**ACCIDENT**

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|---|---|
| **Aircraft Type and Registration:** | SZD-24-4A Foka 4, G-DBZZ |
| **No & Type of Engines:** | N/A |
| **Year of Manufacture:** | 1966 |
| **Date & Time (UTC):** | 8 August 2010 at 1410 hrs |
| **Location:** | Bicester Airfield, Oxfordshire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - 1 (Fatal) Passengers - N/A |
| **Nature of Damage:** | Aircraft destroyed |
| **Commander's Licence:** | Gliding Certificate |
| **Commander's Age:** | 25 years |
| **Commander's Flying Experience:** | 226 hours (of which 2.5 hours were on type)<br>Last 90 days - 3.7 hours<br>Last 28 days - 1.3 hours |
| **Information Source:** | AAIB Field Investigation |

**Synopsis**

During the second winch launch of the day, the wings of the glider separated from the fuselage. The pilot sustained fatal injuries in the resulting impact. The investigation determined that when the aircraft was rigged, the lower bevel bolt of the wing main fitting had not fully engaged with the lower lug stack of the main spar joint and it was not possible to detect this condition. As a consequence, when the glider became airborne, the partially secured joint was unable to sustain the wing bending moments associated with the winch launch and the lower bevel bolt failed. This allowed the lower attachment lugs to disengage and the wings to fold upwards and separate from the fuselage. Two Safety Recommendations have been made as a result of the investigation.

**History of the flight**

*General*

A gliding club at Bicester Airfield had organised a week of gliding activity for 60 students from universities around the country. Four friends, including the accident pilot, had each brought a glider from Scotland to take part. The owner of G-DBZZ was not attending the event, but the pilot involved in the accident flight had flown the aircraft before and had observed the owner rig and de-rig the glider. The pilot had recently taken out an insurance share in order to operate it as part of a syndicate arrangement. The owner conducted a verbal briefing on the handling of the aircraft with the accident pilot in the presence of an instructor and also provided some notes on operating the glider. The accident pilot had also taken the Flight Manual home and studied it.

*Pre-launch activity*

The friends arose at about 0700 hrs on the morning of the accident and rigged two of the four gliders before attending the daily flying briefing at 0800 hrs. Following the briefing and completion of documentation, the pilot and friends re-read the flight manual Section 7.1 'Wing assembling' and commenced the rigging of G-DBZZ and the other glider. The fuselage was withdrawn from the trailer and placed on the rigging support. This was designed to maintain the glider in an upright position but one of the straps had broken, so one person held the tail fin whilst the others withdrew the wings and laid them out on the ground. One wing was placed in position first, with the accident pilot supporting the wingtip and another person (Pilot A) the wing root. Pilot A inserted the spar root into the fuselage cutout and ensured that the leading and trailing edge spigot bearings were positioned over the bevel pins on the fuselage. Having done this he placed a trestle part way along the wing.

Another pilot joined them and the other wing was placed in position and a trestle placed under it. The person (Pilot A) who had inserted the first wing spar then operated the horizontal rotating bar which operated the forward bevel pins and was mounted on a bulkhead behind the pilot's seat. This pushed the wings apart and so he returned it to its original setting with the wings flush with the fuselage. He then took over from the person holding the fin, who went to assist with rigging another glider. Another pilot (Pilot B) came to assist and he took the left wingtip, with the accident pilot holding the right wingtip; Pilot A supported the fin whilst another pilot (Pilot C) operated the wing main fitting locking mechanism using the speed brace and a rigging tool provided in the rigging tool box.

As none of the pilots had rigged the glider before, the accident pilot, and those assisting, spent some time consulting the Flight Manual. When Pilot C felt resistance, they stopped and adjusted the position of the wingtips until the mechanism moved more freely again before continuing. Pilot C was concerned that there was no way of checking the mechanism had reached full travel. The accident pilot and Pilot A then located Section 7.8 'Assembly sequence', which contained a requirement for '40 half turns' of the mechanism to be made, which they pointed out to Pilot C. It was decided that they would slacken completely the wing main fitting mechanism and start again. This was carried out, during which Pilot C, who was operating the mechanism, felt no resistance and carefully counted that the full 40 half turns required by the Flight Manual were completed. As there was no resistance felt, it suggested to them that the holes were properly aligned. Pilot C made an additional four to six half turns before feeling resistance, at which point he then stopped.

The speed brace and tool were removed and the T-wrench was inserted into the main fitting and the upper fuselage cover for the mechanism access hole was locked in place. The tailplane and control linkages were secured by Pilot A and the accident pilot carried out a duplicate inspection to ensure this had been done correctly. A final check was made of the forward bevel pin adjustment bar, which could not be moved; the pilots assumed this indicated that the bevel pins were at their maximum travel. Having taped over any joints, the accident pilot carried out a daily inspection and was assisted by another pilot whilst carrying out the positive control checks. The gliders were towed to the launch point and the accident pilot tried to contact the owner to ensure they had carried out the rigging correctly. The owner did not answer the call and so a message was left for him.

*The first launch*

The weather at Bicester was good with the surface wind variable at less than 5 kt, visibility in excess of 10 km and cloud scattered at 4,500 ft. Runway 36 was in use and the pilot of G-DBZZ was planning to attempt a distance flight of 317 km over a set route. For this reason, the glider logger was operating.

The glider was moved forward to the launch point and the duty instructor asked the pilot what type of glider it was. The pilot told him and added that it launched like an 'Astir'. The instructor was not familiar with the type and so instructed the winch driver to launch it like a 'K8'. After a short ground run the glider lifted off and adopted a climbing attitude. Shortly after, the nose was lowered, which was the signal to the winch driver to increase the launch speed, which he did. The glider continued to climb and released from the cable. The pilot had not achieved the hoped for height from the launch and was unable to locate any thermals. Following four orbits, the glider was flown around the circuit and established on the final approach. As the airbrakes were extended, the canopy opened and moved forward on its rails. The pilot held onto the canopy with one hand, to prevent it opening further, and controlled the glider with the other hand. As a consequence, the glider was landed with the airbrakes extended but the touchdown was without incident. The pilot was shaken by the experience but was happy to continue flying, so the glider was towed back to the launch point.

At this point the owner returned the accident pilot's call and they discussed the rigging and the canopy coming open. The pilot and friends had some light refreshments before preparing the glider for a subsequent launch. The owner telephoned a second time to suggest that the canopy opening may have been associated with the opening of the airbrakes. As a result of the two telephone conversations, the pilot was reassured that they had followed the correct rigging procedure and understood that providing the forward bevel pin adjustment mechanism could not be moved anymore, the bevel pins were fully extended in the spigot bearings.

*Second launch*

The duty instructor checked what type of launch was required and the pilot responded that the climb would be at 60 kt and similar to an 'Astir', but gently initially for the ground roll. The pre-flight and control checks were performed and the canopy checked for security. The launch cable with the correct weak link was attached and the launch initiated following a radio call to the winch driver. The acceleration and rotation into the climb appeared normal although, as the aircraft climbed, some witnesses thought it appeared fast. The glider yawed to the right but it was not clear if this was the commencement of the yawing signal to slow down. The winch driver reduced power, as he normally would, and the glider continued the climb a little steeper and faster than normal. Witness estimates of the height at which the next sequence of events occurred varied between 600 ft and 1,000 ft, but the described sequence was generally similar.

The glider was still on the launch when the left wing bent up approximately 20° and the aircraft banked slowly to the left. The right wing then bent up by a similar amount. The glider appeared not to have released from the winch cable at this point but the wings separated from the fuselage, remaining attached to each other at the main spar joint. The fuselage adopted a steep nosedown attitude before striking the ground. The wings descended at a slower rate falling to the ground short of the fuselage. A number of persons were very quickly on the scene but the accident was not survivable.

**Pilot information**

The pilot started gliding in July 2001 and up until the accident flight had accumulated 226 hours and 19 minutes total flying time in 531 flights. This was broken down into; 75 hours 49 minutes on single-seat gliders, P1 multi-seat gliders10 hours 53 minutes and P2 multi–seat gliders 139 hours 37 minutes.

The pilot held A and B British Gliding Association (BGA) certificates issued in September 2002 and a BGA Bronze award in September 2003, with a qualifying cross-country in April 2004. The pilot also held a BGA Silver award, completing the height element in May 2004, distance in August 2004 and duration in November 2004.

The first flight on the Foka 4 was on 19 June 2010 and in four flights a total of 2 hours 30 minutes were flown.

**Medical and pathological information**

A post-mortem examination revealed that the pilot had no medical history which would have been relevant to the accident and there was no evidence of significant pre-existing natural disease. Toxicology revealed no evidence of drugs or alcohol. It concluded that the pilot died of multiple injuries which were caused when the glider struck the ground.

**Aircraft description**

The SZD 24-4A Foka 4, a single-seat standard class sailplane, was designed and manufactured by Szybowcowy Zaklad Doswiadczalny (SZD) Bielsko in Poland in the 1960s. The type is no longer in production and the Type Certificate for the aircraft is currently held by a Polish aircraft manufacturer.

The Foka 4 is of predominantly wooden construction, with a fibreglass composite forward fuselage section. The ailerons, elevator and rudder are fabric covered and the wings are of stressed skin laminated plywood construction. The wings do not have a conventional spar; however a root spar allows connection of the wing to the fuselage.

**Wing attachment philosophy**

There are three attachment points for the wings of the Foka 4 glider: the wing root main attachment fittings, which form the main spar joint and resist wing bending loads; trailing edge fixed bevel pins, and leading edge movable bevel pins, which resist torsional loads.

*Wing to wing attachment*

The aircraft has a shoulder wing configuration. A spar cutout in the fuselage, behind the cockpit, accommodates the wing root spars. Two latches on the forward wall of the spar cut-out engage catches on the wing roots, allowing each wing half to be mounted separately thereby reducing the number of people required to rig the aircraft. The latches have no structural significance.

The left wing has a single upper and a lower horizontal attachment lug at the root spar. The right wing has a double set of upper and lower attachment lugs. The attachment lugs of each wing meet in the centre of the fuselage forming an upper and lower lug stack. Correct alignment of the lugs in the upper lug stack is achieved using an 'L-shaped' tool. This tool is inserted through a small access hole in the top of the fuselage and into the upper lug stack. It is 'joggled' until the lugs come into alignment. The spar joint is then secured by expanding the bolts of the wing main fitting, which is mounted on the end of the right wing root spar, between the attachment lugs. Figure 1(a) and 1(b) refer.

**Figure: 1 (a)**

Right wing root with Wing Main Fitting

**Figure: 1(b)**

Fuselage spar cut-out, right wing installed; access hole visible in top of fuselage

The wing main fitting (Figure 2) is a double expanding bolt arrangement consisting of two tapered steel bevel bolts, mounted between aluminium guide plates, which travel upwards and downwards into the lug stacks on a hollow threaded screw. The fitting is operated by means of a special tool, referred to in the Flight Manual as a 'T-wrench'. This is inserted into the bore of the threaded screw, and turned by hand in a clockwise direction. Vertical slots, or keyways, machined along each side of the bevel bolts, engage with the edge of the guide plates, such that as the threaded screw rotates, the bevel bolts are restrained from turning and instead travel along the screw threads and into the lug stacks. The central collar of the threaded screw (Figures 3a and 3b) is restrained in a central position between two stops on the guide plates such that symmetrical expansion of the bolts takes place. The attachment lugs are taper-reamed to match the taper profile of the bevel bolts. To expand the bolts fully it is necessary to ensure the wings are correctly aligned and the T-wrench is operated for approximately 40 half turns. It may be necessary to oscillate the wingtips up and down to achieve correct alignment of the lugs.

Full expansion of the upper bevel bolt can be visually confirmed through the access hole above the wing main fitting – as a minimum, the 8 mm tapered lead-in of the bolt should protrude above the upper lug on the right wing (Figure 4a). It is not possible to verify the position of the lower bevel bolt.

The mechanism is locked in position by inserting the T-wrench such that the bent arm engages with one of four holes cut in the top of the spars (Figure 4b.) A sprung access panel is then placed in the access hole.

*Wing to fuselage attachment*

Two fixed and two movable horizontal bevel pins are mounted on the fuselage in the area of the wing root and these are positioned to engage with self-aligning spigot bearings (Items 8 and 9, Figure 5) on the wing root ribs when the wings are offered up to the fuselage. The rear set of bevel pins are fixed (Item 5, Figure 5). The forward set of bevel pins (Item 3, Figure 5) are movable and are extended and retracted by means of a horizontal bar with a sprung rotating handle (referred to as a 'screw wrench' in the Flight Manual) (Item 10, Figure 5.) This bar is mounted on the bulkhead behind the pilot's seat (Figure 6). Rotation of the bar drives the bevel pins outboard to engage with the spigot bearings, thereby reducing any gaps between the wing and fuselage and eliminating unnecessary loading in the

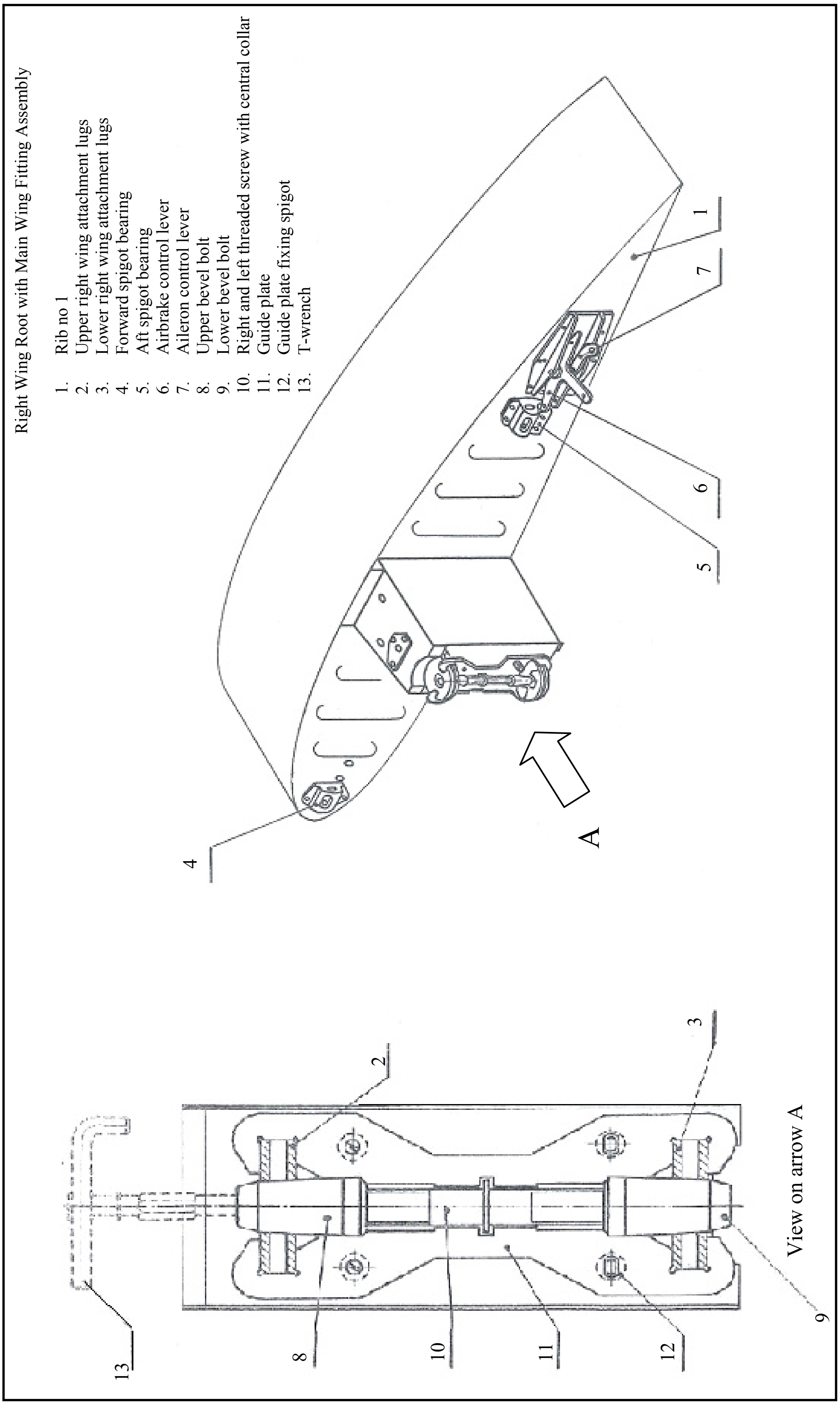


**Figure 2**

Right wing root with Wing Main Fitting Assembly

**Figure: 3 (a)**

Wing Main Fitting, bevel bolts fully retracted

**Figure: 3(b)**

Wing Main Fitting, bevel bolts fully expanded and T-wrench inserted

**Figure: 4 (a)**

Tapered portion of bevel bolt protruding, indicating upper bevel bolt fully expanded

**Figure: 4(b)**

T-wrench locked in position

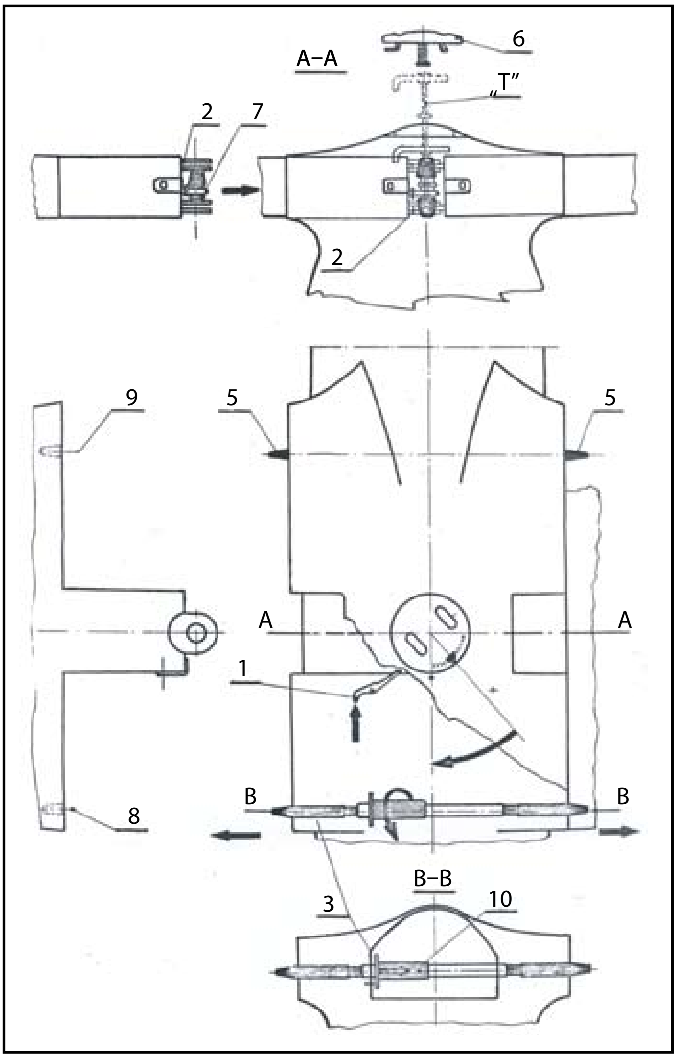


**Figure 5**

Wing attachment philosphy


**Figure: 6**

Horizontal bar ('screw wrench') which operates forward bevel pins wing to fuselage joints. Full tightening of the forward bevel pins can be facilitated by oscillating the wingtips forward and aft. A securing spigot engages a locking disc mounted on the rotating handle to lock the forward bevel pins in position (Figure 6).

**The Aircraft Flight Manual (AFM)**

The Aircraft Flight Manual contains the information and limitations for the operation of the glider. Section 7, '*Assembling and Disassembling',* explains the rigging/de-rigging of the glider and is broken down into a number of sub-sections.

Paragraph 7.1, '*Wing assembling',* provides a technical description of the assembly of the wings to the fuselage. It refers to numbered components shown on an engineering drawing and explains how the various components fit together, as well as what actions are needed to operate the assembly mechanisms. It does not contain any specific sequence of assembly, cautions or methods of assuring proper alignment of the attachment lugs for the bevel bolts. This information is provided two pages later in Paragraph 7.8.

Paragraphs 7.2 to 7.7, cover '*Horizontal tailplane fitting', 'Tools', 'Auxiliary items', 'Assembly team', 'Assembly time' and 'Disassembly time'* respectively.

Paragraph 7.8, '*Assembly sequence*', provides detailed instructions for attaching the wings to the fuselage and the relevant extract is set out below:

*'1. Open the canopy and inspection panels on fuselage top, remove the top covering, remove tail cup.*

*2. Clean and cover with technical Vaseline all working surfaces of fittings, bolts, pins, seats and of control drive joints.*

*3. Unlock the screw handle of the front bevel bolts in the fuselage /3 fig. 9 /*[refer to Item 3, Figure 5]*, and pull the bolts together by turning the screw handle in the right direction till stop /looking from left wing half/ i.e. in direction opposite to marked arrow.*

*4. Pull together the bevel bolts in the fitting of spar root of right wing half by turning with "T" wrench in left direction till stop, i.e. in direction opposite to marked arrow. Remove "T" wrench from the fitting.*

*5. Insert any wing half into fuselage and attach provisionally the spar root by means of lock 1/ fig. 9/* [refer to Item 1, Figure 5], *which is accessible from upper luggage compartment. Insert in the same way the other wing half.*

*6. Align accurately fitting holes by means of duralumin "L" wrench. Insert "T" wrench /fig. 9/* [refer to Figure 5] *and put apart the bevel bolts. Turning of the wrench to the right, in accordance with marked arrow. Obtain full tightening of bevel bolts by unloading the wing tips and performing small oscillations. Check the play /if any/ by finger pressing to the upper bevel bolt. After full tightening of bolts set* *the "T" wrench so as to insert the end of bent handle into hole in the fitting. Put the upper inspection disc and set it according to red marks.*

*Caution:*

*The "T" wrench is to be handled by hand only not by tools! The operation is facilitated by hand holding the wrench flange with left hand. Full pushing apart of the bevel bolts requires ca.40 of half-rotations.*

*7. Unlock the screw handle of front bevel bolts in the fuselage and take bolts apart by turning of handle to the left /looking from the left wing half/ i.e. in direction indicated by arrow. Full tightening may be facilitated by horizontal loading of wing tips in rearward direction /hold on the fuselage/. Secure the handle. Check the play of the connection by observing a gap between fuselage and wing when the wing tips are loaded horizontally.*

*Caution:*

*The handle is to be operated by hand only, without any tools!*

*Overstressing of handle causes shearing-of of safety pin. A new safety pin is to be made from soft steel wire Ǿ 2 mm /steel SP 1A/.'*

**Recorded data**

An 'EW microRecorder' unit was recovered from the accident site. The unit was designed to automatically start and stop recordings depending on speed and altitude changes. The start criteria were such that the ground run of a takeoff would be captured. The trigger to stop the recording was if the altitude and speed did not vary by more than 50 m or 5 km/hr, respectively, in the last 90 minutes.

The recorder captured the complete flight prior to the accident flight. The recording stopped 19 minutes after landing, indicating that the unit was manually switched off rather than automatically stopped. The technology is such that had the unit been switched back on, appropriate date/time stamped data would have been present in the memory of the unit even if power had subsequently been lost. There was no such data relating to the accident flight, indicating that the unit had not been switched on before the accident flight.

**Accident site and wreckage examination**

*Wings*

Examination of the wreckage showed that wings had become detached in flight and had fallen separately from the fuselage, coming to rest inverted to the right of Runway 36.

The wings (Figure 7), which were still attached to each other, were largely intact except for a 2.15 m section of the left wing inboard trailing edge, which had detached on impact with the ground. Examination of the wing root fitting in the as-found inverted position, revealed that the lower bevel bolt was only partially engaged in the lower right wing attachment lugs and the lower left wing attachment lug was disengaged from the lug stack (Figures 8a and 8b).

After turning the wings over into their correct orientation, examination revealed that although the upper attachment lugs of the right wing had splayed apart, the wings had remained connected by the upper lug stack and bevel bolt. The T-wrench was still installed in the internal


**Figure 7**

G-DBZZ Wing assembly (inverted)

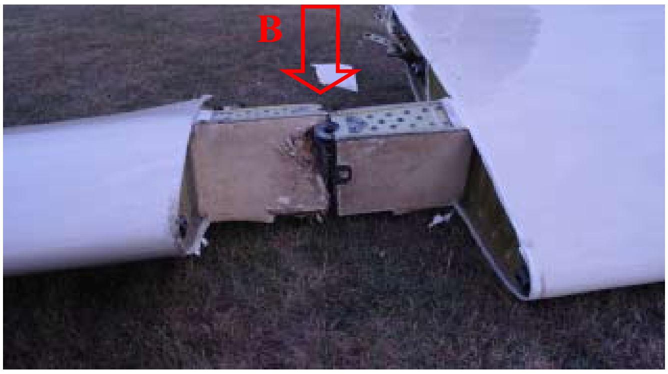


**Figure 8 (a)**

View on Arrow A from Figure 7

**Figure 8 (b)**

View on Arrow B from Figure 8 (a)

diameter of the threaded screw and locked in position (Figure 9). Both the T-wrench and the threaded screw of the wing main fitting were distorted where they passed through the upper bevel bolt and lug stack.

It was noted that the upper and lower bevel bolts had not expanded symmetrically along the threaded screw and the central collar of the threaded screw had been dislodged from the cut-out in the guide plates.

**Figure 9**
Wing main fitting in correct orientation

The self-aligning spigot bearings on the left and right wing root ribs were examined. All displayed evidence of fresh damage around the edges of the bearing housing, consistent with the bevel pins being dislodged from their seats under considerable load. This indicates that the bevel pins were engaged at the time the wing separated from the fuselage.

*Fuselage*

The fuselage struck the ground inverted and at high speed, approximately 160 m forward of the wings, in the direction of the launch. The fuselage structure forward of the wing was severely disrupted in the impact. The tail section remained attached until ground impact. It was found adjacent to the fuselage, remaining connected via the elevator and rudder cables. The fuselage wreckage was oriented on an approximate heading of 349º. The front skid from the underside of the fuselage was firmly embedded in the in the ground. These facts, together with the absence of any ground marks leading up to the wreckage, indicate a near vertical impact.

The rear fixed bevel pins had remained attached to the fuselage structure, and were protruding approximately 16 mm. The forward bevel pins on the rotating horizontal bar were also intact and were protruding 17 mm. The rotating bar was bent, and the securing spigot was not engaged in the locking disc. A small witness mark was evident where the spigot had contacted the face of the locking disc. The wooden bulkhead on which the rotating bar was mounted was largely intact; however, the surrounding fuselage structure had been disrupted.

*The winch cable*

The winch cable, drogue and associated linkages were located approximately 40 m forward, and to the left of the location of the wings. All components in the winch cable arrangement were intact and in good condition. A Tost No 4 blue weak link and a Tost No 1 black weak link were found to be connected in series, between the launch strop which attached to the aircraft and the cable parachute, by means of a quick release hook and ring.

The wreckage was removed the following day for detailed examination at the AAIB's facility in Farnborough.

**Detailed examination of wing main fitting**

Detailed examination of the wing main fitting using Computed Tomography (CT) images, determined that there was no damage to the threads of the threaded screw or bevel bolts, which may have prevented symmetrical expansion of the bevel bolts.

A specialist company, under the supervision of the AAIB, conducted a detailed metallurgical examination of the wing main fitting, the fractured portion of the lower bevel bolt, the wing attachment lugs and the guide plates.

*Bevel Bolt Fracture Surfaces*

The fractured portion of the lower bevel bolt was approximately 8 mm in length and was observed to be elliptical in shape, having been deformed during the failure. It exhibited a fracture surface on one face and a machined finish on the other indicating that it was the 8 mm tapered lead-in at the bottom of the bolt which had been fractured.

Detailed examination of the fracture surface by a Scanning Electron Microscope (SEM) showed that the majority of the fracture surface exhibited shear dimples, indicating a failure in shear. Some mechanical damage was also evident and was most likely the result of contact with the lugs or contact between the opposing fracture surfaces during the failure. Both the shear dimples and mechanical damage indicated that the direction of failure was across the minor diameter of the ellipse.

It was noted that the inner diameter of the sheared section exhibited an area of mechanical damage (Figure 10), which is consistent with contact with the end of the T-wrench during the failure of the bevel bolt.

The fracture surface of the lower bevel bolt (Figure 11) was found to be positioned flush with the top face of the bottom lug in the lower right wing lug stack. In this position, the left wing lower lug could not have disengaged, therefore it was concluded that the threaded screw, and hence both bevel bolts, must have moved downwards by approximately 8 mm after the lower left wing lug separated from the lug stack.

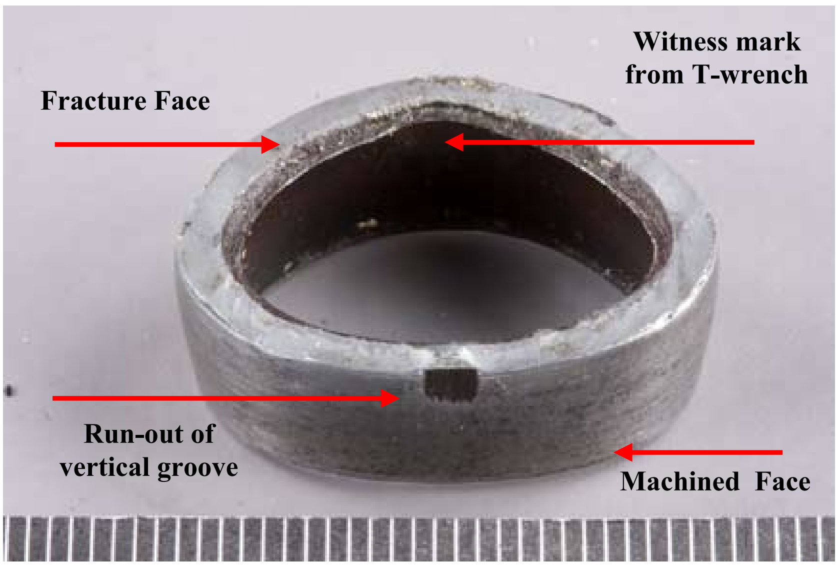


**Figure 10**

Fractured section of lower bevel bolt

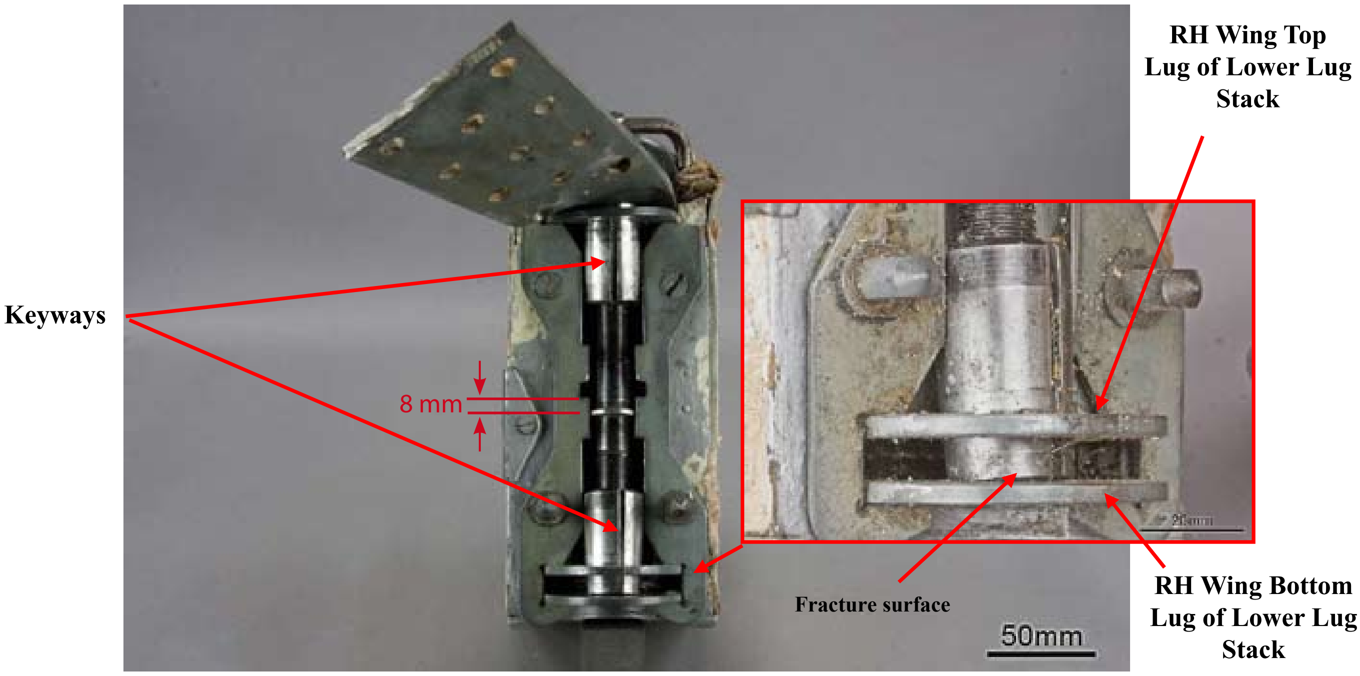


**Figure 11**

Wing Main Fitting

The central locating collar of the threaded screw was not in its correct position within the guide plate recess. The lower face of the collar was approximately 8 mm below the lower land of the recess. The keyways of both the upper and lower bevel bolts were disengaged from the guide plates (Figure 11). The ends of the bevel bolt keyway (Figure 10) were observed on the sheared portion of the lower bevel bolt at approximately diametrically opposite sides of the minor diameter of the ellipse. It was therefore concluded that the keyway of the lower bevel bolt was not engaged in the guide plates at the time the left lower lug pulled out of the lug stack.

There were 28 threads showing on the upper part of the threaded screw but only 17 threads visible above the lower bevel bolt. This suggests that the lower bevel bolt disengaged from the guide plate approximately 11 turns before the upper bevel bolt disengaged.

Dimensional checks were carried out on the upper bevel bolt and key dimensions are shown on Figure 12. A witness mark on the bolt indicated where it normally came into contact with the upper lug stack. Both bolts are assumed to be identical.

The depth of the keyway on both bolts was measured as 2.3 mm within the cylindrical section, running out to 0.5 mm at the end of the middle taper section. The dimension between the flats of the keyways on the cylindrical section of the bolts was therefore 24.1 mm.

The width between the guide plates was measured between the limits of vertical movement of the upper and lower bevel bolts and noted as varying between 28.1 mm and 29.1 mm in the region of the upper bevel bolt and between 28.9 mm and 28.5 mm in the region of the lower bevel bolt. The guide plate spacing was therefore greater in places than the maximum diameter of the bolts and the distance between the keyways.

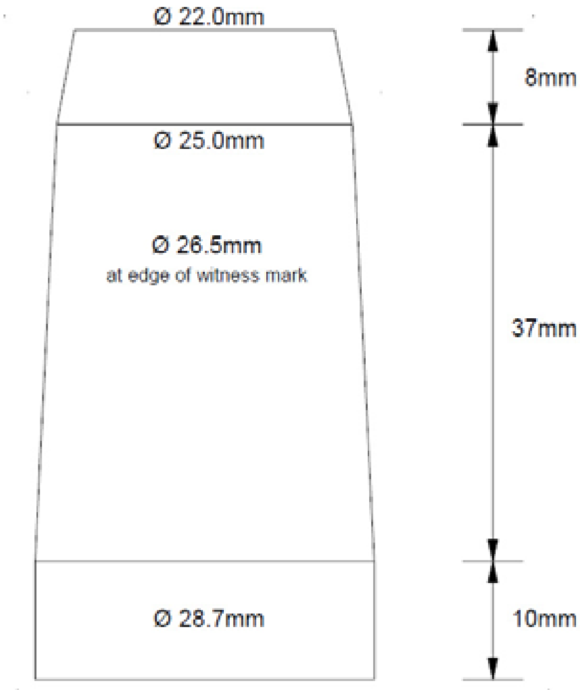


**Figure 12**

Dimensions of the bevel bolts

The guide plates are secured to the inboard end of the right wing root spar with two screws (upper attachment point) and two locating spigots (lower attachment point.) Spacer washers are used under the guide plate on each fastener. At the upper fastener position the stand-off was measured as 5.1 mm and 4.8 mm for the forward and aft plates respectively; at the central position 6.7 mm (forward) and 5.9 mm (aft); and at the lower fastener position 4.2 mm (forward) and 6.4 mm (aft).

After dismantling the guide plates, it was found that different thickness washers had been used on the lower fasteners of the forward (0.55 mm) and aft plates (1.9 mm) (Figure 13).

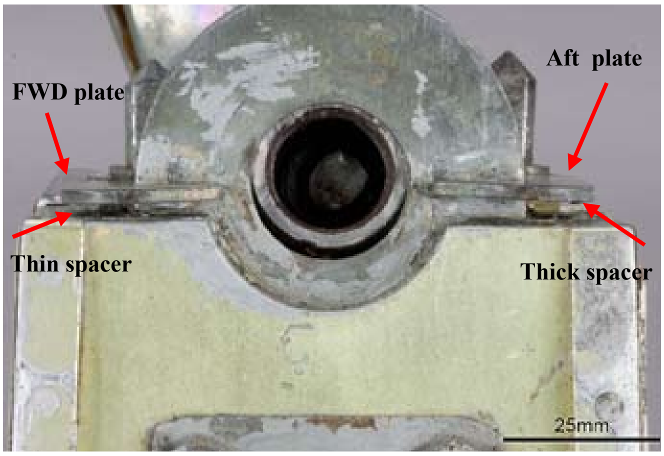


**Figure 13**

Difference in stand-off between forward and aft guide plates

The wear marks from sliding contact between the bevel bolt keyways and the edges of the forward and aft guide plates were examined. The contact depth appeared to vary from approximately 2.2 mm - 2.4 mm towards the centre of the plates, to 1.2 mm -1 .4 mm at the ends. However, there was very little evidence of a witness mark on the lower end of the back face of the aft guide plate, suggesting minimal engagement of the guide plate with the keyway of the lower bevel bolt. There also appeared to be some edge rounding ( Figure 14).

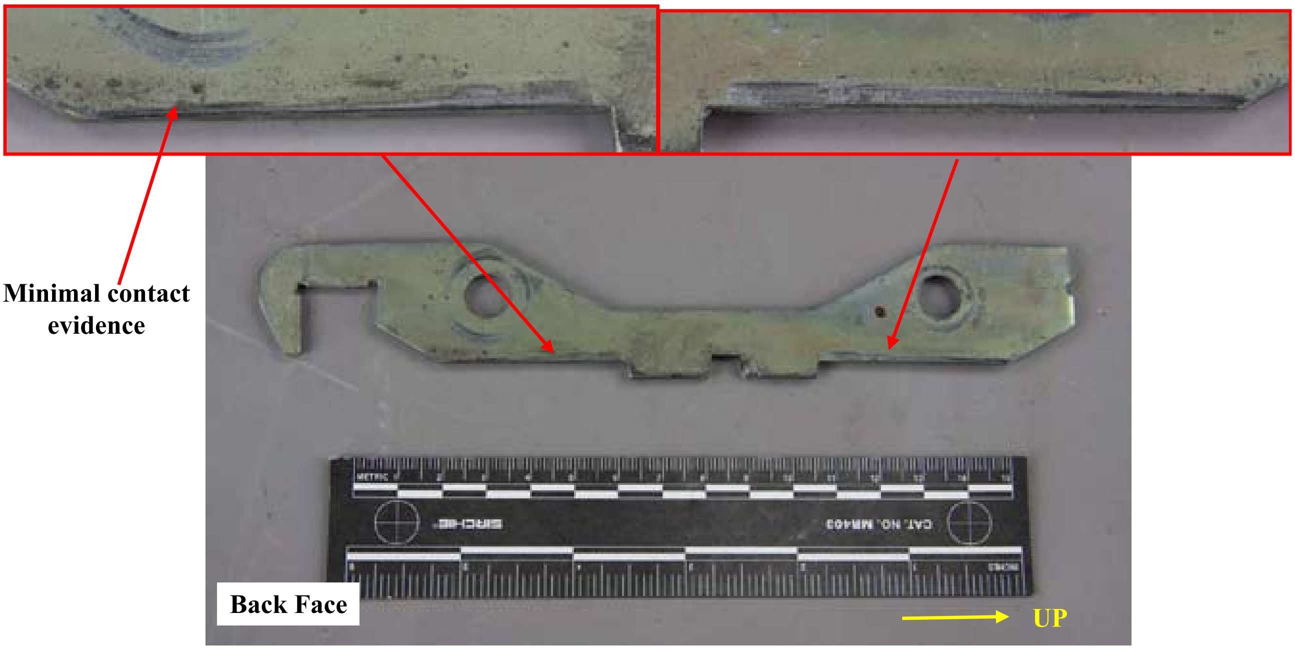


**Figure 14**

Wear marks on back face of aft guide plate

*Damage to guide plate and central collar*

Examination of the guide plates showed that mechanical damage was present on the edge of the back face of the forward and aft guide plates over a length of 8 mm from the lower land of the central recess.

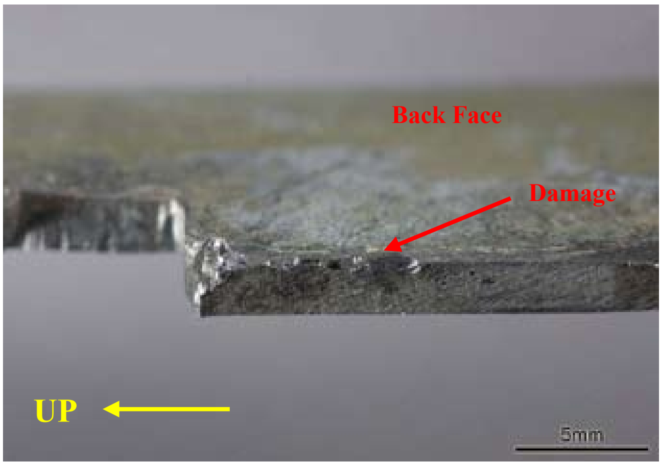


**Figure 15**

Forward guide plate below recess
(Aft guide plate exhibits similar damage)

This corresponds to the position in which the central collar of the threaded screw was found. However, the first 1 - 2 mm of damage on both forward and aft plates is consistent with rotational movement of the collar (horizontal scoring) rather than vertical movement of the collar. This indicates that the collar had been damaging the lower edge of the guide plate recess on both forward and aft guide plates while the mechanism was being operated (Figure 15).

Mechanical damage was also evident above the guide plate recess. Unlike the damage below the recess, which occurred only on the back face edge, the damage above the recess was evident on both the visible and back face edges for a distance of approximately 5 mm from the upper land of the recess. The mechanical damage resulted in horizontal scoring of the plate, consistent with rubbing against the collar during rotation (Figures 16 and 17). Examination of the collar showed similar horizontal scoring (Figure 18), which is consistent with the collar moving up out of the recess as the T-wrench was turning.

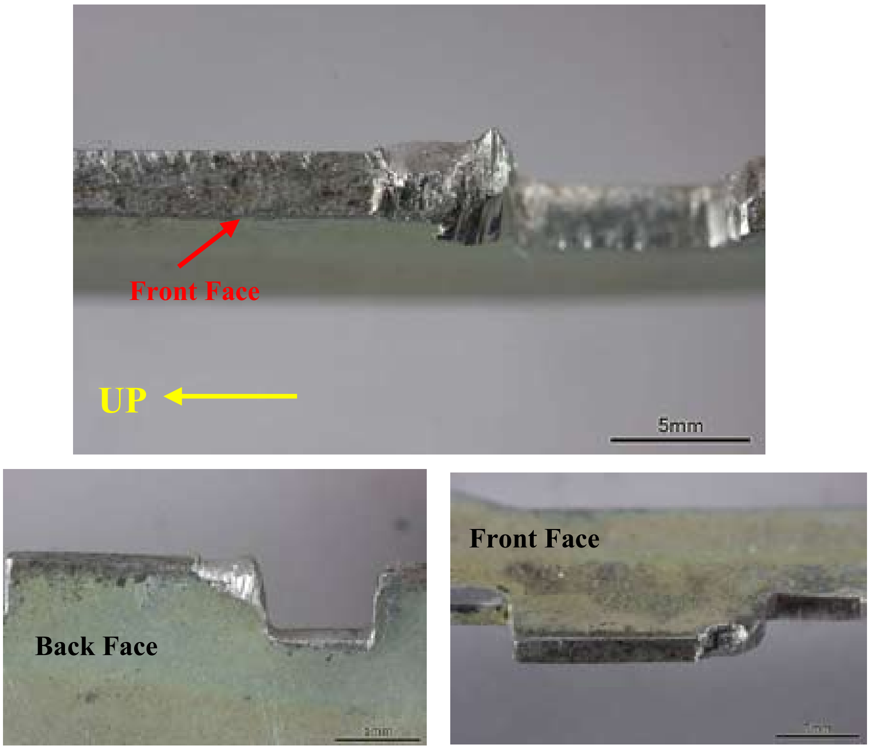


**Figure 16**

Forward guide plate above recess

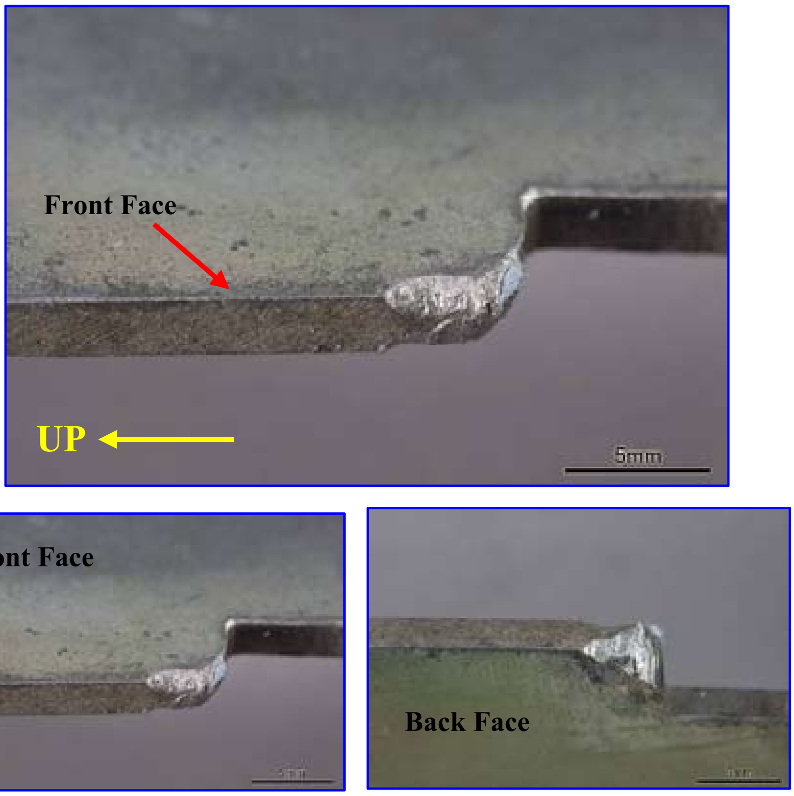


**Figure 17**

Aft guide plate above recess


**Figure 18**

Mechanical damage observed on surface of collar

*Wing attachment lugs*

Damage was observed on the upper surface of the upper right hand lug (Figure 19). The damage was circumferential for a width of approximately 2 mm at the edge of the LH side of the hole.

The left hand (centre) lug exhibited a semi-circular witness mark on the upper surface approximately 6 mm from the right hand edge of the hole (Figure 20) as well as radial scoring from the hole.

The remaining damage observed on the lugs was consistent with scoring damage caused as the bevel bolt sheared and the left hand lug disengaged.

The majority of the damage on the upper and lower right hand lugs was consistent with damage caused as the lower bevel bolt sheared and the left hand lug pulled out of the lug stack. The semi-circular damage on the upper surface of the left hand (centre) lug is consistent with contact with the lower surface of the lower bevel bolt indicating that the bolts were expanded while the left hand lug was not fully aligned in the lug stack.

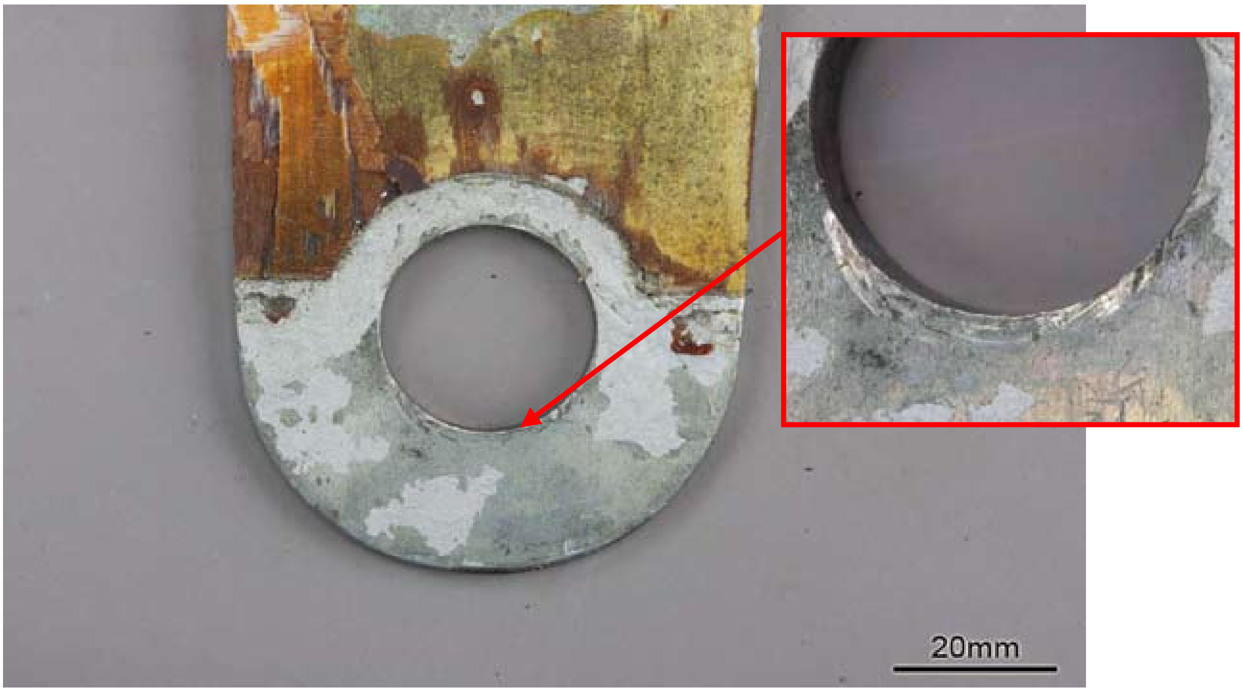


**Figure 19**

Mechanical damage observed on upper right hand lug

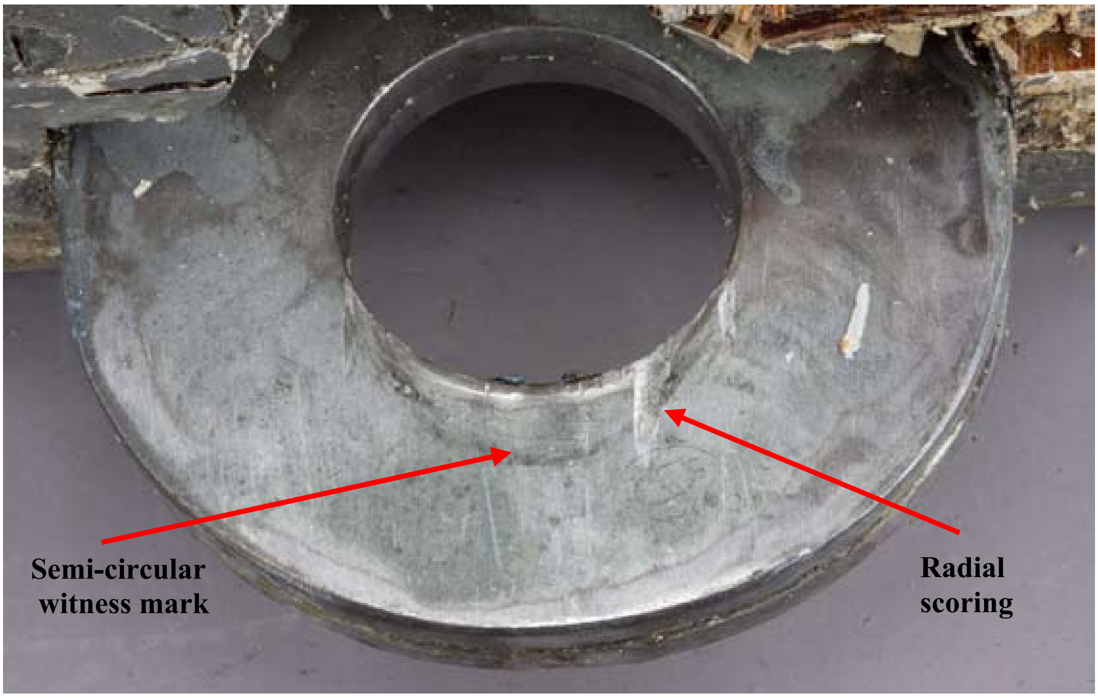


**Figure 20**

Mechanical damage on upper surface of the left hand (centre) lug

**Weak links**

Weak links are commonly used in glider winch cable arrangements to prevent structural overloading of the airframe during winch launching. The weak link is designed to fail if an overload situation arises, thus disconnecting the winch cable from the glider. Weak links come in a variety of colours, with each colour being rated to a certain load. For each type of glider a specific colour of weak link is recommended. The recommended weak link for the SZD-24-4A Foka 4 is a blue weak link, which is rated to a load of to 600 deca Newtons (daN) +/- 10%.

The blue weak link recovered from the winch cable used to launch G-DBZZ, when tested, failed at a tensile load of 621.7 daN. A control specimen was also tested and this failed at tensile load of 620.9 daN. These were within the rated load.

A black weak link, rated to 1,000 daN was also found in the G-DBZZ winch cable arrangement. However as both weak links were connected in series, the blue weak link would have failed first.

**Rigging tools**

The rigging tools recovered from the aircraft's trailer were examined. These included the T-wrench and L-shaped tool described in the AFM. In addition, there was a speed brace and a straight drive. On inspection, the straight drive tool appeared to have been manufactured by welding the straight section of a T-wrench to a hexagonal-drive, such that it could be used in conjunction with a standard speed brace. The Type Certificate holder confirmed that this was not a manufacturer approved tool. This tool and the speed brace had been included with the rigging tools when the owner purchased the aircraft.

**Rigging experience**

When the owner acquired the aircraft, the previous owner had provided some notes on rigging; these referred to using the speed brace. Consequently, the owner routinely used the speed brace and modified tool to operate the bevel bolts of the wing main fitting. His experience of rigging the aircraft was that considerable care was required to ensure the wing attachment lugs were properly aligned. Little force was required to operate the speed brace on the wing main fitting when the lugs were fully aligned. Upon expanding the bevel bolts, if any resistance was encountered he considered it imperative to stop and wind the bolts back in, before attempting to realign the lugs. The process could then be commenced again, with the appropriate number of turns being counted. Given the limited visibility of the wing main fitting, the primary indicator of whether the rigging was progressing as expected was the mechanical 'feel,' or feedback, through the rigging tool. The owner believed that the T-wrench was to be used only as a locking mechanism to secure the wing main fitting at the end of the rigging process. When he had demonstrated the rigging of the aircraft to the accident pilot, it was in accordance with his normal practice. The owner had anticipated that in the initial stages of the syndicate arrangement they would jointly be rigging the glider. The accident pilot, as a member of the syndicate, was entitled to take the glider to Bicester.

**Aircraft service bulletins**

*Service Bulletin BE-005/75 'Foka 4'*

In 1975 the manufacturer issued Service Bulletin (SB) BE-005/75 'Foka 4' – '*Introducing the Annex Nr 1 to Technical Service Manual concerning the extended range of glider periodic inspections'*, which introduced additional maintenance requirements on the basis of in-service experience. This SB included requirements to inspect the wing main fitting for ovalisation of the bevel bolts, non-linearity of the cone-generating line and surface contact between the bevel bolts and attachment lugs. The annex also included instructions on how to remove any observed defects in accordance with the overhaul manual.

*Service Bulletin BE-06/4A/80 'Foka 4'*

The Foka 4 Service Manual, issued at the time of aircraft manufacture stipulated that the first overhaul was due at 650 hours or within 5 years and indicated that further overhaul periods were to be defined subsequently based on operational experience.

In 1980 the manufacturer published SB BE-06/4A/80 'Foka 4' – '*Changes of repair time periods and further operation'*. As a result of prolonged observation, technical inspections and the results of a wing fatigue test on Foka 4 aircraft, new overhaul periods were introduced at 1,300 hrs and 1,900 hrs. These replaced the previous overhaul periods described in the Service Manual.

This SB required that SB BE-005/75 be carried out and in addition that the wing main fitting and spar root was inspected for the presence of cracks. The SB indicated that a further extension to the life of the glider would have to be endorsed by the Type Certificate Holder and the 'authority' based on the results of the inspection. The SB also introduced certain operational limitations for gliders with more than 1,900 hrs.

**Aircraft maintenance history**

G-DBZZ, serial number W-308 was manufactured in 1966, and transferred onto the British register in 1967. The aircraft was acquired by the current owner in July 2007, at which point it had accumulated 1,913 flight hours and 1,353 launches. One flight was undertaken in October 2007, and after that the aircraft was not flown until it was transitioned to a non-expiring EASA Certificate of Airworthiness in June 2008. The work required to complete the transition was carried out by the owner who was an approved British Gliding Association (BGA) Inspector. At the time the aircraft was transitioned the owner could not find any information relating to the life of the glider, and assumed it to be 12,000 hrs, which is a standard life for wooden gliders.

The subsequent Airworthiness Review Certificate (ARC) renewal was carried out in August 2009, by which time the aircraft had 1,924 hrs and 1,373 launches. In the intervening period the owner had become aware of the requirement for a Life Extension inspection to be carried out at 1,900 hrs, in accordance with SBs BE-064A/80 and BE-005/75. As the aircraft had already passed 1,900 hrs, the owner grounded the aircraft until the inspection could be completed. The necessary work was carried out coincident with the ARC renewal. Negligible ovalisation of the bevel bolts and lugs was noted and the contact between the bolts and lugs was within the limits quoted in the SB. All the components of the wing main fitting were observed to be in good condition. Following the inspection, the wing main fitting was reassembled and mounted on the wing in accordance with the instructions in the SB.

The next ARC renewal was carried out on 2 August 2010, by which time the aircraft had accumulated 1,940 hours and 1,390 launches. This included a visual inspection of the main spar joint. No findings were noted.

**Examination of other similar aircraft**

Another Foka 4 glider was examined and rigged in the course of the investigation and a number of observations were made.

When the bevel bolts of the wing main fitting were fully retracted there were no threads visible in the upper section of the threaded screw however five threads were visible on the lower portion.

It took approximately 62 half turns of the T-wrench to achieve full expansion of the bevel bolts rather than the 40 half turns quoted in the flight manual. With the bolts fully expanded, there were 30 threads visible below the upper bevel bolt and 37 threads visible above the lower bevel bolt. The upper and lower bevel bolts protruded from the lug stack by 12 mm and 13.5 mm respectively.

Additionally, it was noted that the aircraft had been modified to incorporate an access hole, which would allow inspection of the position of the lower bevel bolt with a torch and inspection mirror. This enables positive identification that the lower bevel bolt is fully engaged in the lug stack during rigging.

**Previous accidents**

In March 2007 an SZD-36-A 'Cobra' aircraft, registration N6SZ, crashed in the USA after in-flight separation of the wings from the fuselage, fatally injuring the pilot. The Cobra employs the same wing rigging philosophy as the Foka 4, albeit with some dimensional differences of the key components. As with G-DBZZ, misalignment of the lower attachment lugs during rigging prevented full expansion of the lower bevel bolt.

The US National Transportation Safety Board (NTSB) conducted an investigation into the circumstances of the accident (NTSB reference ATL07LA066 refers). The probable cause was cited as:

> *'The pilot's improper installation of the left wing attachment pin, which allowed it to disengage during cruise flight, resulting in wing separation.'*

There were no safety recommendations resulting from the investigation.

This accident prompted the owner of a UK registered Cobra to inspect his aircraft, and his findings led to the BGA issuing an awareness item on their Technical News Sheet (reference 02/2007), advising owners of Foka and Cobra gliders that damage incurred during rigging could cause failure of the wing main fitting. A possible cause was noted as holding the wings too high during rigging.

In June 1968 an SHK 1 glider, registration BGA 1390 crashed, fatally injuring the pilot, at Doncaster Aerodrome, UK. During rigging the bevel bolts jammed against the lugs of the opposite wing due to misalignment; this was at less than the requisite number of turns on the operating mechanism. The wings separated from the fuselage during the subsequent winch launch.

## Analysis

*General*

From the aircraft examination and the detailed metallurgical investigation, it is apparent that the lower bevel bolt of the wing main fitting had not fully engaged with the lower lug stack during rigging. This significantly reduced the load-carrying capability of the joint. As a consequence, when the glider became airborne the partially secured joint was unable to sustain the wing bending moments associated with the winch launch and the lower bevel bolt failed in shear. This allowed the lower attachment lugs to separate and the wings to fold upwards and detach from the fuselage.

*Rigging of the aircraft*

In order to fully expand the bevel bolts of the wing main fitting it is imperative that correct alignment between the attachment lugs of the left and right wings is achieved, and that the T-wrench is operated for the required number of turns. Correct alignment of the upper attachment lugs is facilitated by using the L-wrench tool and can be verified visually, however alignment of the lower lugs cannot. If the wings' tips are held too high or if the wing is trestled too close to the root, this may cause the lower lugs to be misaligned. Misalignment of the lugs may therefore only become apparent when the bevel bolts are being expanded. Therefore, when operating the T-wrench to expand the bevel bolts, it may be necessary to unload the wingtips and perform small oscillations to progressively achieve correct alignment.

If the lugs are not correctly aligned it is possible for the expanding bolts to foul against the left wing (centre) lug and not expand fully into the lug stack. The primary indications of any such misalignment would be resistance encountered while operating the T-wrench, in particular if the T-wrench stopped rotating prior to the requisite number of turns.

*Incorrect tooling*

When operating the approved T-wrench, using only hand force, any resistance is likely to be immediately evident. The flight manual emphasises the importance of using only hand force to turn the T-wrench. The required number of turns is quoted in half turns, because articulation of the wrist is limited to a half turn at a time. The effect of using the speed brace with the modified tool was that the tactile feedback would have been reduced. Additionally, because of its cranked shape, the speed brace would have provided significant mechanical advantage when turning the bevel bolts and it would have been much easier to overcome any resistance encountered using, what would seem to the operator, as a very light force.

The precise history of the modified rigging tool and speed brace are unknown, however they were provided with the aircraft and routinely used to operate the wing main fitting. This suggests that many successful riggings had previously been performed using these tools.

*Experience of individuals*

The rigging team was not experienced in rigging this particular type of glider nor gliders with a similar rigging philosophy. The accident pilot had observed the aircraft being rigged by the owner, but the extent to which the pilot participated in this rigging is not clear. During this demonstration the owner used the speed brace and modified tool to expand the bevel bolt and used the T-wrench only as a locking tool. The pilot is therefore likely to have considered this to be the correct rigging method.

The owner's experience of rigging the aircraft was that care was required to ensure the wings were correctly aligned and that the rigging process should be stopped immediately if any resistance was encountered. It is not clear if, or to what extent, this experience was communicated during the rigging demonstration.

Despite having previously read the flight manual, the accident pilot experienced some difficulty in locating the correct rigging information within the manual on the morning of the accident. However, when the information was correctly located, the instructions (with the exception of the rigging tool) were followed. The rigging team did not have any experience base for what was 'normal' for this aircraft or what potential rigging issues may be encountered. In particular, the person operating the speed brace had not participated in the previous rigging and therefore would not have had any 'feel' for what might be considered a normal amount of resistance and / or force required to operate the tool.

Although the pilot attempted to call the owner to verify that the aircraft had been rigged correctly, the main concern was relating to the operation of the rotating bar that adjusted the forward bevel pins rather than the main fitting itself. By the time the pilot established contact with the owner, the first circuit had already been completed and although the rigging was briefly discussed, the pilot was by that time somewhat preoccupied by the fact that the canopy had opened and this became the focus of the conversation.

*Interpretation of flight manual*

While translation of the flight manual from Polish into English has resulted in the manual being difficult to read in places, all the information necessary to rig the aircraft is largely present. The manual is however laid out in such a way that the information on 'Wing assembly' and 'Assembly sequence' is split between two different sections and this evidently caused some confusion during the rigging. The manual is however emphatic about the use of hand force only to operate the T-wrench.

No specific guidance is given on how to verify full expansion of the bevel bolts other than the statement '*Check the play if any by finger pressing to the upper bevel bolt'*. Additionally the manual contains no reference to the fact that it is possible for the upper bolt and lug stack to appear correctly assembled while the lower joint is not.

Observations made during the rigging of another Foka 4, which required 62 half turns of the T-wrench to achieve full expansion of the bevel bolts, would suggest that the figure of 40 half turns quoted in the flight manual can be considered an approximate figure only. It is likely that some variation can be expected between individual aircraft to account for manufacturing tolerances, age and wear in the lugs. However, in the case of G-DBZZ, the rigging team carefully counted 40 half turns and when it became apparent that the tool was still rotating, added a few additional turns until it stopped. The fact that the required number of turns had been accomplished would have given them confidence that the spar joint was correctly assembled.

*Sequence of events*

Witness marks on the lower lug stack indicate that the expansion of the bevel bolts was performed while the lower left hand (centre) lug was not correctly aligned in the lower lug stack. The lower bevel bolt contacted the upper surface of the left (centre) lug in the lower stack which stopped it from moving further down into the lower stack.

The resistance encountered by the lower bevel bolt under continued rotation of the rigging tool caused the wing main fitting assembly to be pushed upwards. This caused the central collar of the threaded screw to disengage from the guide plate cut-out and move upwards past the upper land of the recess, leading to the mechanical damage that was observed on the edges of the guide plate. The rotational scoring in this area and on the collar indicates that the rigging tool was being operated when this damage was caused.

As the collar had moved out of the recess, this is likely to have forced the guide plates slightly apart allowing the lower bevel bolt keyways to disengage from the guide plates. It is not clear whether the difference in stand-off between the forward and aft guide plates, due to the thicker spacer washer at the lower fastener position and / or the reduced contact noted between the aft guide plate and lower bevel bolt keyway, may also have been contributing factors to this.

With the central collar out of the recess, the bevel bolts would no longer have expanded symmetrically. With one or both bolts disengaged from the guide plate, the bolts would have turned with the threaded screw rather than travel along it.

The relative positions of the bolts on the threaded screw indicated that both bolts did not disengage from guide plates at the same time. The lower bolt disengaged approximately 11 turns prior to the upper bolt. It is only possible to give an approximate indication as it is not known whether any threads were visible when both bolts were fully retracted. The upper bolt would therefore have continued to travel along the threaded screw for some time, and this may explain why the upper bolt would have appeared to be correctly located.

As rotational scoring was present above the recess on both the front and back faces of the guide plates, it is considered possible that the direction in which the rigging tool was being turned was reversed (ie in an attempt to retract the bolts) which could have caused the collar to damage the opposite face of the plate.

At the time of failure, the bottom of the lower bevel bolt was flush with the upper surface of the lower right lug. As the lower bevel bolt is considered to have fouled initially on the upper surface of the left lug, there must have been some re-alignment of the lugs to allow the lower bevel bolt to move through the left lug into its final failure position.

When found after the accident, the fractured end of the bevel bolt was flush with the upper surface of the lower right hand lug. Therefore, it is evident that the whole wing main fitting assembly moved downwards by approximately 8 mm during the wing separation sequence and / or impact with the ground.

*Failure of the joint*

As a minimum, the lower 8 mm lead-in taper of the bevel bolt should protrude from the lug stack when correctly assembled. Given the position of the bolt in the lug stack when it failed, it can be concluded that the lower bevel bolt was at least 12 mm short of its intended position. It is also considered that the upper bolt was not in its fully expanded position. As neither bevel bolt was in the correct position, the diameter of the bevel bolts would have been smaller than the diameter of the lugs, so there would have been some play in the wing main fitting. The lower bevel bolt failed in single shear. If correctly assembled, it should have resisted the wing root bending loads in double shear. Because of the tapered profile of the bevel bolt the wall thickness at the point of failure was less than it would have been if the bolt had been fully inserted. The lower joint, in this condition, had less than half the normal shear strength of a correctly assembled joint.

The lower joint resisted the wing bending loads during the first launch and circuit, which indicates that the loads experienced during first launch must have been within capability of the compromised joint. However, it is not possible to say what, if any damage to the fitting was caused during this launch. The second launch, at the pilot's request, was faster and therefore increased wing bending loads would have been encountered which exceeded the capability of the compromised joint.

*Identification of correct rigging*

The design of the wing main fitting is such that correct assembly can only be checked by visual inspection of the top joint. It is not possible to verify correct assembly of the lower joint, neither visually nor by feel; rather this must be assumed by reference to the top joint.

The upper bevel bolt was installed to the satisfaction of the rigging team. It is evident however from this accident, and by reference to previous similar accidents, that misalignment during rigging can cause the lower bevel bolt to jam, while the upper bevel bolt provides a false indication of correct assembly.

Although the wing main fitting was damaged during rigging due to improper alignment of the lower lugs and use of a non-approved tool, this accident may have been prevented had there been a means of positively and independently verifying the correct assembly of the lower joint. Examination of another Foka 4 aircraft revealed that it had been modified by the addition of an access hole below the position of the lower bevel bolt in order to do this.

The following Safety Recommendations are therefore made to EASA:

**Safety Recommendation 2011-003**

It is recommended that the European Aviation Safety Agency require that the Type Certificate holder of the Foka 4 introduce a means of determining that the lower bevel bolt is fully engaged in the lower lug stack during rigging.

**Safety Recommendation 2011-004**

It is recommended that the European Aviation Safety Agency require that the Type Certificate holders of aircraft with a similar wing attachment philosophy to the Foka 4 ensure that there is a means of determining that both the bevel bolts are fully engaged in the lug stack during rigging.

**Safety action**

As a result of the preliminary findings of this investigation the BGA issued a Safety Alert on

2 September 2010 to raise awareness of potential rigging issues among owners of aircraft with a similar rigging mechanism to the SZD-24-4A Foka 4. Those aircraft include, but are not limited to, the SZD Cobra, Bocian and Jaskolka together with the Schempp-Hirth SHK, Austria Series. The Safety Alert reiterated the importance of following the Flight Manual guidance and only using approved tools. The alert also advised that if any resistance was experienced during expansion of the wing main fitting, then the rigging should be stopped immediately in order to establish the reason for the resistance.