Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Schweizerische Unfalluntersuchungsstelle SUST
Service d'enquête suisse sur les accidents SESA
Servizio d'inchiesta svizzero sugli infortuni SISI
Swiss Accident Investigation Board SAIB

Aviation Division

Final Report No. 2169 by the Swiss Accident Investigation Board SAIB

concerning the accident involving the Aero AT-3 R100 aircraft, registration HB-SRA

on 12 August 2011

Worbboden, Worb/BE

Aéropôle 1, CH-1530 Payerne
Tel. +41 26 662 33 00, Fax +41 26 662 33 01
info@sust.admin.ch
www.saib.admin.ch

Ursachen

Der Unfall ist auf eine Notlandung mit anschliessender Kollision mit Hindernissen zurückzuführen, weil der Motor mangels Treibstoff im Flug abstellte.

Zum Unfall beigetragen haben:

- Ungenügende Auslegung des Messsystems zur Anzeige des Treibstoffvorrats.
- Falsche Angaben des Herstellers bezüglich des Tankinhalts.
- Die für diesen Flugauftrag zu knapp bemessene Treibstoffmenge.

General information on this report

This report contains the Swiss Accident Investigation Board's (SAIB) conclusions on the circumstances and causes of the accident which is the subject of the investigation.

In accordance with Art 3.1 of the 10th edition, applicable from 18 November 2010, of Annex 13 to the Convention on International Civil Aviation of 7 December 1944 and Article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

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 = CET = UTC + 2 hours

Final Report

Aircraft type	Aero AT-3 R100	Registration HB-SRA	
Operator	Alp-Air Bern AG, Bern-Belp Airport, 3123 Belp, Switzerland		
Owner	Alp-Aircraft GmbH, Bern-Belp Airport, 3123 Belp, Switzerland		

Pilot (flight instructor)	Swiss citizen, born 1956			
Licence	Commercial pilot licence aeroplane (CPL(A)), first issued by the Federal Office of Civil Aviation (FOCA) on 24 March 1982			
Essential ratings	Class rating for aeroplane single-engine piston (SEP), valid till 16 August 2012			
	Flight instructor aeroplane (FI (A)), valid till 16 July 2013			
Medical fitness certificate	Class 1, VNL (shall have available corrective lenses), valid from 4 August 2011 till 12 August 2012			
Flying hours	**total**	13 750:38 hours	**during the last 90 days**	169:59 hours
	on the accident type	390:25 hours	**during the last 90 days**	87:13 hours
Pilot (trainee pilot)	Swiss citizen, born 1975			
Licence	---			
Essential ratings	---			
Medical fitness certificate	Class 2, valid from 6 July 2011 till 6 July 2016			
Flying hours	**total**	6:24 hours	**during the last 90 days**	6:24 hours
	on the accident type	6:24 hours	**during the last 90 days**	6:24 hours

Location	Worbboden, Worb/BE municipality		
Coordinates	608 862 / 198 204	**Elevation**	566 m AMSL
Date and time	12 August 2011, approx. 17:40		

Type of operation	VFR, training
Flight phase	Cruising
Accident type	Emergency landing as a result of fuel shortage followed by collision with obstacles

Injuries to persons

Injuries	Crew	Passengers	Total number of occupants	Others
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	0	0
None	2	0	2	Not applicable
Total	2	0	2	0

Damage to aircraft Heavily damaged

Other damage Minor damage to terrain

1 Factual information

1.1 Pre-history and history of the flight

The Aero AT-3 R100 aircraft, registration HB-SRA, was one of the three AT-3s which the flying school based at Bern-Belp Airport (LSZB) had operated since 2009 as replacements for the AS-202 Bravo. According to the manufacturer's information, the fuel tank capacity of this type is 73.5 litres, of which 70 litres are usable.

On 12 August 2011, the flight instructor filled HB-SRA with 34 gallons of gasoline. On the basis of the fill level, the figure 70 was entered in the technical / journey log of HB-SRA, in the fuel on board (litres) column. Then a trainee pilot made his solo "270 km navigation flight". After a total flying time of 2:29 hours, with two intermediate landings on the airfields of Ecuvillens (LSGE) and Wangen-Lachen (LSPV), HB-SRA returned shortly before 14:00 to Bern-Belp airport. The flight instructor then took over HB-SRA in order to conduct a flying lesson with another trainee pilot.

Together with this trainee pilot, using the dipstick integrated into the tank, he determined a remaining quantity of fuel of 30 litres, which was entered as such in the technical / journey log. During this lesson, the trainee pilot and flight instructor flew four circuits of the aerodrome, which resulted in a flying time of 26 minutes.

At approximately 16:00, the flight instructor met another trainee pilot to discuss his planned training flight. For the trainee pilot, this was to be the seventh flight of his flight training. A flight of approximately 40 minutes duration was planned to take place in the Kirchberg area, in order to fly simulated aerodrome circuits over the A1 motorway. The two went to the aircraft and prepared it together. The aircraft was positioned with its nose towards the runway and the flight instructor pushed the aircraft down at the rear, in order to rotate it through 180 degrees.

It was the trainee pilot's task to measure the amount of fuel remaining. He described this process as follows: "*(...) Mr* [name of flight instructor] *was standing next to me and observing me. I opened it* [the tank] *to check the level with the dipstick. When I did so, I saw very clearly for the first time the mark of the gasoline level. It was less than half-way between the marks 20 and 30. I therefore estimated the level to be between 22 and 25 litres. I repeated this, with an identical result.*"

The tank was then closed again correctly. An estimate by the flight instructor gave the result that the determined quantity of fuel ought to suffice for the training flight of approximately 40 minutes. Once the pre-flight check had been completed, the two crew entered the cockpit. After the engine was started, the trainee pilot taxied to the holding point for runway 32. After all the checks had been completed, HB-SRA was cleared to turn onto the runway and take off from runway 32. HB-SRA took off at 17:02. Once the aircraft was free of obstacles, the trainee pilot controlled the AT-3, to maintain an airspeed of 65 KIAS. In the left downwind leg of runway 32, the crew of HB-SRA received clearance to fly a left turn in the direction of reporting point ECHO.

The crew flew over the Lindental valley in the Kirchberg area, in order to begin the simulated aerodrome circuits over the A1 motorway. After three simulated approaches the return flight towards reporting point ECHO was initiated. In the process, the check for approach was carried out, as during the previous approaches. The trainee pilot recalled this as follows: "*The fuel gauge was always ¼ to ½ full*". Shortly afterwards, the crew reported again to Bern-Belp air traffic control. Shortly before the aircraft entered the control area, the engine began to

stutter. In addition, there was a continuous reduction in power. The instructor immediately took over control of the aircraft. He tried unsuccessfully to improve the situation with different throttle positions. Shortly afterwards the engine quit completely. At 17:39:30 the flight instructor reported: "*Ah we are not able to reach the field we make a NOLA* [emergency landing] *outside the region of Worb*." Since the height above ground was insufficient to identify the cause of the problem, the flight instructor then concentrated on the forthcoming emergency landing.

A first field, which initially seemed ideal, could not be approached because of a high-voltage line. Another field in Worbboden was chosen as the emergency landing site. After the flaps had been extended and the fuel valve closed, HB-SRA turned onto its final approach. Because of the topographical conditions, this field could only be approached slightly diagonally. After the aircraft touched down, it rolled out in the direction of a field of sunflowers. After the right wing contacted the sunflowers, HB-SRA turned to the right around its vertical axis and came to a halt, rolling backwards, after approximately 25 metres. Both occupants were uninjured and were able to exit the aircraft unassisted. Fire did not break out. The aircraft was heavily damaged.

1.2 Meteorological information

1.2.1 General meteorological situation

A shallow ridge of high pressure extended from the Bay of Biscay to the western Mediterranean. A westerly wind prevailed at altitude, caused by a depression west of the British Isles and the high-pressure system on the Azores.

1.2.2 Weather in the Bernese Mittelland

In the late afternoon moderate banks of cloud were being conveyed from France towards the Alps. The cloud base was at almost 9700 ft AMSL, corresponding to 2950 m AMSL. The MeteoSwiss radar recordings indicated a few weak echoes south and west of Bern. These were precipitation trails from the altocumulus clouds. Over the western Swiss plateau, visibility was 30 to 60 km. Below 1500 m AMSL, the wind field was comparatively homogenous. The wind was blowing from the south-west. The average speed was between 10 and 15 knots.

1.2.3 Weather at the time of the accident

The following information was taken from the 15:50 UTC Bern-Belp airport METAR report.

Cloud	overcast, with base at 8000 feet above ground
Visibility	over 10 km
Wind	280 degrees, 7 kt
Temperature/dewpoint	22 °C / 09 °C
Atmospheric pressure QNH	1015 hPa

In Bern-Zollikofen, the meteorological visibility at the times of issue of 12 and 18 UTC was 60 km. Similar visibility was confirmed by webcam images at the time of the incident. The precipitation trails caused some variation in the observed visibilities.

The landing field was leeward of the saddle between the Dentenberg and the Wisle ridge. A comparison with surrounding observation stations suggests that the wind close to the ground was blowing over the foothills of the Dentenberg from the western sector and that the wind speed was 5 to 10 knots.

1.2.4 Astronomical information

Position of the sun	Azimuth: 259°, Elevation: 30°
Lighting conditions:	Daylight

1.3 Aircraft information

1.3.1 General information

Characteristics	Two-seat passenger and training aircraft, piston-engined, in low-wing metal construction with flaps and tricycle fixed landing gear.
Manufacturer	AERO Sp. Z o.o. Mielec, Poland
Year of manufacture	2009
Serial number	051
Certification basis	EASA CS-VLA[1] dated 14 November 2003
Engine	Manufacturer: Bombardier Recreational Products (BRP) Powertrain GmbH & Co. KG, Gunskirchen (A). Type Rotax 912 S2, serial number 4.923.768, manufactured in 2009.
Operating hours	Airframe: 738:12 hours since new Engine: 738:12 hours since new
Number of landings	2365
Max. permitted masses	Max. permitted take-off mass 582 kg Max. permitted landing mass 582 kg
Mass and centre of gravity	The mass of the aircraft at the time of departure was approx. 555 kg. The mass of the aircraft at the time of the accident was approx. 545 kg. Both the mass and centre of gravity were within the permitted limits according to the aircraft flight manual (AFM).
Maintenance	The last scheduled maintenance work, a 50-hour and 100-hour check, was attested on 26 July 2011 at 690:08 hours.
Technical limitations	None registered
Registration certificate	Issued by the FOCA on 15 July 2009 / No. 1
Airworthiness certificate	Issued by the FOCA on 21 July 2009, valid till revoked

[1] VLA – very light aeroplane – Single-engined aeroplane with a maximum of two seats, a maximum take-off mass of 750 kg and a stall speed in landing configuration not in excess of 83 km/h.

Airworthiness review certificate	Date of issue: 4 July 2011 Date of expiration of validity: 15 July 2012
Certification	Private
Category	VFR day

1.3.2 Aircraft flight manual

The aircraft flight manual (AFM) is published and revised by the manufacturer in Polish and English. An AFM in English was found in the aircraft, bearing the revision status No. 8 dated 2 October 2009. The revision status of the English version of the AFM at the time of the accident was No. 12 dated 20 June 2011.

Revision No. 11 dated 7 March 2011 should be mentioned. Among other things, the tank capacities were amended in the “Limitations” section as follows:

“2.12 Fuel

Fuel tank: capacity:

Airplane to AT3-054 [up to and including serial number 054]

- *Total capacity* *73.5 litres / 19.42 US gal*
- *Consumable fuel* *70.0 litres / 18.5 US gal*
- *Unusable fuel* *3.5 litres / 0.92 US gal*

Airplane from AT3-055 [from serial number 055]

- *Total capacity* *68.5 litres / 18.09 US gal*
- *Consumable fuel* *65.0 litres / 17.7 US gal*
- *Unusable fuel* *3.5 litres / 0.92 US gal”*

1.3.3 Fuel system

According to the manufacturer's information, HB-SRA had a fuselage tank between the fire bulkhead and the cockpit with a capacity of 73.5 litres, of which 70 litres are usable.

An analogue fuel gauge in the cockpit shows the pilot the current tank contents. A red warning lamp “FUEL RESERVE - 10 L” is designed to illuminate in the cockpit when the remaining fuel in the tank falls below ten litres. According to the information from the flight instructor and the owner, this indication is supposed to have been independent of the fuel gauge system. It is not clear from the manufacturer's system description whether this is the case.

The AT-3 could be operated with the following types of fuel with a minimum octane number of 95 RON:

- EN228[2] Premium
- EN228 Premium plus
- AVGAS 100LL

The owner of the aircraft had set up a refuelling installation with EN228, which was allowed to be operated only by trained personnel. This installation was used exclusively for the operation of the three AT-3 aircraft.

[2] European standard designation

Figure 1: Fuel gauge (yellow circle) and red FUEL RESERVE warning lamp (yellow arrow)

The investigation indicated that there were at least three different sensors for measuring the tank content:

Originally HB-SRA was equipped with a capacitive sensor. With this sensor, after it was correctly calibrated, on the one hand the quantity of fuel in the tank is measured and on the other hand the signal is generated for the red warning lamp when the tank level falls below ten litres.

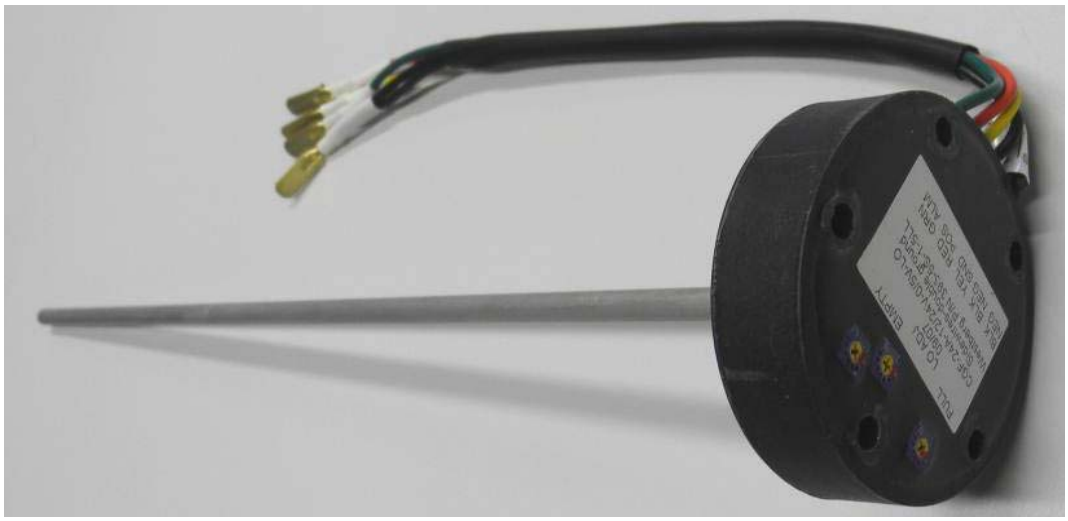

Figure 2: Sensor “Variant III”

In September 2009 the capacitive sensor on HB-SRA was replaced by the manufacturer with a sensor with a different operating principle. This sensor, designated the Variant IV has a float, which measures the tank content by means of a potentiometer. With this type of sensor, the signal for the red warning lamp is generated via the corresponding float position by the position of the potentiometer.

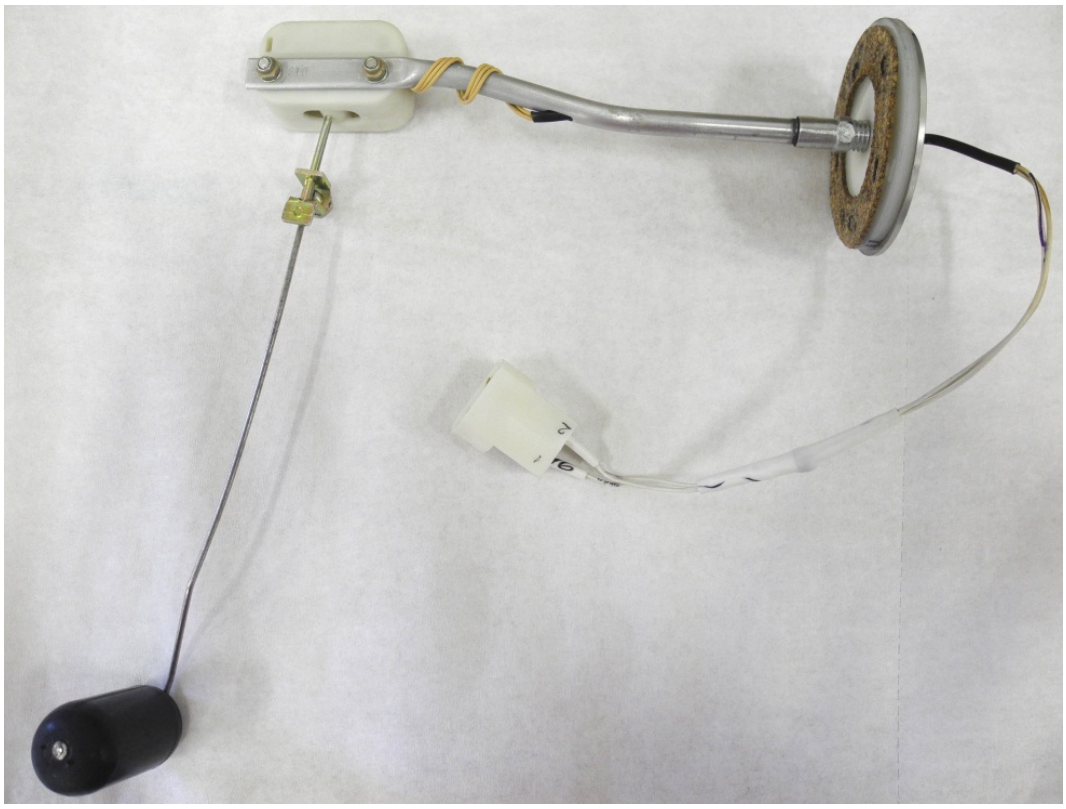

Figure 3: Sensor “Variant IV”, P/N AT3.61.460.0 for aircraft up to S/N AT3-053

The sensor consists of a cover which is screwed onto the tank. In the middle of this cover there is a thread with a sleeve. An aluminium tube is inserted into this sleeve. At the lower end of the aluminium tube, a plastic housing in which the potentiometer is located is screwed on. A 21 cm long float is mounted on the axis of rotation of the potentiometer.

Reference is also made to a third type of sensor, which was stocked by the maintenance company as part of a spare parts order placed by the owner. This sensor also measures the tank level using a float. The signal for the red warning lamp is generated separately.

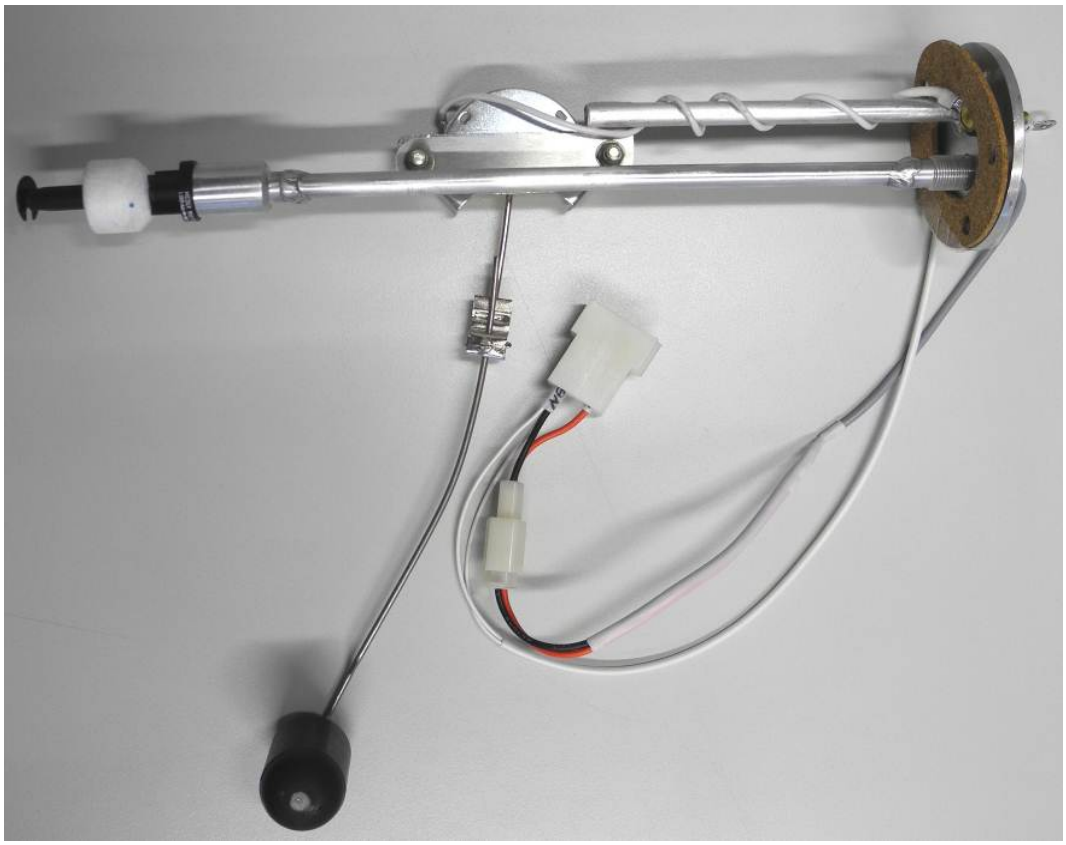

Figure 4: Sensor “Variant IV”, P/N AT3.61.500.0 for aircraft from S/N AT3-054

Finally, the fuel content could also be measured by using a dipstick built into the filler cap. There were several holes on this dipstick, representing a scale with 10-liter-steps. The scale ranged from 10 litres up to 70 litres. No definition of the scale could be found in the AFM. The filler cap lock was fixed to the dipstick.

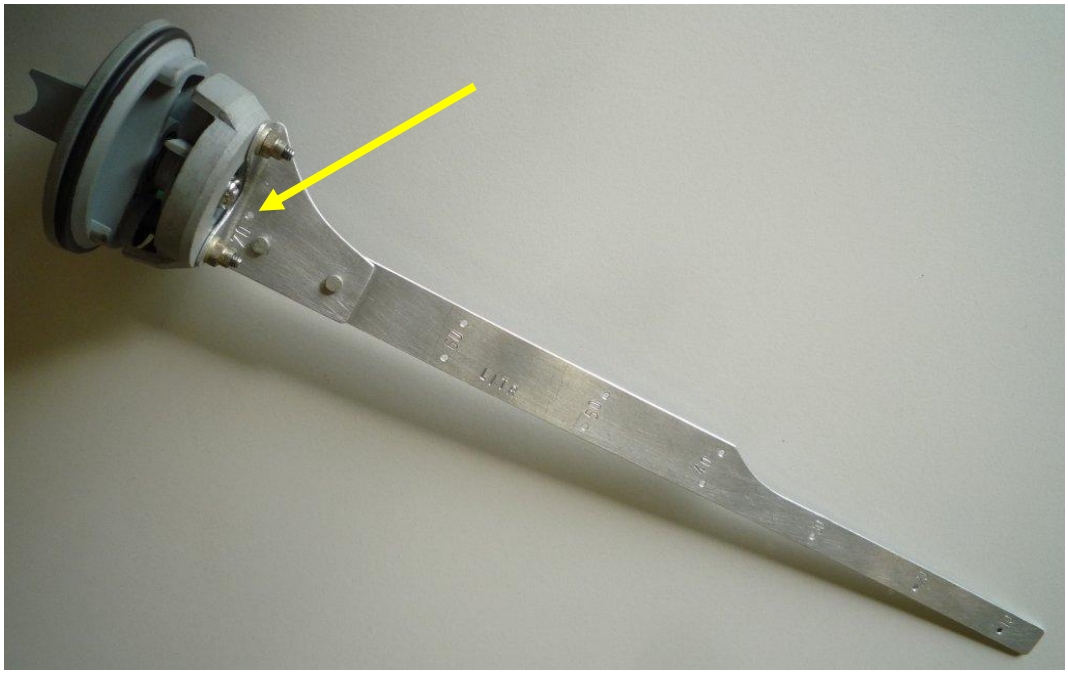

Figure 5: Dipstick with scale up to 70 litres (yellow arrow)

The owner made the pilots of the AT-3 aware of the correct way of inserting the dipstick in order to close the filler cap. According to this it must be ensured that the dipstick, viewed in the direction of flight, is inserted obliquely into the right half of the tank. Shortly before the filler cap reaches the locking position, the dipstick can be brought back to the vertical again. After that, the filler cap can be locked. Thus the dipstick in the tank is also rotated by approximately 90°. Consequently, viewed from the direction of flight, the dipstick ends up on the right of a connecting tube in the tank, which carries through the throttle linkage from the pilot sitting on the right in the cockpit . The force required to lock the tank is low.

Another type of gauge with a scale up to 65 litres was found in the spare parts inventory of the maintenance company. It can be assumed that this dipstick was intended for use with fuel tanks with a 68.5 litre capacity.

Figure 6: Dipstick with scale up to 65 litres

1.3.4 Fuel consumption and fuel on board

According to the information from the owner, fuel consumption was as follows:

- Cruise power 75%, according to Rotax Manual: 18.5 l/h
- Cruise power 75%, according to experience: 20.0 l/h
- Aerodrome circuits only: 16.0 l/h
- Average for all three AT-3s: 17.8 l/h

Prior to the accident flight, the crew determined a quantity of 22-25 litres of fuel, which, taking into account the average consumption, would have been sufficient for approximately 1:20 hours of flying time.

1.4 Wreckage and impact information

1.4.1 Wreckage

The lap and shoulder belts were being worn and withstood the deceleration forces.

It was possible to drain 2 dl of fuel from the tank. There were no indications of a possible loss of fuel.

On the measuring sensor of the fuel tank, it was found that the aluminium tube to which the float is attached could be twisted clockwise, without any significant force, by up to 40° from its original position.

It was also found that as a result of this twisting, the float was resting in the tank on the connecting tube which carries through the throttle linkage of the pilot sitting on the right in the cockpit. The float was able to move freely upwards and was able to indicate fuel levels from full down to one-third.

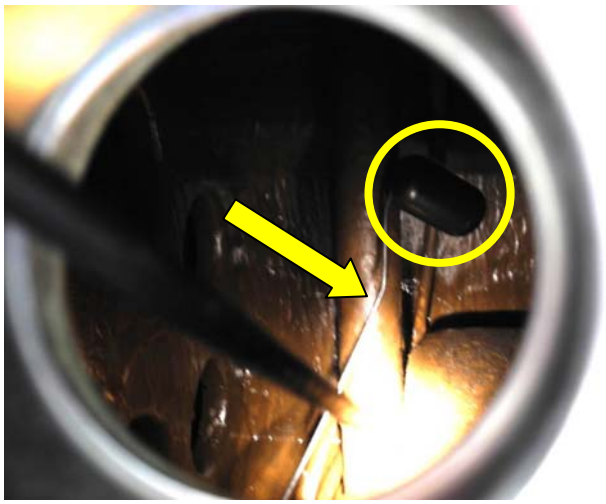

Figure 7: Float (yellow circle) on connecting tube (yellow arrow)

1.4.2 Impact

The aircraft initially touched down normally on the emergency landing site. Because of the diagonal approach, the right wing collided with the sunflower field in the roll-out phase. As a result, HB-SRA was rotated clockwise around its vertical axis by almost 180° and rolled backwards to come to a halt after approximately 25 m.

1.4.3 Scene of the accident

The scene of the accident was a harvested grain field, which was chosen as the emergency landing site. This field bordered directly onto a field of sunflowers.

Figure 8: Scene of the accident – white arrow = direction of flight

1.5 Tests and research

1.5.1 Fuel gauge system and fuel on board

The fuel gauge system and in particular the tank were examined; the following findings were made, among others:

- The effective fuel capacity was 66 litres.
- The dipstick is very inaccurate in the range from the 10 to 30 markings and may indicate up to seven litres more than the actual value.
- As a result of the movement of the dipstick in the fluid, caused by insertion, closing and opening of the filler cap to determine the fuel level, a measurement may indicate up to 10 litres more than the actual value.
- It took at least three consecutive measurements to achieve a respective tolerance of 5 mm.
- When a value of 22 litres was measured using the dipstick, there were actually 18 litres of fuel in the tank.
- When a value of 25 litres was measured using the dipstick, there were actually 22 litres of fuel in the tank.

The twisting of the float due to the dipstick was able to be reproduced. To do this, the following conditions had to apply:

- The tank had to be more than half full.
- The dipstick was not inserted correctly.

If the dipstick was inserted into the left half of the tank, it could come into contact with the left side of the float linkage. When the tank filler cap was closed, the aluminium tube of the float was twisted clockwise to such an extent that the float was brought above the connecting tube and rested on it as the level dropped.

This incorrect state may persist even if the dipstick is subsequently inserted correctly.

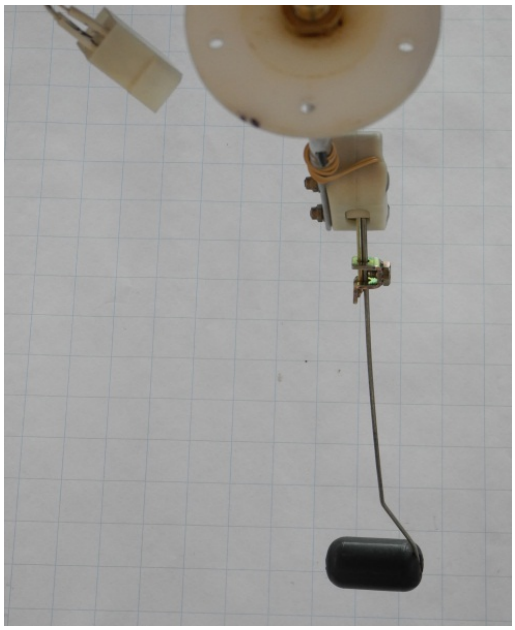

Figure 9: Float in normal position

Figure 10: Float in skewed position

On the day of the accident, HB-SRA was fully refuelled only in the morning. Taking into account the consumption values indicated in section 1.3.4, it can be assumed that the following amounts of fuel must have been on board:

- Before the navigation flight: 66 L, duration 2:29 hours, consumption approx. 49 litres
- Before the training flight: 17 L, duration 0:26 hours, consumption approx. 7 litres

Prior to the flight involved in the accident there were therefore still over 10 litres in the tank. The accident flight lasted 37 minutes; the engine cut out after approximately 35 minutes. This gives an actual fuel consumption of 17.1 l/h, which seems plausible.

1.5.2 Engine

A static engine test was carried out. The engine started easily after two attempts. During the subsequent static test, it could be established that all parameters conformed to the norm.

The engine was then started with one litre in the tank and allowed to run at approximately 4000 RPM until the engine cut out due to lack of fuel. The following findings were made:

- Approx. 50 seconds before shutdown, the gasoline pressure gauge fell below the minimum of 2 bar and the engine revs dropped by up to 200 RPM.
- A few seconds before shutdown the engine was running irregularly (± 400 RPM) before it quit completely.

The residual fuel in the tank was then measured. As in the flight involved in the accident, there were still approximately 2 dl in the tank.

1.6 Information on the operator

Alp-Air AG was a company based at Bern-Belp airport which operated a fleet of 10 aircraft. In addition to various services, Alp-Air operated a flying school which carried out its training activities within the framework of the umbrella organisation, SwissPSA[3], of which it was a member.

Among other things, the SwissPSA operating manual (OM) also regulates how much fuel had to be on board an aircraft before the commencement and at the end of a flight:

*"OM. 2.03 Consumables (*2.5.5)*

Oil and fuel must be checked before every flight. A flight may be made only if the amount of fuel calculated for the planned flight plus a reserve of 45 minutes is available. The reserve of 45 minutes must be present after landing."

In the operational flight plan, there was a field at the bottom right in which the quantity of fuel was calculated and entered. This consisted of the following:

[3] SwissPSA is an FTO (Flying Training Organisation) in accordance with the regulations of the European Aviation Safety Agency EASA.

Fuel calc.	Time	Trip
Trip		
Alternate		
Reserve	45’	
Minimum		
Extra fuel		
Block fuel		

Taking into account the above guidelines, the following calculation of the fuel requirement could be carried out for the accident flight:

Trip fuel	40 minutes at 18 l/h	12.0 l
Alternate	20 minutes at 18 l/h	6.0 l
Reserve	45 minutes at 16 l/h	12.0 l
Minimum	1:45 hours	30.0 l

2 Analysis

2.1 Technical aspects

According to the aircraft manufacturer's information, the fuel tank of the AT-3 involved in the accident should have had a capacity of 73.5 litres. However, subsequent measurement revealed that the tank on HB-SRA could hold only 66 litres. This tank system also included a dipstick integrated into the filler cap, the calibration of which was scaled up to 70 litres on the basis of false assumptions; it should correspond to the effectively usable quantity of fuel. Furthermore, various tests indicated that owing to various factors a measurement using the dipstick could indicate up to 10 litres more than the actual value. It must therefore be stated that the design of this system in HB-SRA was inherently dangerous, because it provided the crew with no reliable indication of the remaining quantity of fuel.

The fuel gauge in the cockpit received the signal from a sensor in the tank. The capacitive sensor originally fitted was replaced by the manufacturer with a sensor fitted with a float. This sensor had design shortcomings in that as a result of incorrect insertion of the dipstick the float could be twisted so that it ended up lying on a connecting pipe in the tank, as a result of which the indication in the tank remained blocked at approximately 1/3. Since the “FUEL RESERVE - 10 L” warning lamp also received its signal from the same float potentiometer, the corresponding warning would never be triggered in this situation. It is expected of a system with a low level warning lamp that the corresponding signal is generated by an independent system.

The crew stated that during the pre-flight check the tank filler cap was closed correctly. It is quite possible that the filler cap was closed incorrectly at date prior to the accident.

2.2 Human and operational aspects

2.2.1 Aircraft flight manual

The aircraft flight manual of HB-SRA was not up to date.

From the description of the fuel system in the aircraft flight manual it is not apparent whether the fuel indication in the cockpit and the “FUEL RESERVE - 10 L” warning lamp would function independently of each other. The investigation showed that on the aircraft involved in the accident they both received their signals from the same float. Since the crew was of the opinion that the signals were independent of each other, they had a false sense of security. Therefore, it is imperative that the technical descriptions in the AFM are complete and correspond to the actual construction variant.

2.2.2 Flight preparation

From its introduction the AT-3 was operated under incorrect assumptions concerning the fuel on board. Since HB-SRA was fully refuelled on the day of the accident only in the morning, 66 litres of fuel were on board at the beginning of flight operations. Taking into account the various consumption values, it can be assumed that before the flight involved in the accident only approximately 10 litres of fuel were on board.

The measurement of 22 to 25 litres taken before the flight involved in the accident, which involved a possible measurement error of 10 litres using the defective dipstick, unfortunately corresponded to the fuel quantity indication which was already at the 1/3 position. In the estimates of the remaining quantity of fuel, the flight instructor assumed a tank filled with 70 litres. Thus there was no reason for

the crew to doubt the amount of fuel measured before the flight using the dipstick. It should also be noted that immediately before the measurement, the aircraft had been turned through 180 degrees around its vertical axis by pushing the tail down. This brought the amount of fuel remaining in the tank into motion. The resulting wave movement of the tank's contents undoubtedly contributed to further falsifying the measurement.

In the present case a 40 minute flight was envisaged. If one calculated the fuel requirement in accordance with the regulations of the flying school, the minimum quantity of fuel (minimum block fuel) would be approximately 30 litres. If it was intended to have available after landing only the fuel for the flight time reserve of 45 minutes, i.e. without fuel for a flight to an alternate airport, at least 24 litres would have been required for this flight.

It should be mentioned that with aircraft of this category, caution should be applied when operating them with a small amount of fuel because of the frequently encountered inaccuracy of the fuel gauge. Insufficient consideration was given to this fact.

2.2.3 Accident flight and emergency landing

If the “FUEL RESERVE - 10 L” warning had been functioning, the corresponding red warning lamp would have been illuminated shortly after take-off, whereupon the flight instructor would very probably have landed again after a circuit of the airfield.

However, since the float was lying on the connecting pipe, this warning could never be generated during the flight involved in the accident. However, it is surprising that throughout the flight neither the instructor nor the trainee noticed that the fuel gauge was constantly indicating the same value. During the three simulated approaches in the area of the A1 motorway, the fuel supply was addressed multiple times. The same also applied on the occasion of the “*check for approach*” on the return flight to Bern-Belp. Thus it was completely unexpected for the crew when the engine quit after approximately 35 minutes flying time.

The flight instructor immediately took over the controls and did not undertake a time-consuming search for the cause of the problem, focusing instead on the impending emergency landing. The fact that it was impossible to approach a first field because of a power line did not facilitate the final approach on the alternate emergency landing. This landing site could only be approached diagonally in relation to the centerline of the field, so during the roll-out the right wing came into contact with the adjacent sunflower field, causing the damage to the aircraft. These actions of the flight instructor were appropriate to the situation and contributed to the fact that the accident was survivable.

3 Conclusions

3.1 Findings

3.1.1 Crew

- The flight instructor was in possession of the necessary licences for the flight.
- The trainee pilot was in possession of the necessary ratings for the flight.
- There are no indications of any of the crew suffering health problems during the accident flight.

3.1.2 Technical aspects

- After the accident, 2 dl of fuel were found in the tank.
- After the accident, a static engine test was conducted during which it was found that all parameters conformed to the norm.
- According to the aircraft manufacturer's information, the tank should have had a capacity of 73.5 litres. Actually the tank had a fuel capacity of 66 litres.
- The unusable amount of fuel was 3.5 litres, according to the manufacturer.
- The scale on the dipstick integrated into the tank filler cap was erroneous and misleading for this tank system.
- A measurement with the dipstick could indicate up to 10 litres more than the actual value.
- The fuel measurement sensor had design deficiencies. If the filler cap was closed incorrectly, the dipstick could twist the float of the sensor over the connecting pipe in the tank.
- The twisting of the float could persist even if a subsequent correct insertion of the dipstick was carried out.
- The time at which the float had been twisted could not be determined.
- The signals for gauging the fuel level and triggering the “FUEL RESERVE - 10 L” warning lamp were generated by the same sensor.
- If the float is lying on the connecting pipe, the indication in the cockpit remains at approximately 1/3 and the “FUEL RESERVE - 10 L” warning lamp does not light up. This corresponds to the situation found after the accident.
- The technical description of the fuel system in the AFM was incomplete.

3.1.3 Operational aspects

- HB-SRA's aircraft flight manual was not updated to the latest revision status.
- The owner as well as the crew were of the opinion that the fuel gauge in the cockpit and the “FUEL RESERVE - 10 L” warning were independent of each other.
- The aircraft was fully refuelled in the morning on the day of the accident, so 66 litres of fuel were on board at the beginning of flight operations.
- After the refuelling, a navigation flight and a training flight of a total of 2:49 hours were made with the aircraft.

- The minimum block fuel for the accident flight would have been approx. 30 litres, with the inclusion of an alternate aerodrome.
- The minimum block fuel for the accident flight would have been at least 24 litres without the inclusion of an alternate aerodrome.
- The trip fuel for the planned training flight of 40 minutes was approximately 12 litres.
- Prior to the accident flight, the crew determined a fuel quantity of 22-25 litres using the dipstick.
- The amount of fuel carried was insufficient for this flight.
- The accident flight lasted 37 minutes; the engine quit after approximately 35 minutes.
- Taking into account the various consumption values, it can be assumed that before the flight involved in the accident approximately 10 litres of fuel were on board.
- The flight instructor took over the controls immediately and initiated an emergency landing.
- During the roll-out, the right wing collided with a sunflower field, so that the aircraft rotated around its vertical axis and was damaged.
- The mass and centre of gravity of the aircraft were within the permitted limits.

3.1.4 General conditions

- The weather conditions had no influence on the accident.

3.2 Causes

The accident is attributable to an emergency landing with a subsequent collision with obstacles, because the engine quit in flight owing to a shortage of fuel.

The following factors contributed to the accident:

- Inadequate design of the measurement system for indicating the amount of fuel.
- Incorrect information from the manufacturer concerning the tank capacity.
- The inadequate amount of fuel for this flight.

4 Safety recommendations and measures taken since the accident

In accordance with Annex 13 of the ICAO, all safety recommendations listed in this report are addressed to the supervisory authority of the competent State, which must decide on the extent to which these recommendations are to be implemented. However, every agency, undertaking and individual is invited to attempt to improve aviation safety in the sense of the issued safety recommendations.

In the Ordinance on the Investigation of Air Accidents and Serious Incidents, Swiss legislation provides for the following regulation:

"Art. 32 Safety recommendations

[1] DETEC shall address implementation assignments or recommendations to FOCA, based on the safety recommendations in the reports from SAIB or on the foreign reports.

[2] FOCA shall inform DETEC regularly about the implementation of the assignments or recommendations.

[3] DETEC shall inform the SAIB at least twice a year about the progress made by FOCA with implementation."

4.1 Safety recommendations

4.1.1 Safety deficit

On 12 August 2011 the aircraft Aero AT-3 R100, registration HB-SRA, had to execute an emergency landing near the village of Worb/BE as a result of a fuel shortage. The investigation revealed as contributing factors to the cause the following technical deficiencies:

- Inadequate design of the measurement system for indicating the amount of fuel.
- Incorrect information from the manufacturer concerning the tank capacity.

4.1.2 Safety recommendation No. 465

The European Aviation Safety Agency (EASA) shall ensure that the design of the fuel quantity indication system and the manufacturer information relating to the fuel capacity are reviewed and corrected for the entire fleet of the aircraft model Aero AT-3 R100.

4.2 Measures taken since the accident

With a letter dated 14 December 2012, the FOCA informed the SAIB concerning measures taken as follows:

„Der Certification Manager General Aviation der EASA wurde über die konstruktiven Mängel des Treibstoffmesssensors informiert. Des Weiteren wurde durch das BAZL eine Flotten-Inspektion durchgeführt, wobei unter anderem sichergestellt wurde, dass sich der Eigentümer der betroffenen Flugzeuge der Problematik bewusst ist.“

Translation: EASA's certification Manager General Aviation has been advised about the constructive design deficiencies of the fuel measuring sensor. Furthermore the FOCA carried out a fleet inspection ensuring among other, that the owners of the aircraft became aware of the problem.

Payerne, 5 February 2013 Swiss Accident Investigation Board

This final report was approved by the management of the Swiss Accident Investigation Board SAIB (Art. 3 para. 4g of the Ordinance on the Organisation of the Swiss Accident Investigation Board of 23 March 2011).

Berne, 21 February 2013