ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15-912, G-BZMI
No & Type of Engines:	1 Rotax 912 piston engine
Year of Manufacture:	2000
Date & Time (UTC):	21 March 2010 at 1630 hrs
Location:	Longacre Farm, Bedfordshire
Type of Flight:	Air Experience flight (Exercise 3)
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Serious)
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	1,051 hours (of which 963 were on type) Last 90 days - N/K hours Last 28 days - N/K hours
Information Source:	AAIB Field Investigation

Synopsis

After rotation, the flex-wing microlight entered a constant gradual right turn, which could not be controlled by the pilot. Eventually the aircraft lost height, the right wingtip hit the ground and the aircraft came to rest in a field. The investigation identified that the battens, received with the wreckage, had been adjusted significantly more than the manufacturer's published limits permitted.

History of the flight

The passenger had been given a flight experience voucher purchased by her husband, which entitled her to a 30-minute flight in both a 3-axis and a flex-wing microlight at a local flying school. She returned from the flight in the 3-axis microlight and was provided with the necessary protective clothing for her flight in the flex-wing aircraft. This was to be the fifth flight of the day in G-BZMI for the pilot. The pilot, with the passenger in the rear seat, taxied the aircraft to Runway 17, and tookoff at 1615 hrs. The weather was fine, but with a 15 kt crosswind from the west. After rotation, the pilot found that a constant, but controllable, uncommanded turn to the right, that had been present on the aircraft all day, had become noticeably worse. He therefore flew a circuit and landed to address this issue.

The pilot stated that he removed one of the two elastics, which held the wing ribs/battens in place, on each of the wingtip ribs, in an effort to reduce the tension in the wing. He also recalled trying to adjust the shape of ribs 8 and 9 on the left wing, in-situ, by attempting to

bend the trailing edge approximately 5 mm, to 'tune-out' the turn. The passenger stated that the pilot was away from the aircraft for approximately a minute and worked on the left wing for around 30 seconds, appearing to shake it. The pilot then returned to his seat and taxied the aircraft to Runway 17 for a second takeoff. This time, following rotation at a height of 20 to 30 ft, the pilot found that even with full opposite control input, the aircraft continued to bank right and he could not recover to straight and level flight.

The pilot attempted to manoeuvre the aircraft to land on the alternate east/west runway, but could not turn the aircraft to align with the runway centreline. He continued to bank right in an effort to complete the circuit and land back onto Runway 17, but lost height, resulting in the right wing striking the ground and the aircraft coming to rest in a field, lying on its right side. The aircraft was significantly damaged and both the pilot and passenger suffered serious lower limb injuries.

Aircraft information

The Pegasus Quantum is a two-seat, permit-to-fly, flex-wing microlight. It can be flown solo or dual. During flying training the student pilot generally occupies the front seat and the instructor the rear. The pilot occupies the front seat when carrying a passenger not under instruction or during air experience flights. Due to CG restrictions, the pilot must sit in the front seat when flying solo. The sail is manufactured from

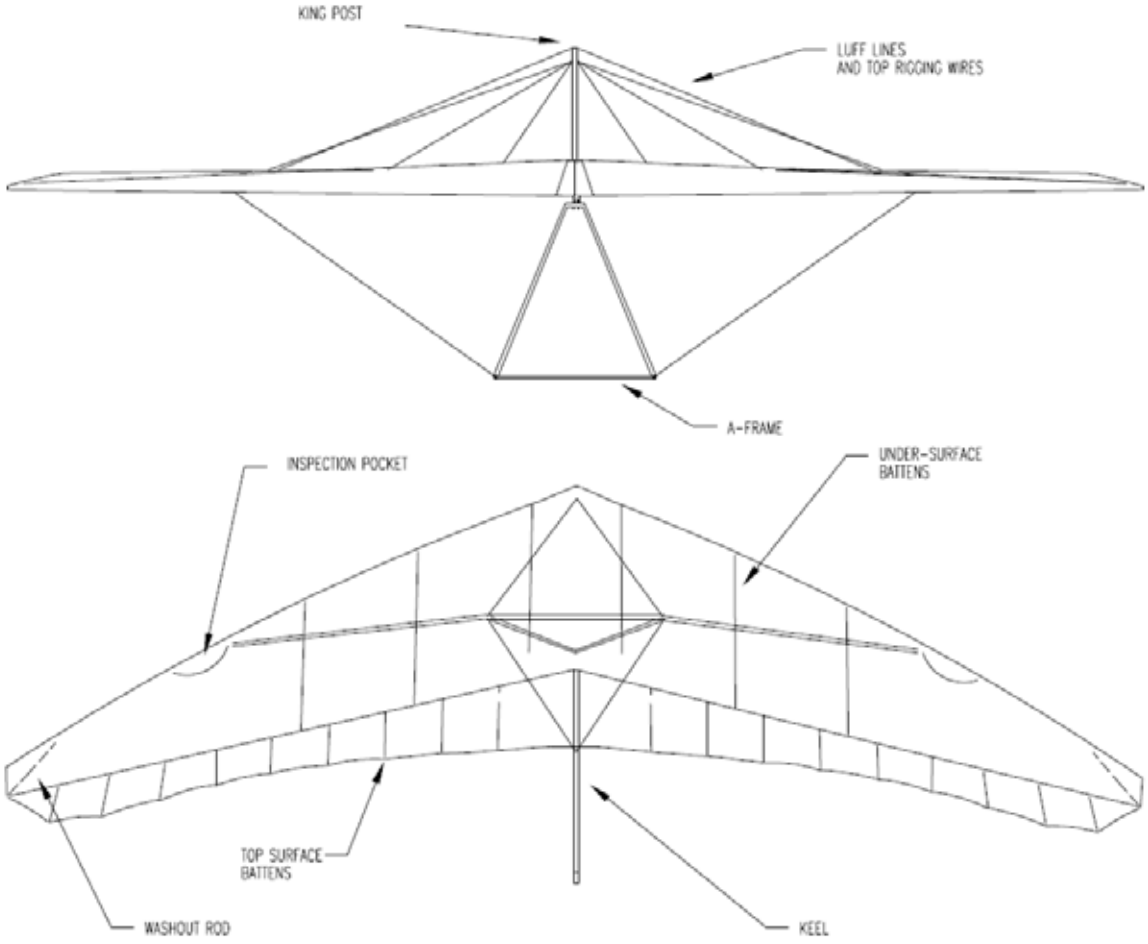

Figure 1

Pegasus Quantum wing diagram (by courtesy of P&M Aviation)

stabilised polyester, reinforced with Tri-lam and Kevlar. The aerofoil section is defined by pre-formed aluminium and aluminium/composite ribs or battens which are located in pockets stitched into the sail fabric (Figure 1). Wing tension is maintained by various cables, including 'luff lines' which run from the 'king post' to the wing trailing edge. The luff line tension can be adjusted in-flight by the pilot, allowing the wing to be trimmed in pitch for the selected cruise speed.

Aircraft control

Roll control in a flex-wing weight-shift microlight is achieved by the action of the pilot moving the CG of the trike relative to the hang-point (Figure 2). At normal cruising speeds of 45 mph upwards, turns are initiated by the A-frame control bar being positioned to the side away from the required direction of turn. As the required bank angle is reached the roll control input should be relaxed. Rollout is achieved by positioning the control bar towards the lower wingtip.

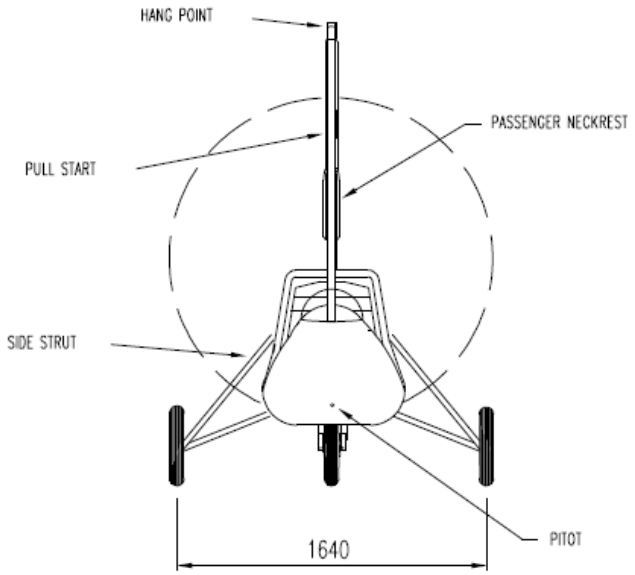

Figure 2

Pegasus Quantum trike diagram
(by courtesy of P&M Aviation)

Roll response is aided by the intentional flexing of the airframe and the sail, assisted by a 'floating keel' design, which reduces the effort required by the pilot to produce and stop a roll manoeuvre. As the wing is only deflected a certain amount by the action of the pilot, the rate of roll varies with airspeed, becoming faster with increasing speed.

Wing tuning

A flex-wing microlight's wing should be trimmed so that in the absence of any control input, it flies straight at steady speed. A properly tuned wing allows the pilot to fly at a range of steady speeds without the need to apply correcting control inputs. However, an incorrectly tuned wing will often result in a constant turn at all speeds or an increasing turn with increasing airspeed, which must be continually corrected by the pilot. This can become tiring for the pilot and can cause difficulties during takeoff, landing and when flying through turbulence. A turn induced by a grossly out-of-trim wing can exceed the control authority available to the pilot, preventing controlled flight.

The Quantum wing is fitted with tip turn adjustors at each wingtip. These can be adjusted to tune out turns occurring at all airspeeds. For turns which are more pronounced with increasing airspeed, adjustment can be made by bending battens numbered 7 to 10 (11 being the wingtip batten) to change the wing profile. Applying an upward reflex (bend upwards) in the trailing edge results in a small downforce being generated, this changes the incidence of the wing section increasing the lift generated. As lift is a function of airspeed, the effect increases with increased airspeed. By only adjusting the inside wing of the turn in this manner, for example the right wing in a right turn, this undesirable handling characteristic can be tuned out.

Guidance on tuning the Quantum's wing is provided in the aircraft Operator's Manual, the relevant sections of which are shown in Figures 3a to 3c.

11. TUNING THE WING

11.1. NEW AIRCRAFT

⚠ WARNING

Prior to delivery to the customer all new aircraft are flown and set up by either the Factory or by Appointed Dealers. A full check flight is carried out and adjustments made to the wing to ensure that it is properly trimmed out and flies hands off at the right speed. Owners are discouraged from making any adjustments. If you feel your new Pegasus aircraft is not performing as it should, it is essential that your dealer is immediately informed.

The following notes are for guidance only. Since tuning of flexwings is a specialised technical procedure, no adjustment should be made without a full understanding of the principles involved. Please observe the following simple guidelines:

1. Before making any adjustments check for correct rib profiles against the rib plan supplied. If the aircraft is not new, then also check the airframe components, particularly the outer leading edges.
2. Never exceed the adjustments specified in this Tuning Guide.
3. Make notes of every adjustment made. Only ever make one adjustment at a time, and carry out a flight test to gauge the effect before making further adjustments.
4. When the exercise is complete, you should discuss any adjustments made with your Instructor or Dealer and then enter them in the Aircraft Technical Log.
5. If you cannot get the aircraft to fly as it should, then first return all the settings to standard and reassess the situation. If this cannot be made to work, contact your Dealer immediately.

11.2. WING TRIM

A well tuned wing will fly in a straight line hands-off and will respond to control inputs equally in each direction. However, fabric can stretch slightly with age and ribs can alter shape and get bent or distorted. The most common problem with flexwings is the tendency for the wing to acquire a turn one way which can be irritating and tiring on a long flight. Turns like this can be tuned out and are invariably due to rib shape or tip setting problems. However, it may be that airframe damage has occurred so if a turn becomes apparent the first thing to do is to check the frame carefully, inspecting for bends and distortion particularly in the leading edges. If the frame is alright, you should check the ribs against the template and adjust accordingly.

Figure 3a

Extract from Aircraft Operator's Manual

11.3. TUNING GUIDE

For successful tuning, the weather conditions must be smooth, small adjustments must be made ONE AT A TIME, and notes must be made immediately any changes have been made and check flown. The loading of the aircraft must also be similar for trials to have comparable results.

⚠ WARNING

If the wing used to fly straight but has recently developed a turn, then the probability is that damage has occurred. It is necessary to strip and inspect the aircraft before your next flight. Failure to do so may result in injury or death.

Tuning turns

Example: The aircraft turns right at all speeds. The trim speed is correct.

Solution: In this case the tip turn adjusters. On the tips you will find an adjustment scale where the leading edge emerges from the sail. Rotate the starboard tip plug 1mm on the scale anti-clockwise (i.e. trailing edge down). Check in flight. If the turn persists, rotate the tip one further mm. Check fly. Rotate the left tip 1mm anti-clockwise (i.e. trailing edge up). Check results before moving the tips further.

⚠ WARNING

Do not exceed the adjustment range which is ±6mm (1/4 inch) from the initial factory setting, or the aircraft may become unstable.

Example: At high speed, the aircraft turns to the right. At low speed, the turn is not so pronounced. The trim speed is correct.

Solution: Use ribs numbers 7-10 (the tip rib is number 11 and has very little effect) on the **starboard (right wing)** side to tune out the turn. The tip ribs respond well to "tab effect", i.e. application of reflex near to the trailing edge will produce a downforce at the trailing edge which will increase the incidence of the section as a whole. The overall effect is to increase the lift on the side where reflex is applied, so correcting the turn. The effect becomes more pronounced as the speed rises. The reflex should be applied 200mm (8 inches) from the trailing edge and applied in small increments up to a maximum of 25mm (1 inch). Start with 10mm (3/8 inch) reflex, test fly, then 15 - 20 - 25mm (5/8 - 3/4 - 1 inch) as required. Do not exceed 25mm reflex!

Example: The wing flies completely straight sometimes, and turns to the right at other times!

Solution: This is happily an easy problem to solve, since it usually only happens when you have to rig everytime you fly. Then it is a question of exactly how the tension sets up on the outer leading edge webbings. Simply take hold of the leading edge cloth right out near the trailing edge and twist it anti-clockwise; you should feel it move. It will then be held there by the tension.

Figure 3b

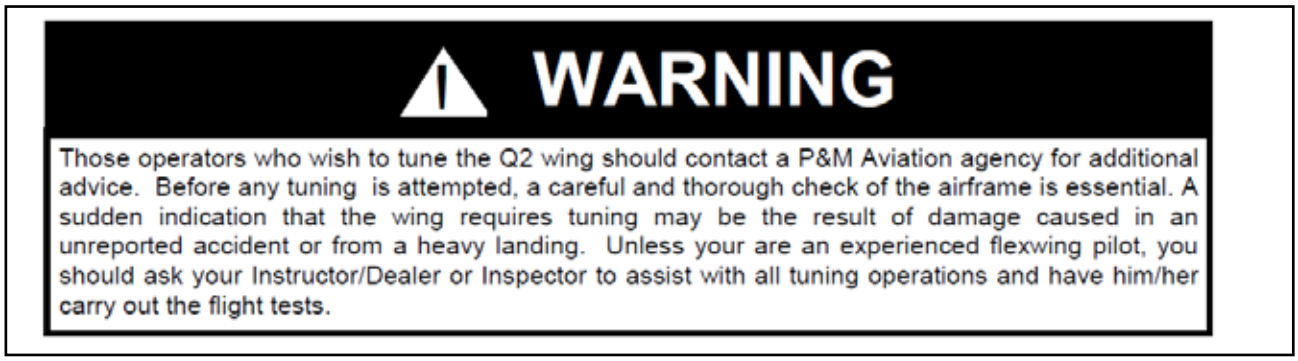

Figure 3c

Manufacturer's maintenance recommendation

The aircraft Operator's Manual recommends that the wing ribs/battens are inspected every 50 hrs for aircraft which remain rigged and every 25 hrs for aircraft subject to continual rigging and de-rigging. When under tension in the wing, over time, the battens may lose their initial profile. To address this, the manufacturer recommends the battens be removed and adjusted until they match a batten profile template.

Aircraft inspection

The aircraft was recovered from the accident site by the owner and stored in an open access hangar for a period of time prior to being moved to the AAIB's facilities for inspection. The battens forming the left wing were separate from the sail when the aircraft was collected from the owner's facilities. Inspection of the wing battens identified that a number of them had been re-shaped and were not to the manufacturer's recommended profile.

Right wing

Batten 6 was bent up at the trailing edge end by 20 mm; battens 7 and 8 had a downward bend at the trailing edge end. Batten 9 had suffered impact damage and distortion during the accident. The profile of Batten 10 still matched the manufacturer's profile template. The tip trim adjustor at the end of the leading edge pole had been adjusted four divisions down.

Left wing

Battens 1 to 5 matched the manufacturer's profile template. Battens 6, 7, 8 and 9 had a trailing edge upward reflex of 50 mm at the end of the batten (Figure 4; note the rule in this picture indicates where the adjustment measurement was taken). Batten 10 had a bend which was consistent with the upward reflex being applied with the batten still in the sail; the bend was orientated differently from the other battens which were all consistent with bends having been applied with the battens removed. The position and amount of bending of the battens was not consistent with impact damage. The tip trim adjustor at the end of the leading edge pole had been adjusted one division down.

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Aircraft storage and adjustment

G-BZMI was owned by the flying school's proprietor/ chief flying instructor and was operated as a flying school aircraft. It was stored in a hangar with the wing detached from the trike, but continuously rigged. The wing had not been fully de-rigged for several months. The pilot's understanding was that the wing battens were only re-profiled when someone noted a reduction in performance in-flight, at which point the wing would be de-rigged and the battens adjusted. The pilot advised that he had some experience of this activity during the assembly and rigging of previously disassembled aircraft, but not on a regular basis.

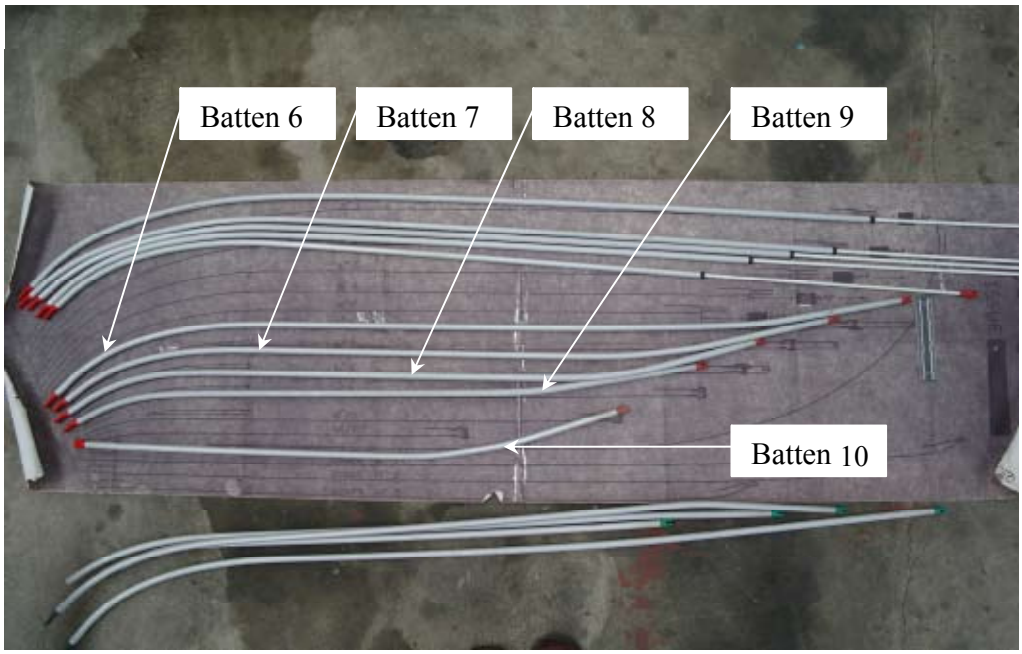

Figure 4

Batten profile for left wing showing trailing edge reflex on outboard battens

The proprietor of the flying school stated that students were taught how to reprofile battens in accordance with the manufacturer's template, but that tuning of battens on flying school aircraft was only permitted to be done by him or by the manufacturer. The aircraft logbook contained three entries for batten reprofiles, all completed by the proprietor, at various intervals since the aircraft was purchased in January 2008. The last of these entries was on 30 September 2009, 87 flight hrs prior to the accident.

Records from the annual permit to fly renewal inspection for G-BZMI, dated 8 January 2010, showed the check item covering batten conformity to the manufacturer's template was ticked as satisfactory. However, guidance provided to inspectors for this check item does not require them to physically compare the battens to the manufacturer's template in order to satisfy the requirement, unless they consider it necessary. The guidance does require confirmation that the aircraft is being maintained to the manufacturer's recommended maintenance schedule or an alternative agreed means of compliance.

Context of the flight

Air experience flights provided by microlight flying schools should be delivered within the framework of the Microlight National Private Pilot's Licence (NPPL) Syllabus, the content of which has been approved by the CAA and standardised with other forms of recreational flying and their respective training syllabi. The Microlight NPPL syllabus consists of a number of exercises, which teach the skills necessary to obtain a licence. Experience flights are covered by Exercise 3 from the syllabus, which consists of the following:

> *'Ex 3. Air experience*
>
> *Aim: To introduce and become accustomed to the aircraft, the sensation of flying and to sample the aspect of the ground from the air. Detailed instruction is not normally undertaken*

on this flight. It can, however, be a valuable lesson. It is an opportunity for the instructor to become acquainted with the student and decide upon the most suitable approach for subsequent instruction. During the flight all actions performed by the instructor should be accompanied by an explanation. Any sudden manoeuvring or expected turbulence should be discussed before it is encountered. The student should inform the instructor of any discomfort, in order to allow a rapid return to the airfield. During the latter part of the flight, the student should have the opportunity to handle the controls to provide a foundation for the next exercise. If the student has some previous flying experience, then this exercise can be combined with 'effects of controls.'

The passenger, in her statements following the accident, did not consider that she was receiving flying training and that important aspects of instruction, such as the pre-flight briefing were not conducted prior to the accident flight. The flying school's website offers *'Experience Flights'* as a separate option to *'Training'*. The description of the experience flight on the website suggests that some elements of instruction are involved and states an extensive pre-flight briefing is conducted prior to each flight. The passenger also received an information pack with the voucher, which contained a set of Frequently Asked Questions (FAQ). These stated that a pre-flight briefing would be provided and also advised that the flight time counted towards the minimum experience required to obtain a licence.

The British Microlight Aircraft Association (BMAA) includes a specific section on flying training and conducting first lessons in their code of good practice:

'Lesson plans

All lessons should follow a similar format. The student should be briefed on the exercise to be carried out. The flight should be flown in accordance with the briefing. The student should be de-briefed on the actual sequence and content of the flight.

***Briefing**. The briefing should prepare the student pilot for the planned flight. The BMAA Instructor and Examiner Guide contains specific guidance on the conduct of flight briefings. The content of the brief must always be relevant to the flight.*

***For first flights**, referred to as Trial Lessons or Air Experience flights (BMAA Exercise 3) the briefing is generally not technical but will prepare the student for the experience of flying in a microlight. It is usual to include a basic brief on the effect of the controls to prepare the student for some "hands on" during the flight.*

Many first time flyers are not aware that lessons in microlights are not treated by the Authorities in the same way as commercial flights in Airliners and it is important that the student is made aware of this and not lead to believe that there is "no risk". Making the student aware of this difference does not take away any responsibility from the school to ensure that the flight is conducted safely.

The briefing must cover the normal requirement for pilots to brief any passenger on the safety aspects of the flight. The brief must include use of seat belts, doors and helmets if applicable and actions in the case of an emergency.'

Pilot qualification

The pilot held a National Private Pilot's Licence, with an instructor's rating for flex-wing microlights. He had held an assistant instructor's rating since 2007 and was granted full instructor authorisation in April 2009. The pilot stated that he had not been put under any external pressure to continue with the flight given the issues with the aircraft, but had felt a certain amount of self-induced pressure not to disappoint the passenger by cancelling the flight.

Analysis

Accident flight

During the aborted flight prior to the accident, the pilot experienced an uncommanded roll which was significant enough that he felt it necessary to land and perform adjustments to the wing. Following these reported adjustments a flight test was not conducted to assess whether the uncommanded roll had been rectified, prior to flying with a passenger.

Regardless of whether a flight is for 'valuable consideration' or private there is a responsibility when carrying passengers to conduct the flight in a safe manner. As highlighted in the BMAA code of good practice, this should also be the case for flying training. A key aspect of this is to maintain and operate an aircraft which is appropriately serviceable for the intended purpose of the flight. When defects become apparent, comprehensive maintenance investigation and rectification work should be completed before further flight and the serviceability of the aircraft ensured before the carriage of passengers.

Whilst the provenance of the left wing battens which were provided with the wreckage could not be confirmed, analysis has been made based on the received battens having been removed from G-BZMI subsequent to the accident. The downward reflex identified in battens 7 and 8 on the right wing would result in a worsening right turn in-flight. Adjusting the battens in this manner is not permitted by the manufacturer. The excessive upward reflex applied to the left wing battens would lead to an extreme right roll in-flight. The 50 mm deviation from the manufacturer defined profile was double the limit of 25 mm of adjustment permitted in the aircraft Operator's Manual and was significantly greater than anything tested by the manufacturer during aircraft development. The position of the wingtip trim adjustors in isolation would have resulted in a constant left turn at all speeds.

The pilot stated that following the initial aborted flight, he adjusted the elastics holding the wingtip battens in place and slightly adjusted the profile of battens 8 and 9 of the left wing in situ and by no more than 5 mm each. This is consistent with the statement made by the passenger, who reported that the pilot was only away from his seat for a minute between flights. Manipulation of the battens within the sail is not endorsed by the manufacturer, as it prevents accurate adjustment and could result in a larger change in profile than anticipated. However, only batten 10 displayed the characteristics associated with an in situ adjustment and it is unlikely that the consistent adjustment of 50 mm found on battens six to nine in the left wing could have been achieved by the pilot bending the battens within the sail during the short period between the initial aborted flight and the accident flight. It was not possible to confirm when or how the battens came to be adjusted to the extent evident during inspection of the wreckage.

The adjustment to the battens, as found, exceeded the manufacturer's limits by such a significant amount that, combined with the downward reflex on two of

the right wing battens, severe control problems would be anticipated even before any apparent adjustment reported by the pilot. Nevertheless, manipulation of the trailing edge by applying an upward reflex to the left wing instead of the right wing would have exacerbated, rather than reduced a right turn. Whilst increasing airspeed can increase the severity of the turn induced by an out-of-trim wing, as the problem occurred almost immediately after rotation on both flights, it was not possible to determine why the aircraft was reported as uncontrollable on the accident flight, but not on the initial aborted flight, or why the aircraft handling deteriorated after the flights successfully undertaken by the pilot in G-BZMI earlier in the day. However, in the absence of any evidence of other pre-impact defects, it is likely that the uncommanded right roll experienced by the pilot was the result of the wing being excessively out of trim.

Inappropriate adjustments to the sail profile of a flex-wing microlight can have a marked effect on the handling characteristics, particularly on modern aircraft which can cruise at speeds of around 100 mph. Although an older, slower design, this is still true of the Pegasus Quantum and the manufacturer includes a number of warnings in the Operator's Manual to proceed with caution when tuning the wing. They advise that initially the wing should be reset to the datum profile, adjustments should then be incremental and made in a controlled manner, with test flights carried out to confirm the effects of each change. The manual recommends this work should only be conducted by experienced pilots or by a representative of the manufacturer and that any changes should be recorded in the aircraft logbook. Routine checks of the wing at the appropriate intervals, as recommended by the manufacturer, would allow this work to be properly planned and controlled. If the aircraft develops a sudden increase in out-of-trim forces, the Operator's Manual highlights that this could indicate a more serious defect on the aircraft, which should be properly investigated and rectified before further flight.

This highlights the need that following any work completed on an aircraft which affects the handling characteristics, consideration should be made of the requirement to ensure the maintenance has been appropriately conducted, recorded and coordinated with any associated check/test flying. Flight tests to confirm serviceability need to be conducted by pilots with appropriate experience and skills and be planned and conducted as a distinct activity from routine flying.

Passenger information and briefing

Experience flights provided by flying schools are a valid and important stage in the process of learning to fly a microlight, providing they are conducted within the context of the NPPL syllabus. The passenger stated that in her opinion she was not undertaking a flying lesson and was unaware of the training context in which experience flights are provided. The content of the flying school's website and the information sent with the experience voucher also lacked clarity in this respect and did not fully inform the passenger in line with the recommendations relating to first time flyers within the BMAA code of good practice. Discussion with the CAA highlighted that the need for flying schools to provide clear information, with regard to the context in which experience flights are provided, is an issue which exists across all forms of recreational flying. Most significantly however, was the passenger's recollection that important safety-related aspects of instruction, such as the pre-flight briefing, had not been completed before the flex-wing flight. Microlight operators are encouraged to comply with the BMAA code of good practice as its guidance is intended to improve safety.