

# Investigation Report

3X221-0/03  
October 2009

## Identification

Type of Occurrence: Accident  
Date: 30 September 2003  
Location: Büchig Soaring Site  
Aircraft: Sailplane with auxiliary motor  
Manufacturer / Model: Walter Binder Motorenbau GmbH / Eta  
Injuries to Persons: None  
Damage: Aircraft badly damaged  
Other Damage: Slight damage to forest trees  
Source of Information: Investigation by BFU

seat sailplane from the front seat, and an observer occupied the rear seat.

The pilot and observer subsequently described the flight as follows:

"The sailplane climbed under its own power to a height of 2 650 metres above the airfield. On reaching this altitude, the engine was shut down and retracted into the fuselage. At a height of 2 600 metres above ground, the cambered trailing edge flaps were deployed to the second lever notch position (22°+). The airspeed was slowly reduced to 75 km/h. The pilot then gave full right rudder and full left aileron, which initiated a right wing drop. The pilot pulled back on the stick to give maximum up-elevator. The wing drop characteristics were exactly the same as those determined in earlier test flights. The sailplane assumed a vertical nose-down position and completed a half-turn. The nose then pitched up to a flatter attitude (50° to the horizon) and the sailplane completed a further half-turn, after which it rapidly adopted a steeper attitude and became slightly inverted. After a further turn of about one third full circle with the airspeed indicator at 140 km/h, the pilot gave opposite rudder to terminate the rotation. At this point, the rear fuselage broke off with a loud bang. At this moment the sailplane was about 2 300 metres above ground and uncontrollable. It assumed an inverted position."

## Factual Information

### History of the Flight

A number of sailplane spinning flights were conducted as part of the test-flying programme prior to application for the Type Approval Certificate. These took place without incident. The next test flight was a further spinning trial, this time with asymmetric distribution of fuel for the auxiliary motor.

The self-launching sailplane took off under its own power from the Büchig Soaring Site at 14:00<sup>1</sup>. The 16-litre fuselage fuel tank was full; the right wing fuel tank held about 30 litres of fuel, and the left wing fuel tank was empty. The pilot flew the two-

The pilot and observer left the aircraft one after the other and deployed their parachutes.

The inverted sailplane then descended without the crew, with the rear fuselage and empennage trailing by the control cables, to fall in a horizontal attitude into a pine forest.

<sup>1</sup> Unless otherwise specified, all times are indicated in local time

#### Personnel Information

The 56 year-old pilot had a total flight time of 5 636 hours. He possessed a pilot's licence issued in conformity ICAO regulations valid to 11.08.2003 with licence attachments A, B and C and was also a qualified gliding instructor. He had no further licenses or ratings. At the time of the accident he had 143 hours and 111 landings on the ETA. In the 90 days before the accident he had made twelve flights on the type in question.

In addition, he had acquired experience during the course of the flight test programme of another comparable sailplane (ASH 25).

The 49 year-old observer possessed a pilot's licence issued in conformity ICAO regulations, valid to 11.08.2003 with licence attachments A, B and C. His total flight experience was 1 200 hours.

#### Aircraft Information

The Eta is a sailplane with an auxiliary engine, intended for certification as a self-launching motor glider. It had a wingspan of 30.90 metres and a maximum take-off weight of 850 kg.

The sailplane was built in 2001 by Walter Binder Motorenbau GmbH and bore the manufacturer's serial Number 2, since when it had flown 143 hours. The last airworthiness check was conducted in February 2003, since when it had flown 50 hours. The last maintenance check of the Solo 2625/2 motor was conducted in February 2003.

The sailplane had a Permit to Test Fly (VVZ) prior to Type Approval and Certification. The Permit to Test Fly bore limitations allowing only test flights to determine flight characteristics and performance in accordance with a predetermined test schedule. The limitations specified a maximum manoeuvring speed of 170 km/h EAS (Equivalent Air Speed).

At the time of the accident, the sailplane mass was between 873 kg and 884 kg.

#### Meteorological Information

At the time of the accident, visibility in the area around Büchig was better than 10 km with surface wind 160 ° / 5 kt. Cloud cover was one to two oktas at 2 500 ft with the tops at 3 000 ft. The ground temperature was 18 °C, and the air pressure (QNH) 1026 hPa. The entire flight was undertaken in daylight.

#### Flight Recorders

The sailplane was not equipped with a Flight Data Recorder (FDR) or a Cockpit Voice Recorder (CVR); recording devices of this kind were not required by the relevant aviation regulations.

The aircraft was equipped with a Glide Computer and a GPS Datalogger. The data recorded by these two items of equipment confirmed the statements given by witnesses.

#### Wreckage and Impact Information

The inverted sailplane hit flat ground in a pine forest clearing, in a horizontal wings-level attitude. The rear fuselage had broken off about 0.7 metres behind the engine compartment. The rear fuselage and empennage still remained attached to the front fuselage by control cables, which were twisted some eight to ten times. The base of the fin had broken away from the fuselage but remained attached by the control cables. The rudder, tailplane and elevator were missing. These components were found in a field about 500 metres away. The left wing was destroyed by impact with a tree stump. There was a 0,3 m<sup>2</sup> hole in the torsion nose about three metres from the wing root rib. As seen externally, the right wing was virtually undamaged. All the ailerons and cambered flaps were there, but destroyed. The propeller and motor projected a little from their box recess; the hinged recess covers had broken off and lay on the ground nearby. Cockpit canopy sections were found in a field about 500 metres away; the cockpit frame was not found. With the exception of those components damaged by the impact, all the control linkages were without technical defect.

The sailplane's composite structure was examined by the *Institut für Strukturmechanik des Deutschen Zentrums für Luft und Raumfahrt e.V. (DLR)* in Braunschweig (Institute of Structural Mechanics, German Centre for Aerospace Research), which reported as follows:

*"There was considerable variation (from 49.0 % to 58.7%) in the volumetric density of fibre samples taken from various parts of the structure. The hand-layup fabrication process used in this instance tended to favour a somewhat irregular distribution of resin and the occurrence of trapped air bubbles. This was particularly evident in the waves and troughs on the surface of the composite material. There was differential compacting of the composite material when subjected to the vacuum curing process, (see Appendix 4: compare Quadrant 1 with Quadrants 2 or 4), with the result that there was a*

tendency to somewhat higher fibre volumetric content in those sections. In Quadrant 3 the sample appears to have been taken just at the transition between the reinforced and non-reinforced rovings.

To obtain cross-sectional photomicrographs of the composite material layup, samples were taken from Quadrants 1 and 3 at the 0° orientation, and for Quadrants 2 and 4 at 90° orientation. (See Appendices 2 and 3: Enlarged cross-sectional photographs of the composite layup).

All the enlarged cross-sectional photographs revealed large trapped air bubbles, resin pools and some slightly warped roving layers. It can be demonstrated that there were differences between the layup sequence as described in the plans and those actually present in the structure (Appendix 4). In Quadrant 1 the number of woven threads in the photomicrograph indicates four 0°-layers instead of three 0°-layers (see Appendix 2), while the 0°-layer is completely absent in Quadrant 2 (see Appendix 3). Another indication is that no 0°-fibres could be found in the residual carbon fibres within Quadrant 2; inspection also revealed that this strip, which is only a few centimetres wide, has a very thin wall. In Quadrants 3 and 4, the layup is identical to that of the planned layup sequence."

The photomicrograph samples taken from the four Quadrants were 15x20 mm, while that for the incineration test was 7x7mm.

The composite fibre layup plan at the fuselage break point specified (from the outer surface inwards) the following sequence: two layers of CCC886 ±45° with HM M40J 200 g/m<sup>2</sup> carbon; one layer of KDU 1012 with HT DU 300 g/m<sup>2</sup> carbon (0°); four rovings (0°), double layer of KDU 1051 with HT DU carbon, 75 mm wide 480 g/m<sup>2</sup>; and a further layer of CCC886 ±45° with HM M40J carbon 200 g/m<sup>2</sup>.

The designers say that from manufacturing point of view, limited overlapping and the occurrence of local gaps between adjacent rovings in the 0°-layup are not completely avoidable in the fuselage mould. Gaps and overlaps of up to 10 mm have no significant effect upon the final strength.

Physical inspection of the wreck identified two further parts of the broken rear fuselage that appeared to be very thin (approx. 1800 mm before transition to the fin leading edge). Inspection revealed that the unidirectional (UD) layer was interrupted over a width of 45 mm at the middle of the left fuselage half, and over a width of about

20 mm in middle of the right fuselage half. (See Appendix)

The manufacturer observes that air bubbles, resin pools and slightly distorted rovings are associated with the hand layup process and are regarded as normal.

#### Additional Information

The sailplane was to be certificated in accordance with *JAR-22 Sailplanes and Powered Sailplanes*. JAR-22 specifies that on sailplanes and powered sailplanes, the fin should be designed to meet the following load conditions:

#### JAR 22.351 – Flight in conditions of yaw

The sailplane must be designed to withstand yaw loads on the fin as described in JAR 22.441 and JAR 22.443.

#### JAR 22.441 – Operational Loads

The fin must be designed to accept operational loads that occur under the following conditions:

(a) Full rudder deflection at the greater of speeds  $V_A$  and  $V_T$ ;

(b) One third full rudder deflection at speed  $V_D$ .

#### JAR 22.443 - Gust Loads

(a) The fin must withstand lateral gusts up to the value described in JAR 22.333 (c).

(b) If a more precise calculation is undertaken for the actual conditions, the gust must be calculated as follows:

$$P_s = a_s S_s \frac{\rho_0}{2} V U k_s$$

Where

$P_s$  = The gust load on the fin (N),

$a_s$  = The increase in fin lift (in radians),

$S_s$  = Fin surface area (m<sup>2</sup>),

$V$  = Airspeed (m/s),

$U$  = Gust speed (m/s),

$k_s$  = Gust factor; defined as 1.2,

$\rho_0$  = Air density at sea level (kg/m<sup>3</sup>).

#### JAR 22.303 - Safety Factor

If no other value is specified, the safety factor to be used is 1.5.

No combination of yaw angle and rudder deflection is envisaged.

The ETA designer conducted a study of the load situation under conditions of yaw and rudder deflection. Under conditions of 11° yaw and 25° rudder deflection, the ETA fin had a lift coefficient of  $c_A = 1.85$ , which is about 76 % above the JAR 22 calculation requirement of  $c_A = 1.05$  in straight and level flight and hence does not reach the required safety factor. Report eta-140-002 describes the rear fuselage construction as having a static safety factor  $j = 1.55$  and  $j = 1.6$  for prevention of local buckling.

Since the accident in question the constructors have modified the Eta design such that the combination of yaw and rudder deflection loads cannot exceed the safe load.

The modified sailplane has undergone further test flying towards Type Certification. To this end the aircraft was equipped with a number of sensors (including static pressure, angle of incidence, accelerometers in the x-, y- und z-planes, plus rate of roll sensors about the x-, y- and z-axes. Evaluation of the test data showed that, with the cambered flaps in the second position and the sailplane established in a spin, the angle of attack reduced to less than 15° in less than two seconds if the elevator was returned to the neutral position. The sailplane remained in a yaw condition that was opposite to the original direction of rotation with a True Air Speed of up to 144 km/h. In this attitude it accelerated very rapidly.

## Analysis

The sailplane fuselage was designed and built to absorb the operational loads as defined in JAR 22. Consequently the combination of loads occurring during flight testing (rudder deflection in opposite direction to yaw) was a condition that had not been considered during the structural design phase, even though with the benefit of hindsight such a condition is quite probable.

Samples were taken from the rear fuselage structure in the vicinity of the primary fracture line for examination by the DLR (see Appendix 1). Examination revealed an irregular distribution of resin and parts of the fibre volume, also air bubbles and irregularities on the outer surface of the composite structure. There was also an absence of the solely envisaged 0°-layer at several points in the structure over a width of several centimetres. No

investigation was made to determine whether the rovings were completely absent, or had only been shifted. In both cases, the fuselage did not have the strength assumed from calculation.

A valid Permit to Test Fly (VVZ) was in force. No technical defects were found either during the pre-flight inspection or during the flight prior to the accident.

The pilot was in possession of a valid pilot's licence with the required Licence Attachment. With a total flight time of 5 636 hours -- of which 143 were on the type in question, plus test flying experience on the ASH 25 -- must be regarded as properly experienced for the task. He had not undergone further training, nor did he have further ratings, that would have especially qualified him for the spinning trials. Nor was there any such legal requirement.

The fact that the aircraft was overloaded by up to 4% is not strictly relevant to the accident. However, it is not understandable why the flight was conducted in this condition.

The pilot initiated the spin at a speed of 75 km/h by applying right rudder and left aileron. After  $1\frac{3}{4}$  turns and at an Indicated Air Speed of 140 km/h, the pilot applied opposite rudder to terminate the rotation. After the accident, further flight trials were conducted and data recorded. The pilot said that the sailplane adopted an increasingly steep nose down attitude. The inference is quite possible, that at this point the sailplane was yawing to the left in a steep spiral dive.

Rudder deflection in the direction of yaw resulted in the application of a force to the fin that was considerably greater than that envisaged by the construction regulations. The fuselage could not have withstood this aerodynamic force. The fact that the fuselage structure had transposed rovings was only of minor relevance.

## Conclusions

### Findings

- The load condition which occurred in the accident was one in which rudder was applied in opposite direction to yaw. This load condition was absent from the construction regulations.
- This load condition was not a consideration during the sailplane design phase.

- The composite layup in the structure deviated from that assumed by calculation.
- The pilot was licensed in accordance with the regulations then in force for the flight, and properly qualified for the task.
- The aircraft mass was between 2.7 and 4 % above the maximum permitted gross mass.
- Prior to the accident, there was no indication of a pending structural failure or system malfunction.
- Immediately after finishing the spin, the aircraft was in a steep spiral dive with yaw.
- The pilot attempted to end the spiral dive by use of rudder. The forces arising resulted in a break of the rear fuselage tubular structure.

#### Causes

The load imposed by *rudder deflection in opposite direction to yaw* was absent from the constructional regulations and was not considered during the design phase. As a consequence, application of rudder to terminate the spiral dive resulted in breakage of the rear fuselage tubular structure.

## Safety Recommendations

Recommendation No.: 32/2009

The European Aviation Safety Agency (EASA) should incorporate "maximum possible aerodynamic loads resulting from a combination of rudder deflection and yawing condition" into the certification specifications for designs of vertical fins of sailplanes and powered sailplanes.

Investigator-in-Charge

Kostrzewa

Assisted by (investigation on site)

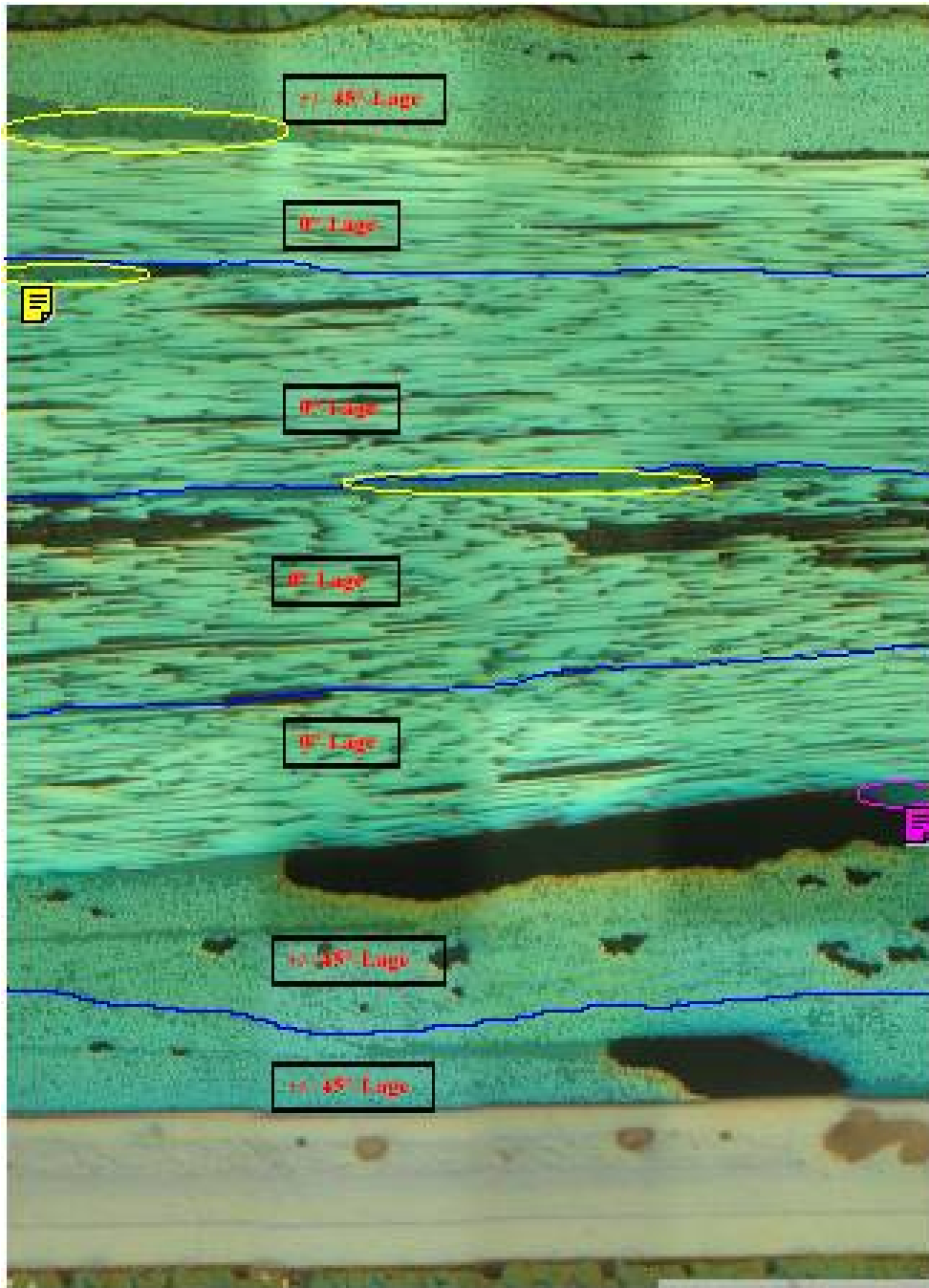
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Appendix 1



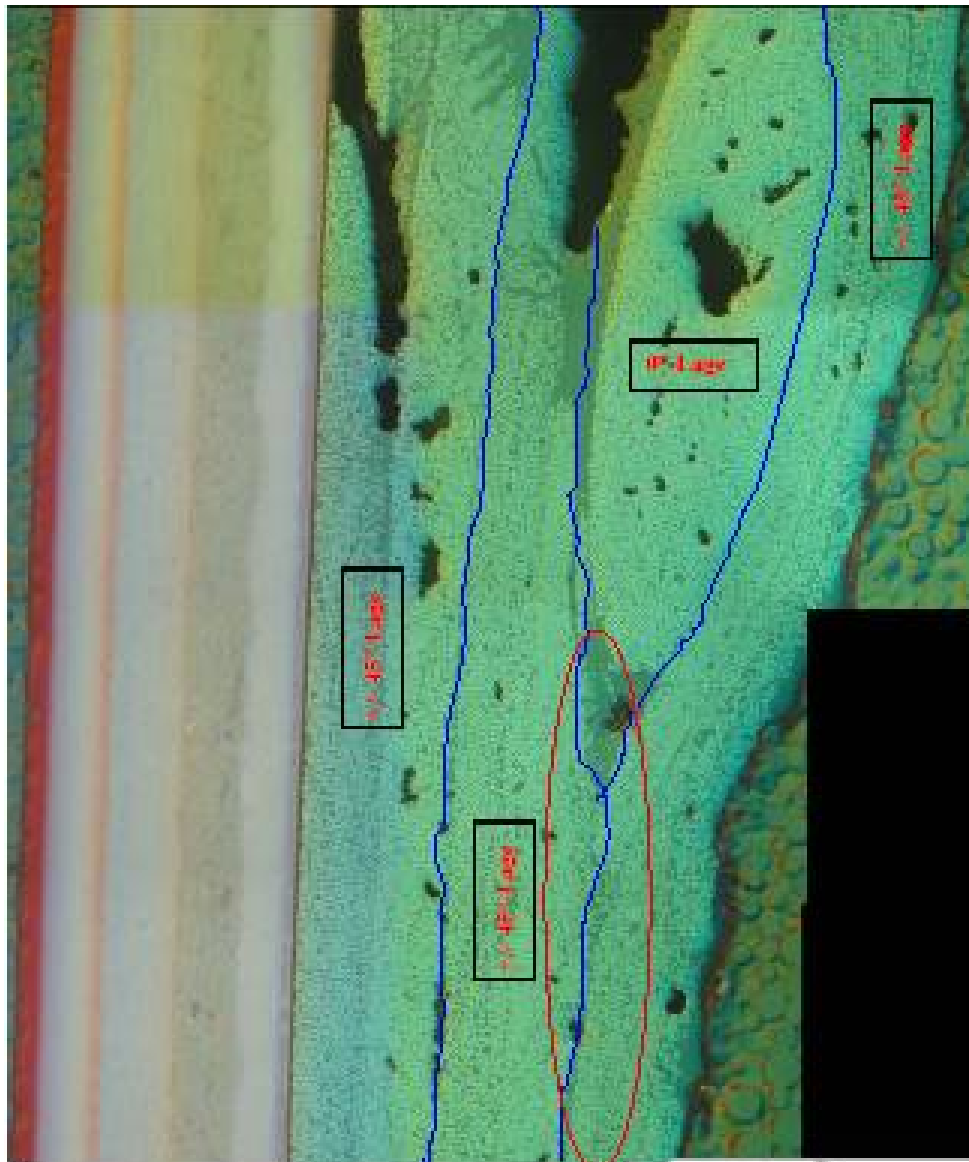
The fractured section of the rear fuselage with three of the four quadrants marked (Number four is on the upper side).

Appendix 2



Photomicrograph of Quadrant 1 (ground in the 0°-direction)

Appendix 3



Photomicrograph of Quadrant 2 (ground in the 90°-direction)

## Appendix 4

**Actual composite layup at four sample points, as compared with the layup design**

Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
±45°-Layer	±45°-Layer	±45°-Layer	±45°-Layer
0°-Layer	±45°-Layer	0°-Layer	0°-Layer
0°-Layer	missing	0°-Layer	±45°-Layer
0°-Layer	±45°-Layer	0°-Layer	±45°-Layer
0°-Layer		±45°-Layer	
±45°-Layer		±45°-Layer	
±45°-Layer			
Type and number of layers as defined by composite layup plan			
3 x 0°-Layer	1 x 0°-Layer	3 x 0°-Layer	1 x 0°-Layer
3 x ±45°-Layer	3 x ±45°-Layer	3 x ±45°-Layer	3 x ±45°-Layer

Appendix 5



Left Fuselage half: Approx. 20 mm gap in the unidirectional layer UD-Layer



Right Fuselage Half: Approx. 45 mm gap in the unidirectional layer