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Swiss Transportation Safety Investigation Board STSB

Final Report No. 2289 by the Swiss Transportation Safety Investigation Board STSB

concerning the accident involving the SIAI Marchetti S.205-18/R aircraft, registration N108MW,

on 19 October 2014

Speck-Fehraltorf Aerodrome (LSZK), Fehraltorf/ZH

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Ursachen

Der Unfall ist darauf zurückzuführen, dass das Flugzeug nach dem Abheben kaum Höhe gewann und der Pilot den Anfangssteigflug abbrach. Der mangelnde Höhengewinn ist höchstwahrscheinlich auf eine unzweckmässige Starttechnik in Verbindung mit einer hohen Startmasse zurückzuführen. Beim Ausrollen im Gelände wurde das Flugzeug stark beschädigt.

Folgende Faktoren haben zum Unfall beigetragen:

- Eine nicht funktionierende Überziehwarnung.
- Eine nicht vorhandene Berechnungsgrundlage für die Startleistung.

General information on this report

This report contains the Swiss Transportation Safety Investigation Board's (STSB) conclusions on the circumstances around and causes of the accident under investigation.

In accordance with article 3.1 of the 10th edition of annexe 13, effective from 18 November 2010, to the Convention on International Civil Aviation of 7 December 1944 and article 24 of the Federal Aviation Act, the sole purpose of an aircraft accident or serious incident investigation is to prevent further accidents or serious incidents from occurring. Legal assessment of the circumstances and causes of aircraft accidents and serious incidents is expressly excluded from the aircraft accident investigation. It is therefore not the purpose of this report to establish blame or to determine liability.

Should this report be used for purposes other than those of accident prevention, this statement should be given due consideration.

The German version of this report constitutes the original and is therefore definitive.

All information, unless otherwise indicated, relates to the time of the accident.

All times in this report, unless otherwise indicated, are stated in local time (LT). At the time of the accident, Central European Summer Time (CEST) applied as local time in Switzerland. The relation between LT, CEST and coordinated universal time (UTC) is:
LT = CEST = UTC + 2 h.

Final Report

Aircraft type	SIAI Marchetti S.205-18/R	N108MW
Operator	Plane Fun Inc. TR Trustee, 2003 Deerfield Run, Snellville, GA 30078-2403 (USA)	
Owner	Private	

Pilot	Swiss citizen, born 1959			
Licence	Private pilot licence aeroplane PPL(A) issued by the Federal Aviation Administration of the United States of America (FAA) on 20 September 2009			
Flying hours	**total**	1047:38 h	**during the last 90 days**	9:21 h
	on the accident type	63:17 h	**during the last 90 days**	9:21 h

Location	200 m beyond the end of runway 30 at Speck-Fehraltorf aerodrome (LSZK)		
Coordinates	699 168 / 248 367	**Altitude**	535 m AMSL
	N47° 22’ 43.1” E008° 45’ 06.5		1755 ft AMSL
Date and time	19 October 2014, 17:13		

Type of operation	Private VFR
Flight phase	Take-off
Type of accident	Emergency landing after aborting initial climb

Injuries to persons

Injuries	Crew members	Passengers	Total no. of occupants	Third parties
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	0	0
None	1	3	4	n/a
Total	1	3	4	0

Damage to aircraft	Severely damaged
Third-party damage	Slight damage to the ground

1 Factual information

1.1 Background and history of the flight

1.1.1 General

The subsequent description of the background and history of the flight is based on the pilot's statements, the recorded data of the GPS receiver on board the aircraft as well as the aircraft records.

1.1.2 Background

In 1966, the factory new SIAI Marchetti S.205-18/R was registered as HB-ELK in Switzerland and in operation there until 1997. The aircraft was taken out of service from 1997 to 2010. In 2010, the aircraft was bought by a private individual. After various maintenance work, it was flown again in 2011 for the first time after the decommissioning and was now registered in the United States as N108MW.

The aircraft was flown to Speck-Fehraltorf (LSZK) on 8 October 2014, where it was to be temporarily based for a few weeks.

On Sunday, 19 October 2014, the pilot arrived at Speck-Fehraltorf aerodrome with three passengers. A sightseeing flight lasting about 1 h was planned. The aircraft had been parked in the open on the south-west side of the runway. After the pilot had filed a flight notification in the C-office, he proceeded to the aircraft together with the passengers to prepare the aircraft for the flight. The tie-downs were removed and the pilot checked the engine oil level and other items. During this pre-flight check, it was forgotten to remove the pitot tube cover.

Eventually, all four occupants boarded the aircraft and the pilot started the engine. After the engine had warmed up, the engine run-up was performed and the aircraft subsequently taxied to the begin of runway 30. At 17:02, the first take-off attempt took place. During the take-off run, the pilot noticed that the speed indicator remained at zero. He therefore aborted the take-off and taxied back to the original parking position. There, he set the engine to idle and exited the aircraft together with the passenger sitting in the front right seat to remove the pitot tube cover. Subsequently, both reboarded and the pilot once again taxied the aircraft to the begin of the runway.

1.1.3 History of the flight

At 17:13, the aircraft SIAI Marchetti S.205-18/R, registered as N108MW, began its take-off run on grass runway 30 at Speck-Fehraltorf aerodrome. According to the pilot, he rotated the aircraft to the take-off attitude about two-thirds of the way down the runway, at which point it lifted off the ground. The pilot stated that on rotating he had read an indicated airspeed of approximately 65 kt on the inner dial, i.e. in the green range of the display. The aircraft climbed the first few metres as expected. Approximately 4 m above the ground, the pilot had the impression that the rate of climb was too low. He reduced the pitch angle in order to increase the speed. At the same time, he initiated a turn to the left to avoid the hill beyond the runway extension, as is stipulated in the visual approach chart (VAC). Thereafter, he slightly increased the pitch attitude in order to gain more altitude. However, when doing so he had the impression that the engine power was too low, i.e. lower than usual. During this phase, the engine instruments displayed normal values and the pilot did not observe any changes in engine noise. Eventually, the aircraft descended again. The stall warning did not sound during the entire flight.

The pilot concluded that the aircraft would not continue to fly and pulled the throttle back. The aircraft touched down in a nose-up attitude on adjacent grassland about 57 m beyond the end of the runway and 18 m to the left of the runway centerline.

The right-hand main landing gear made the initial contact with the ground. The mark left by the left-hand main landing gear started at about 9 m, and the marks left by the nose wheel started at about 20 m past the touchdown point of the right-hand main landing gear. The marks made by the landing gear ran at an angle of approx. 12° left of the runway axis.

After 64 m, the aircraft crossed the local road between Fehraltorf and Wermatswil, rolled through a cornfield and finally came to rest 67 m past the road, or 188 m past the end of the runway, with torn-off landing gear and lying on its belly.

All occupants were uninjured and were able to exit the aircraft unaided.

The aircraft was severely damaged.

1.2 Meteorological information

1.2.1 General weather conditions

A high-pressure system with its centre over south-eastern Europe determined the weather. At altitude, a ridge extended from the western Mediterranean to the Baltic countries.

1.2.2 Weather at the time and location of the accident

The weather was sunny with very little wind at ground level. At the time of the accident, there was a slight wind at ground level of two knots from variable directions. Visibility was more than 10 km.

Cloud	No clouds apart from some cirrus
Weather	Dry
Visibility	10 km or more
Wind	Variable, 2 kt
Temperature / dew point	22 °C / 13 °C
Atmospheric pressure QNH	1023 hPa
Hazards / outlook	No significant change

1.2.3 Astronomical information

Position of the sun	Azimuth: 241°	Elevation: 11°
Light conditions	Daytime	

1.3 Information on the aircraft

1.3.1 General information

Specification	Single-engine, four-seater touring aircraft with piston engine, designed as a cantilever low-wing aircraft in an all-metal construction with retractable landing gear in nose-wheel configuration
Manufacturer	Società Idrovolanti Alta Italia SIAI Marchetti
Year of manufacture	1966
Engine	Lycoming O-360-A1A, air-cooled four-cylinder horizontally opposed engine with carburettor, s/n L-9021-36A, year of manufacture 1966, 134 kW (180 hp) continuous power

Propeller	Two-blade, variable-pitch Hartzell propeller HC-C2YK-1B, s/n CH-333, year of manufacture 1965
Equipment	VFR equipment
Operating hours	Airframe 3914:54 h (TSN)[1]
	Engine 3914:54 h (TSN); 1864:58 h (TSO)[2]
	Propeller 3914:54 h (TSN); 365:56 h (TSO)
Max. permissible mass	Max. permissible take-off mass of 1200 kg
Mass and centre of gravity	The mass of the aircraft at take-off was about 1220 kg.
	The centre of gravity was within the permitted limits according to the aircraft flight manual (AFM).
Maintenance	The last annual inspection was performed on 18 September 2014 at 3906:00 hours by a maintenance organisation in Germany.
	On 15 October 2014, a leak in the left-hand brake was fixed.
Technical restrictions	No items were recorded in the flight logbook
Approved fuel quality	Aviation gasoline, minimum grade 91-96
Fuel quantity	After the accident, 88.5 litres of fuel were drained from the tanks. This amount of fuel would have been sufficient for a flight time of about 2:20 h.
Certificate of airworthiness	Issued by the FAA on 20 October 2010.

1.3.2 Information from the aircraft manufacturer

The aircraft flight manual (AFM) contains only a few guidelines for the take-off procedure, and absolutely no information on take-off performance. The take-off is described as follows:

"Take-Off

[...]

Set Trim Tab to take-off position.

Set wing flaps to 15°.

[...]

Mixture control – full forward.

Propeller control – full forward.

Turn ON auxiliary fuel pump.

Secure cabin door.

Apply full throttle.

[1] TSN: time since new

[2] TSO: time since overhaul

After Take-Off

Retract landing gear;

[...]

Initial climb out at 75 MPH (minimum speed for cooling and speed for best R/C at sea level with flaps in take-off position).

Turn OFF auxiliary fuel pump.

Climb

Set trim tab for 85 MPH (speed for best R/C at sea level).”

The airspeed recommended by the aircraft manufacturer for the initial climb of 75 mph is equivalent to 65 kt.

The speed range for standard operation is between 65 and 150 mph (green arc on the speed indicator). The speed range when flying with extended landing flaps is between 57 and 102 mph (white arc on the speed indicator).

1.4 Information on the pilot

The last bi-annual flight review was signed-off on 4 November 2012 in the pilot’s logbook.

His third-class medical certificate was issued by the FAA on 29 April 2013, and included the limitation “*must wear corrective lenses*”.

In addition to the FAA-issued private pilot licence, the pilot also held a commercial pilot licence aeroplane CPL(A), in accordance with Joint Aviation Requirements (JAR), initially issued by the Swiss Federal Office of Civil Aviation (FOCA) on 3 March 2008.

The class rating for single-engine piston (land) (SEP(L)) was valid until 17 February 2012.

According to the pilot, he had taken off from Speck-Fehraltorf aerodrome (LSZK) with N108MW once before. At that time, however, he took off with a lighter load. He added that when flying the aircraft involved in the accident, he usually took off from longer concrete runways.

1.5 Information on the aerodrome

Speck-Fehraltorf aerodrome (LSZK) is situated 10 NM south-east of Zurich-Kloten airport (LSZH).

The grass runway is reinforced with plastic tiles and has the following dimensions:

Runway description	Dimensions	Altitude of airfield
12/30	600x18 m	1758 ft AMSL[3]

The runway length available for N108MW to take off from runway 30 was 600 m.

[3] AMSL: above mean sea level

1.6 Information on the wreckage

Observations made on the wreckage at the accident site included the following:

- The aircraft was lying on its belly on grassland. The nose wheel and the right-hand landing gear were bent backwards; the left-hand main landing gear was bent outwards.
- The propeller made contact with the ground. One propeller blade was bent severely backwards, the other appeared not to be bent. The deformation of the propeller blades indicated that the engine was producing little or no power when they contacted the ground and that engine speed was low.
- The seat belts were worn by all occupants and withstood the loads placed on them.
- Carburettor heat was off.
- The throttle was fully pushed forward (full throttle).
- The propeller control lever was in the maximum speed position.
- The mixture control was in the FULL RICH position.
- The flaps were extended to the first stage, equivalent to 15°. This was consistent with the position of the flap control handle.
- The switch for operating the retractable landing gear was in the GEAR DOWN position. The control lamps of the retractable landing gear were functioning.
- The fuel valve was in the RIGHT TANK position.
- The aircraft was equipped with a Kanad 406 AF-COMPACT emergency location transmitter (ELT). This was not activated by the impact.
- The stall warning did not sound when the stall warning vane was moved upwards.
- The elevator, rudder and aileron could be moved without any faults and deflected in the correct sense.
- From the neutral position, the elevator trim tab was set slightly in the NOSE UP direction.

Illustration 1: Final position of the N108MW

Illustration 2: Aerial view of the accident site

1.7 Medical information

There is no evidence of the pilot experiencing any health problems during the accident flight.

1.8 Technical investigations

1.8.1 General

The general technical condition of N108MW was poor. Examples include the following:

- The exhaust pipe flange on cylinder no. 3 was defective.
- The baffles inside the exhaust muffler were damaged.
- The rubber engine mounts were severely cracked.
- The flexible oil return tubes were severely cracked.
- The rubber sleeves of the manifold pipes to the individual cylinders were cracked.

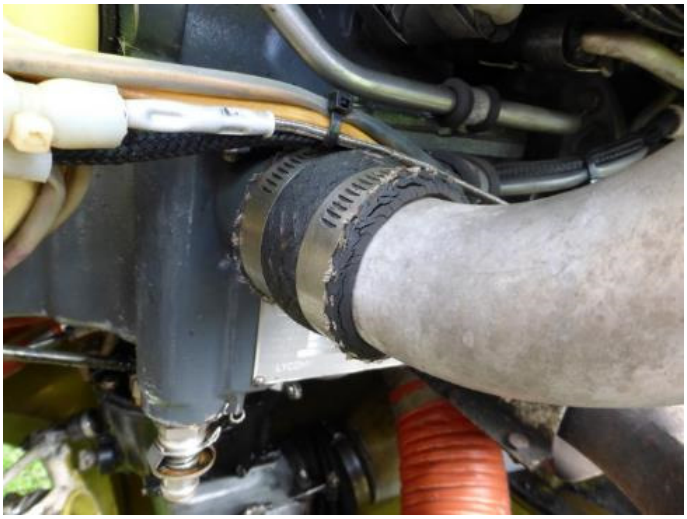

Illustration 3: Cracked rubber sleeves on the manifold pipes to the cylinders

- When the electric fuel pump was disassembled, fuel was found inside the pump and the strainer was clean. The seal on this strainer was cracked and some pieces were missing.

Illustration 4: Strainer of the electric fuel pump with cracked seal

- Upon further examination of the wreckage, it was found that behind the instrument panel, the vacuum filter for the instruments air could chafe on the flight control rods.
- Some of the electrical wiring was improperly installed. There were several loose wires that could chafe on the control rods. Quite a few wires without insulated ends were also found. In addition, lustre terminals were used which are not permitted in aircraft applications.

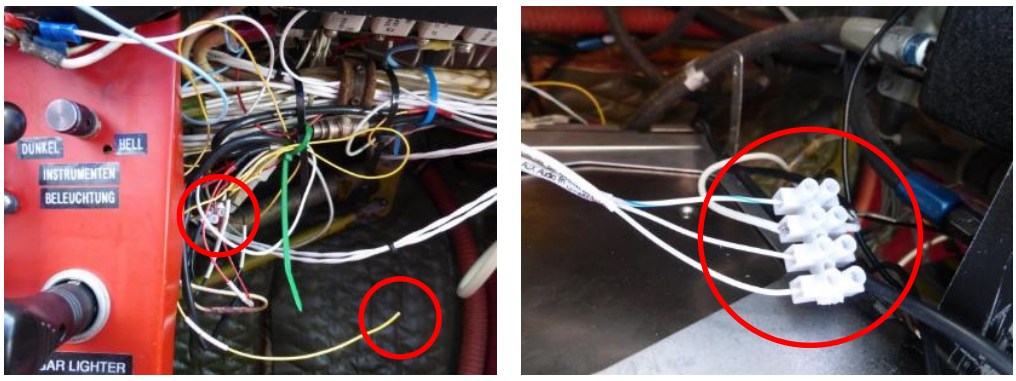

Illustration 5: Electrical wiring behind the instrument panel

- A Garmin GPSMAP 695 GPS device with moving map was installed in the instrument panel and wired to the aircraft's electrical power supply. The installation of this unit was not carried out in a professional manner.

1.8.2 Stall warning system

The stall warning system was inoperative. The stall warning vane contacts were dirty and corroded. With the switch closed, they therefore did not ensure electrical contact. After repeated operation of the stall warning vane in the laboratory with power applied, the functionality of the stall warning system was intermittently restored.

1.8.3 History of the engine

On 3 June 1983, an overhaul was carried out at 2049:56 h TSN. Subsequently, the engine was again fitted to the same aircraft and was in operation until 10 April 1997. The operating time over the period of nearly 14 years since the engine overhaul was 1749:24 h. The aircraft was then taken out of service for around 13 years and stored in a hangar at Buttwil aerodrome. There is no evidence in the technical records that the engine was prepared for long-term storage.

In June 2010, the carburettor and both magnetos were overhauled.

1.8.4 Examination of the engine

The engine was removed from the aircraft wreckage and tested on a dynamometer. The muffler from the aircraft was not used in the set-up for the test, but rather the dynamometer's exhaust pipes were connected directly to the exhaust ports of the cylinder heads.

It was found that the engine performed normally when running on the test bed.

After the test run, the leak rate of the individual cylinders was tested. The results were as follows:

Cylinder	1	2	3	4
Pressure [psi] (starting from 80 psi; tolerance 20 %)	72	73	75	74

Following the test run, the cylinders' internal surfaces were inspected using a borescope. Clear indications for corrosion damage to all four cylinder walls was found.

The oil filter was cut open and inspected. No abrasion particles, swarf or other anomalies were found.

1.8.5 Propeller

The propeller had its last overhaul on 10 December 1993 at 3548:58 h TSN.

On 28 July 2010, a crack inspection of the propeller hub in accordance with Airworthiness Directive AD 2009-22-03_HC-SB-61-269 was signed-off.

The propeller was removed and examined after the accident. Both propeller blades moved normally between the high and low pitch angles when the corresponding amount of pressure was applied. The blade angle could only be measured on one blade; the other was too severely bent to be measured. The minimum blade angle was approximately 2° too low; the maximum angle exceeded the tolerance by 20 angular minutes.

During the subsequent dismantling of the propeller hub, it was found that all ball and needle bearings were smooth-running and well-lubricated. Neither traces of wear or damage nor signs of corrosion were present.

1.8.6 Propeller Governor

The propeller governor was tested on a test bench at a propeller manufacturer.

It was found that the maximum speed of the governor was set to 2365 rpm; the required value was 2330 +/- 10 rpm.

The propeller governor performed faultlessly across the entire speed range. However, it was found that the pump's flow rate, which has a required value of 15.14 - 18.93 l/min, fluctuated between 7.3 and 15.5 l/min.

The delivery pressure was 19.0 bar with a required value of 19.25 - 21.0 bar.

The intermittently low flow rate and the low delivery pressure could have led to a propeller overspeed condition when combined with a certain internal leak rate.

1.9 Fuel

1.9.1 Fuel used

Fuel samples from both tanks were analysed. According to both analysis results, the fuel generally matched the specifications for AVGAS 100LL aviation gasoline. However, the presence of 1.98% and 0.54% of ETBE[4] indicates that there were residues of unleaded automotive fuel in both samples.

A fuel receipt exists proving that on 13 June 2013 at 16:33 in Hohenems (LOIH), N108MW was fuelled with 111.3 litres of Super Plus (unleaded 98 grade) automotive fuel.

[4] Ethyl tert-butyl ether (ETBE) is a chemical compound that belongs to the ether class. ETBE is a means of increasing the octane rating in gasoline.

1.9.2 Specifications from the engine manufacturer

The engine manufacturer has specified the approved fuels in Service Instruction SI 1070S. Apart from AVGAS 100LL, the list includes automotive fuel in compliance with EN228:2008(E) for the engine model fitted in N108MW. For automotive fuel, an octane rating of 93 AKI[5] is stipulated. The octane rating of unleaded 98 grade automotive fuel corresponds to 93 AKI.

Regarding the use of automotive fuel, the engine manufacturer specifies that the vapour pressure must comply with class A, and may contain no more than 1% oxygenated hydrocarbons, whereas ethanol and methanol are explicitly prohibited.

The engine manufacturer writes the following, among other things:

"Automotive fuels usually have Reid Vapour Pressure (RVP) values between 7 and 9.3 psi (48 and 64 kPa) in summer seasons but specifications for the RVP can be as high as 15 psi (103 kPa) in the winter. In some geographic regions, there is no upper limit to RVP in the winter season. As vapour pressure increases, the tendency for vapour lock will increase as well as fuel "boil off" at altitude.

It is also possible that ethanol-based fuels could not be compatible with some fuel system components. In cases of material incompatibility, deterioration of metallic and non-metallic components can occur. Therefore, fuels containing ethanol are not approved in this Service Instruction.

Although the aviation and automotive fuels [...] can be used [...], airframe approval is necessary. Refer to the Pilot Operating Handbook (POH), Type Certificate Data Sheet or Supplemental Type Certificated (STC) for aircraft approved fuels."

1.9.3 Specifications of the type certificate data sheet

The type certificate data sheet of this aircraft stipulates aviation gasoline with a minimum grade of 91 - 96 as the approved fuel.

There is no indication in the technical records that a supplemental type certificate (STC) for using automotive fuel in the aircraft had been implemented.

1.10 Ground effect and take-off technique on short grass runways

In the Airplane Flying Handbook, the FAA describes ground effect as follows:

The ground effect occurs when there is a short distance between the wing and the ground. One of the causes is that the development of the wing tip vortices is impeded as a result of the short distance to the ground. The induced drag therefore decreases and the loss of lift in the outer area of the wingspan is significantly reduced. Therefore, the wing can generate more lift in ground effect and thereby experiences less drag than in the open atmosphere. Due to ground effect, it is therefore possible to lift-off at a speed below the normal stall speed and to sustain flight just above the ground. However, the ground effect rapidly decreases as the distance between the wing and the ground surface increases. Even at a height of half the wingspan above the ground, only approximately 10% of the ground effect remains. Therefore, drag increases and lift decreases when an aircraft climbs out of ground effect after take-off.

When taking off from short runways, in particular from grass runways, it is possible to take advantage of the ground effect using an appropriate take-off technique and lifting-off at low speed. A minimum take-off roll is thereby achieved. However, in

[5] AKI: Anti-Knock Index, a term for the octane rating which is equivalent to the arithmetic average of the Research Octane Number (RON) and the Motor Octane Number (MON).

such a procedure it must be noted that after taking off at minimum speed, the aircraft is only able to sustain flight within the ground effect.

After take-off, the aircraft must therefore accelerate to the speed for best angle of climb (V_x) just above the ground before transitioning into the climb.

If an aircraft that lifts-off with a deficiency of speed is immediately transitioned into a climb then this may result in the aircraft settling down again. Even if it remains airborne, the initial climb will be shallow and climb performance will remain severely limited until the speed for the best angle of climb is reached.

Illustration 3: Take-off at low speed in the ground effect (source: Airplane Flying Handbook FAA-H-8083-3A)

In the Airplane Flying Handbook, the FAA describes the grass runway (soft field) take-off procedure as follows:

"After becoming airborne, the nose should be lowered very gently with the wheels clear of the surface to allow the airplane to accelerate to V_Y, or V_X if obstacles must be cleared. Extreme care must be exercised immediately after the airplane becomes airborne and while it accelerates, to avoid settling back onto the surface. An attempt to climb prematurely or too steeply may cause the airplane to settle back to the surface as a result of losing the benefit of ground effect. An attempt to climb out of ground effect before sufficient climb airspeed is attained may result in the airplane being unable to climb further as the ground effect area is transited, even with full power. Therefore, it is essential that the airplane remain in ground effect until at least V_X is reached. This requires feel for the airplane, and a very fine control touch, in order to avoid over-controlling the elevator as required control pressures change with airplane acceleration."

1.11 Analysis of the GPS data and speed information from the pilot

1.11.1 Analysis of the GPS data

A GPS device was fitted in the aircraft. Every ten seconds, the device recorded the position and the distance – calculated from the difference to the preceding data point – as well as the average speed calculated from the distance and time. Five such data points are available from the take-off run.

The aircraft was at the start of the runway at the first data point; about 80 m from the start of the runway at the second data point; about halfway down the length of the runway at the third data point; shortly before the end of the runway at the fourth data point; and already at the final position at the next data point.

At the fourth data point, the aircraft was approximately 40 m before of the end of the runway. The distance covered in the previous 10 seconds between the third and fourth data point was 304 m, giving an average speed of 110 km/h, which is equivalent to 59 kt. The highest speed reached during the entire take-off could not be accurately determined because of the limited data and the 10-second recording intervals.

At the preceding third data point, the aircraft was roughly in the middle of the runway and the distance covered in the previous 10 seconds was 214 m, giving an average speed of 77 km/h.

The average speed information from the GPS represents ground speed. Wind and air density have to be taken into account to correlate this with the indicated airspeed.

1.11.2 Speed information from the pilot

The pilot stated that, when rotating, he had read an indicated airspeed on the inner dial of approximately 65 kt, i.e. within the green range of the display.

Considering the effect of air density indicates that under the environmental conditions at the time of the accident an indicated airspeed (IAS) of approximately 65 kt corresponded to a true airspeed (TAS) of about 68 kt.

The wind velocity was 2 kt from variable directions. It can be therefore be calculated that at an indicated airspeed of 65 kt, the ground speed must have been in the range of 66 to 70 kt.

2 Analysis

2.1 Technical aspects

2.1.1 General condition of the aircraft

The aircraft displayed numerous technical faults (see chapter 1.8.1). On the whole, the aircraft did not appear to be airworthy at the time of the accident. This is despite the fact that the last annual inspection had taken place one month, about 9 operating hours, earlier.

2.1.2 Summary of the technical investigation results

The investigation of the engine, propeller, and the propeller governor revealed shortcomings. However, these do not explain the course of the accident, especially as the engine performed normally on the testing bed.

To what extent the broken baffles in the exhaust muffler could have reduced the engine power remains unknown. However, it must be noted that according to the pilot, the fully loaded aircraft had already accelerated to an indicated airspeed of approximately 65 kt about two-thirds of the way down the 600-m-long grass runway. He also stated that the engine instruments displayed normal values and he did not notice any changes in engine noise. This suggests that the engine and propeller were not affected and normal thrust was fully available.

The inoperative stall warning system meant that the pilot was not warned of a stall.

2.1.3 Fuel used

The investigation results positively show that the aircraft had previously been filled with fuel that was not permitted for this aircraft. This conduct was not safety-conscious.

2.2 Human and operational aspects

During the pre-flight checks, it was forgotten to remove the pitot tube cover. As a result the speed indicator remained at zero for the first take-off attempt and the pilot aborted take-off. Aborting take-off and taxiing back to the parking position to rectify the problem was the correct decision. The idea of exiting the aircraft with the engine running to remove the pitot cover, whilst leaving the two passengers in the back seats of the aircraft, was little safety-conscious.

Presumably no functional test of the stall warning system was carried out during the pre-flight checks and its failure therefore remained hidden.

The aircraft was heavily loaded and the aircraft flight manual (AFM) provided no take-off performance data to the pilot when preparing for take-off on the 600-m-long grass runway. This is surprising and does not allow the take-off performance to be determined and consequently, no assessment of the available reserve can be carried out. The pilot's experience could compensate for this shortcoming. Because of the high take-off mass and the general prevailing conditions, hardly any power reserves were available for the take-off.

According to the pilot, the aircraft accelerated as expected and took off after a little more than two-thirds of the way down the runway. After gaining a few metres of altitude, the pilot felt, however, that the power was lower than usual and he realised that the aircraft was descending again.

The technical investigation showed that normal thrust was probably available. It is likely that the loss of power felt by the pilot can be attributed to the fact that the

aircraft had climbed out of the ground effect at too low a speed and as a result, climb performance decreased.

The average speeds recorded by the GPS device show that the aircraft steadily accelerated during the take-off run. As these are average speeds, the ground speed just before the end of the runway must have been greater than 59 kt (see chapter 1.11).

With regards to ground speed as calculated from IAS, air density and wind, the indicated airspeed of 65 kt (equivalent to 75 mph) when rotating which the pilot reported seems plausible. It would therefore have matched the recommendation of the aircraft manufacturer for the initial climb. However, the analysed GPS data suggests that this speed was only reached shortly before the end of the runway.

During the course of the accident event, the aircraft gained hardly any altitude. This can be explained if it is assumed that the aircraft was initially pitched too steeply after take-off. As a result, it climbed out of the range of the ground effect and lost speed (see chapter 1.10). The take-off mass was high and required a lower pitch attitude to maintain the correct speed in the initial climb. It is likely that too little attention was paid to this fact. Therefore, N108MW was in a situation that almost inevitably led to the aircraft settling again to the ground.

As the stall warning was inoperative, the pilot was not given advance warning of the impending critical flight condition.

3 Conclusions

3.1 Findings

3.1.1 Crew

- The pilot held the required licences for the flight.
- There is no evidence of the pilot experiencing any health problems during the accident flight.

3.1.2 Technical aspects

- The aircraft was certified for operation.
- The mass was around 1,220 kg.
- The aircraft's centre of gravity was within the permitted limits according to the aircraft flight manual (AFM).
- N108MW displayed numerous technical faults.
- The stall warning system was inoperative.
- The investigation indicated that the engine and propeller delivered normal power.
- The fuel used complied with the manufacturer's guidelines.
- The investigation showed that the aircraft had been filled with unleaded automotive fuel in the past.
- No evidence was found that an STC for using unleaded automotive fuel in N108MW had been incorporated.

3.1.3 Operational aspects

- According to the pilot, he rotated the aircraft about two-thirds of the way down the 600-m-long runway 30 into the take-off attitude and lifted off.
- The indicated airspeed when rotating was about 65 kt.
- As the aircraft climbed out of the ground effect, it did not gain any more altitude and subsequently began to descend.
- The pilot aborted the initial climb and landed on the grassland beyond the end of the runway.

3.1.4 General conditions

- The temperature was 22 °C and the QNH atmospheric pressure was 1023 hPa.

3.2 Causes

The accident can be attributed to the fact that after take-off, the aircraft gained little altitude and the pilot aborted the initial climb. This is most likely attributed to an inappropriate take-off technique combined with take-off mass at the maximum permissible limits. When rolling to a stop in open terrain, the aircraft was severely damaged.

The following factors contributed to the accident:

- An inoperative stall warning system.
- The absence of take-off performance calculation data.

4 Safety recommendations, safety advice and measures taken since the accident

4.1 Safety recommendations

None

4.2 Safety advice

None

4.3 Measures taken since the accident

None

This final report was approved by the Board of the Swiss Transportation Safety Investigation Board STSB (Art. 10 lit. h of the Ordinance on the Safety Investigation of Transportation Incidents of 17 December 2014).

Berne, 5th December 2017 Swiss Transportation Safety Investigation Board