found in the full aircraft nose-down position. This is an incorrect trim position for take-off, which made it difficult to control the pitch during a critical phase of flight. The cause of the full aircraft nose-down trim position could not be determined with certainty, but a technical anomaly in the trim indicator (shifted needle position over the scale) or a human factor (procedure slip or a reading error) are the most likely explanations.

An uncommon amount of stick force and an unusual stick position were required during both the ground roll and when airborne to counteract the nose down tendency due to the incorrect trim setting. When applying such force, it is difficult to set the correct pitch attitude. Therefore, the aircraft may easily have been over-controlled by the pilot, which is supported by the trace in the grass of possibly the tailwheel, no evidence of a ground strike by the propeller and the steep climb angle at low height as seen by eyewitnesses.

The pilot presumably over-rotated the aircraft unintentionally due to the unnatural control feel, which led to an early rotation followed by a steep climb close to the stall speed. The gusty wind may have adversely affected the moment and degree of rotation and the early lift-off at low airspeed. The design of the aircraft is prone to become airborne at low speeds. As maximum take-off power at low airspeed possibly required up to full right rudder, this increased the susceptibility to slip and wing drop.

Once airborne, the aircraft was in a critical situation because of the low height and low airspeed combined with the difficulty to set the correct pitch attitude (due to the unnatural control feel and possible wind gusts) and potential slip condition. Even if the pilot would have been immediately aware of the low airspeed or (imminent) stall, the margins to safely remedy this critical situation were small.

APPENDIX A

Responses to the draft report

In accordance with the Dutch Safety Board Act, a draft version (without recommendations) of this report was submitted to the parties involved for review. The following parties have been requested to check the report for any factual inaccuracies and ambiguities:

- Air Accident Investigation Branch (AAIB) of the United Kingdom,
  - Light Aircraft Association, technical advisor to AAIB
- Civil Aviation Safety Investigation Authority of the Austrian Federal Ministry),
  - BRP-Rotax GmbH & Co KG, technical advisor to the investigation authority
- Human Environment and Transport Inspectorate of the Netherlands (ILT)
- Hilversum aerodrome
- Mechanic
- Co-owner of the aircraft
- Relatives

The responses received, as well as the way in which they were processed, are set out in a table that can be found on the Dutch Safety Board's website (www.safetyboard.nl).

The responses received can be divided into the following categories:

- Corrections and factual inaccuracies, additional details and editorial comments that were taken over by the Dutch Safety Board (insofar as correct and relevant). The relevant passages were amended in the final report.
- Not adopted responses; the reason for this decision is explained in the table.
- Adopted responses; they are also listed in the table.

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