AIRCRAFT ACCIDENT REPORT 2/2005

Air Accidents Investigation Branch

Department for Transport

Report on the accident to Pegasus Quik, G-STYX at Eastchurch, Isle of Sheppey, Kent 21 August 2004

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at Eastchurch, Isle of Sheppey, Kent
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This investigation was carried out in accordance with
The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996

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Department for Transport
Air Accidents Investigation Branch
Berkshire Copse Road
Aldershot
Hampshire GU11 2HH

October 2005

The Right Honourable Alistair Darling
Secretary of State for Transport

Dear Secretary of State

I have the honour to submit the report by Mr D S Miller, an Inspector of Air Accidents, on the circumstances of the accident to a Pegasus Quik, registration G-STYX, which occurred at Eastchurch, Isle of Sheppey, Kent on 21 August 2004.

Yours sincerely

David King
Chief Inspector of Air Accidents

Contents

ANNEXES

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	Air Accidents Investigation Branch
agl	above ground level
amsl	above mean sea level
ANO	Air Navigation Order
BCAR	British Civil Airworthiness Requirements
BMAA	British Microlight Aircraft Association
CAA	Civil Aviation Authority
cm	centimetre(s)
EDX	Energy Dispersive X-rays
ft	feet
g	normal acceleration
hrs	hours (time)
kg	kilogramme(s)
kgf	Kilogrammes force
kt	knot(s)
ltr	litre(s)
M	metre(s)
MF	Microlight Flying
mm	millimetres
MPD	Mandatory Permit Directive
mph	miles per hour
N	Newton
ONC	Ordinary National Certificate
PVC	Polyvinyl choride
SB	Service Bulletins
SEM	Scanning Electron Microscope
TADS	Type Approval Data Sheet
TPM	Technical Procedures Manual
UK	United Kingdom
VHF	Very high frequency
VLA	very light aeroplane
°C	Degrees Celsius

Air Accidents Investigation Branch

Aircraft Accident Report No: 2/2005 (EW/C2004/08/03)

Registered Owner and Operator	Privately owned
Aircraft Type	Pegasus Quik
Nationality	British
Registration	G-STYX
Place of Accident	Eastchurch, Isle of Sheppey, Kent
Date and Time	21 August 2004 at 1341 hrs
	All times in this report are local (UTC +1)

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) at 1417 hrs on 21 August 2004 and the investigation began the same day. The AAIB Investigation team consisted of:

Mr D Miller (Investigator-in-Charge)
Mr N Dann (Operations)
Mr B McDermid (Engineering)
Mr P Wivell (Flight Recorders)

The Pegasus Quik microlight, with an instructor and passenger on board, departed Rochester Airfield for a trial lesson. Thirty five minutes into the flight, as it was flying at 500 ft along the north coast of the Isle of Sheppey, it pitched up steeply to the near vertical and entered a series of tumbling manoeuvres. As the microlight tumbled the trike unit, containing the two occupants, separated from the wing and descended vertically to the ground. Neither the pilot nor his passenger survived the impact. The initiation of the pitching moment and subsequent entry into the tumbling sequence was brought about by the failure of the right upright upper fitting, which caused full nose-up trim to be suddenly applied.

Some time previously the microlight's uprights upper fittings had been modified to comply with Service Bulletin 116 requiring the fitting of additional rivets. The additional rivets were not only fitted incorrectly, and without reference to the Service Bulletin, but two of them did not match the specification of those rivets supplied by the manufacturer in the modification kit. Additionally, no duplicate independent inspection was carried out on the correct embodiment of the modification.

The investigation identified the following causal factors:

(i) Failure of the right upright upper fitting caused the microlight to enter a tumble manoeuvre from which it was not possible to recover.

(ii) Service Bulletin 116, which introduced additional rivets in the upper fitting, was not correctly embodied.

Eleven safety recommendations have been made as a result of the investigation.

1 Factual Information

1.1 History of the flight

The pilot, who had recently qualified as an instructor, arrived at Rochester Airfield early on the morning of the accident and, at 1025 hrs, took off in his own microlight, G-STYX, to conduct a training flight with a student. They landed back at the airfield at 1130 hrs without incident.

Later that morning a married couple arrived at the airfield to undertake a trial lesson, booked with the club for whom the pilot was an instructor. The couple were asked what they would like to see during their one hour flight and each was given a flying suit and helmet to wear. The husband occupied the rear of the tandem seats fitted to G-STYX with the pilot occupying the front seat. The wife occupied the rear seat of another microlight, piloted by another club instructor. At 1305 hrs the first microlight took off from Runway 34. The second microlight followed two minutes later.

The two aircraft flew in loose formation, at an altitude of approximately 2,500 ft amsl, to Maidstone and Mote Park before proceeding to fly over Leeds Castle. Then, as they headed towards Sittingbourne, the two aircraft lost sight of each other. The last time that G-STYX was seen by the pilot of the other microlight was as it was flying, at approximately 1,500 ft amsl, towards the Isle of Sheppey. At that time, everything concerning its operation appeared normal.

At 1340 hrs several witnesses, situated on the north coast of the Isle of Sheppey near the small town of Eastchurch, saw G-STYX flying towards the coast at a height of approximately 500 ft and heard its engine running at a constant pitch. As it approached the coastline the nose of the microlight was seen to pitch up steeply to the near vertical and then tumble several times. Witness statements varied in their description of the direction of the tumble. Some reported the microlight tumbling nose first whilst others stated it tumbled backwards. Witnesses also heard the engine cut out as the microlight pitched up and entered the tumbling manoeuvre.

As the microlight continued tumbling the trike unit, containing the two occupants, separated from the wing and descended vertically to the ground. Several members of the public ran to the scene to offer assistance but on arrival it became apparent that neither the pilot nor his passenger had survived the impact.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	1	-
Serious	-	-	-
Minor/none	-	-	-

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

None

1.5 Personnel information

1.5.1	Pilot in command:	Male aged 50 years
	Licence:	Private Pilot's Licence (Microlights)
	Medical Certificate	Group 2 medical valid until May 2008. (This standard allows solo flight and flight with passengers.)
	Total flying experience:	554 hours
	Total hours on type:	402 hours
	Hours in last 90 days:	47 hours
	Hours in last 28 days:	22 hours

1.5.2	BMAA Inspector:	Male aged 60 years
	Occupation:	Retired
	Qualifications:	No formal engineering qualifications
	Appointed BMAA Inspector:	29 April 1994
	Authorised to:	Inspect flexwings, hybrids and three axis aircraft R examiner on single pilot aircraft BMAA check pilot for flexwing aircraft (from 1991)
	Flying experience:	Over 1,200 hours

1.6 Aircraft information

1.6.1 General Information

The Pegasus Quik, manufactured by Mainair Sports Limited, is a two seat weight shift controlled flexwing microlight aircraft designed as a long-range tourer. The Quik is currently the fastest flexwing production microlight in the world with a maximum level speed of 100 mph, a VNE of 115 mph and a trim speed range of 55 mph to 82 mph. It received its Airworthiness approval, number 28475, issued by the CAA, on 14 January 2003.

1.6.1.1 Aircraft general description

The Pegasus Quik is a flexwing microlight consisting of a wing and trike, connected by a front strut and monopole to the hang bracket located on the wing keel tube (Figure 1). The monopole, which is secured to the hang bracket by the hang bolt, is fitted with a non-load bearing aerodynamic fairing. The trike incorporates a tricycle landing gear, 49 ltr capacity fuel tank and tandem seating arrangement for two pilots.

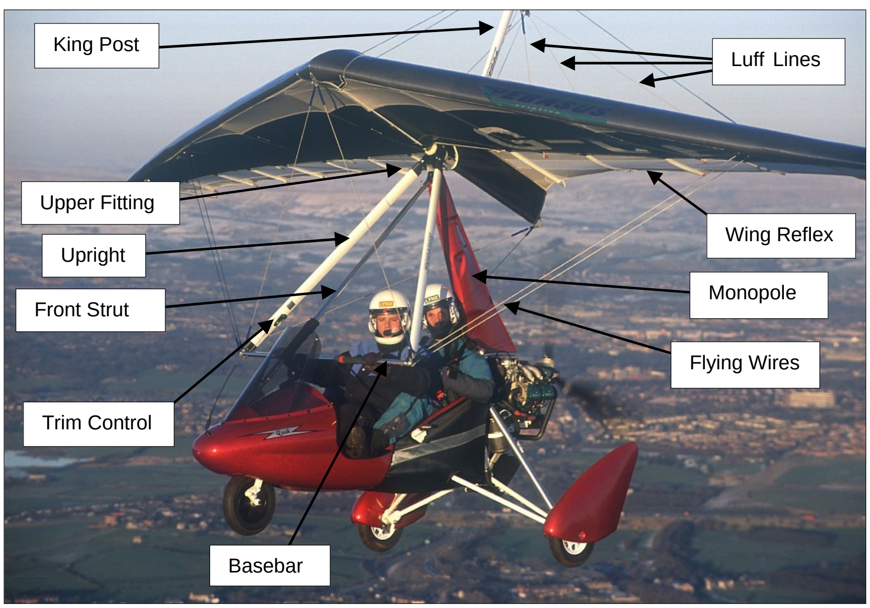


Figure 1 (reproduced by kind permission of Pegasus Aviation)

A twin carbureted Rotax 912ULS engine equipped with a fixed pitch, 3 bladed Arplast propeller, is fitted at the rear of the trike. G-STYX was also equipped with a FLYdat engine data recorder, which recorded and displayed the engine parameters. The front occupant is secured by a 3-point and the rear occupant by a 4-point static harness.

The wing structure consists of a keel, leading edge and cross tubes, over which the sail is stretched. The rear of the sail is stiffened by battens. A tip stick (wash out rod) is fitted towards each wing tip to maintain a minimum amount of washout when the aircraft is flown at high speed. Above the wing is a kingpost through which the luff lines and landing wires are attached. The luff lines are used to maintain the wing reflex at low angles of attack. The length of the luff lines can be adjusted in-flight in order to alter the wing reflex, which changes the wing pitching moment and hence the trim of the aircraft. In the fast trim position the trim control is adjusted until the luff lines just go slack. This normally leaves one to two turns of the trim cable wound around the reel.

The pilot controls the microlight through the ‘A’ frame, which consists of a basebar connected to the wing keel tube by two uprights. The ‘A’ frame forms part of the primary structure and takes the majority of the wing loads via the flying wires, which are connected to the ends of the basebar and the wing structure. The front seat occupant can adjust the trim by turning a wheel on the right upright. This adjusts the length of the trim cable, which runs inside the right upright to a pulley at the top of the king post were it connects to the luff lines.

1.6.1.2 Uprights

The uprights, which are under compressive load during normal flight, each consist of an aerofoil extrusion and an inner tubular sleeve with fittings at each end to connect to the basebar and hang bracket (Figure 2). The compressive load in the upright is taken by the aerofoil extrusion with the inner sleeve, which carries no compressive load, stabilising the upright against buckling. The sleeve on the right upright is secured to the extrusion to ensure that it does not foul on the trim cable that runs inside the extrusion. The left sleeve rests on the lower fitting. The upper fittings slide into the extrusion and are secured by two Monel rivets and two Avdel rivets. The Avdel rivets were introduced by Mandatory Permit Directive (MPD) 2004-009 Mainair Sports Service Bulletin 116 following the failure of an upright fitting in April 2004 (see Annex A and B).

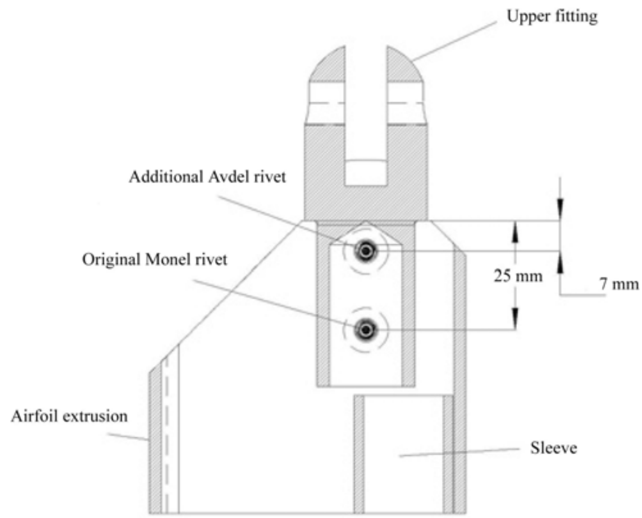


Figure 2 Drawing of upright upper fitting

1.6.2 Maintenance

1.6.2.1 Scheduled maintenance records

Whilst maintenance activity for the aircraft had been recorded in a Lockyears combined airframe and engine logbook, the records were incomplete and did not conform to the recommended maintenance schedules produced by either Mainair Sports Limited or Rotax. There was also no evidence that the owner had followed another approved maintenance schedule. The Air Navigation Order, Article 17(2) and BMAA Airworthiness Guide, state that maintenance must be recorded in a CAA approved logbook to ensure that information is recorded in a structured manner. Neither the CAA, nor BMAA have approved the use of the Lockyears logbook on microlight aircraft.

The Lockyears logbook was provided with the aircraft, which was purchased new from the manufacturer. However, in mid 2004 the manufacturer of the Quik changed to CAA approved logbooks and following a request from the BMAA, in early 2005, changed again to the Pooley's combined engine/airframe logbook.

The BMAA also recommend that maintenance checks due at 25 hrs/3 month and above are recorded in an approved logbook. However, there is no record of a number of maintenance inspections having been carried out on G-STYX. The section recording mandatory modifications and service bulletins was also blank, though this information had been recorded elsewhere in the logbook.

There are no entries in the aircraft logbook to indicate that the 75, 125, 150, 175, 225, 250, 275 and 300 hour schedule maintenance activities, nor the strip and inspection of the wing required at 300 hours, had been carried out. The accident occurred with the aircraft having accumulated 342 hours.

The Pegasus Quik manual also states:

> *'it is important that your Quik is visually inspected, assessed and test flown by an approved Pegasus Aviation inspector every 100 hours/12 months, whichever comes first.'*

The log book indicates that the first inspection and test flight, after leaving the factory, was undertaken during the inspection for the reissue of the Certificate of Validity, which forms part of the Permit to Fly, undertaken on 10 January 2004 at 224 hours and 50 minutes, by the inspector who carried out Service Bulletin 116.

The last entry in the combined engine and airframe log book regarding the airframe and engine operating hours was made on 17 July 2004, 35 days and 33 hours prior to the accident. The ANO Article 17(3)(a) states that log books are to be completed as soon as practicable after the occurrence and the BMAA Airworthiness Guide states:

> *'Each logbook entry must be made as soon as practical, but in any event no more than seven days afterwards'.*

This requirement is to ensure that an aircraft is not inadvertently operated beyond scheduled maintenance or other mandatory maintenance requirement. The airframe hours at the time of the accident was established from the engine hours recorded on the FLYdat engine data recorder.

1.6.2.2 Engine Maintenance

The Rotax engine maintenance schedule is based on a 100 hour inspection frequency unless the aircraft is operated in severe operating conditions when the time between maintenance is reduced. Rotax define severe operating as flight school, glider towing etc. They also recommended that the frequency of the oil change is increased when operating on Avgas. In addition to the mandated inspections, Rotax publish a recommended 50 hour check. There are no entries in the aircraft logbook to indicate that the 50 and 100 hour engine maintenance activities were carried out and it would appear that the 150, 200 and 250 hour maintenance activities were restricted to changing the oil, filter and spark plugs. The 200 hour maintenance activities were subsequently completed at 309 hours.

In June 2004 the owner experienced rough running of the engine and sought help from a professional engineer experienced with Rotax engines. The engineer established that the engine maintenance had been erratic and had not been carried out to any particular schedule. The rough running was a result of the engine operating on Avgas and the exhaust outlet having been welded in place such that it directed exhaust gasses into the right hand air filter. The owner agreed with the proposal to switch to Mogas and to baseline the engine maintenance by undertaking the 200 hour maintenance activities. From the engineers documentation it was established that this maintenance was completed 11 days and 33 flying hours prior to the accident.

1.6.3 Service Bulletin 116

1.6.3.1 Modification of uprights

A modification kit, that included the Service Bulletin, Avdel rivets and drill bit, was sent to the owner, who asked a BMAA inspector to assist him with the embodiment. The inspector sought advice from another individual who assured him that it was a simple job. On the day the modification was carried out, the owner brought with him the four rivets and a drill bit, which were placed in the top of the inspectors tool box; however, the inspector has stated that he did not see a copy of the Service Bulletin before starting the job. After some discussion it was decided to fit the new rivets below the existing ones, because they felt it would be less likely to cause or create a crack in the aerofoil extrusion. They worked together to fit the rivets until the owner had to return to work, leaving the inspector to complete the task. With the wing still fitted to the trike the inspector and owner took it in turns to stand on a small stepladder in order to roll back the PVC boots covering the upper fitting before drilling a pilot hole through the upright using a cordless drill. The supplied drill bit was then used to open up the hole before fitting the rivets. The inspector recalls that when he drilled the holes he could feel the bit biting into the different materials as it went through the upright. This caused him no concern as other individuals had told him that this would happen. At no time were the upper joints on the upright disconnected. It was several days, or possibly weeks, after the modification had been carried out that the owner asked the inspector to make an entry in the logbook to confirm that the work had been carried out. Whilst the inspector read the Service Bulletin prior to signing the aircraft logbook, he still believed that his decision to fit the additional rivets below the existing rivets was correct.

1.6.3.2 BMAA Inspector’s understanding of the upright's construction

The inspector could not explain why the wrong rivets had been fitted and did not appear to be aware of the differing mechanical properties of different types of rivets, how to determine if they had been correctly formed, or the importance of fitting them in the correct positions. He also did not understand how the uprights were constructed. He thought that a load bearing inner tube connected the upper and lower fittings and that the additional rivets were required to prevent the non-load bearing aerofoil extrusion from rotating. However, on the Quik these aerofoil extrusions are essential load bearing structure. Discussions with other inspectors and owners revealed that this inspector was not alone in this misconception.

Similar rivets to the wrong ones fitted to the uprights were later found in the inspector's tool box and were used by him to reattach aircraft and engine data plates. It would appear that the mix up of the rivets occurred when the supplied items were placed in the top of his tool kit for safekeeping.

The instructions in Service Bulletin 116 (at Annex B) state that the wing is to be removed from the trike and the top knuckles, and PVC boots are to be removed prior to drilling the holes 7 mm below the upright top edge. If these instructions had been followed then the owner and inspector would have been able to look inside the aerofoil extrusion and gain an understanding of the construction of the joint. They would also have been able to check that the rivets went through both the extrusion and shank of the upper fitting and would have been able to check the joint for looseness.

1.7 Meteorological information

An aftercast, obtained from the Meteorological Office, describes the weather affecting the area at the time of the accident as a north-easterly wind of approximately 10 kt with a cloud base of about 4,000 ft. There was no evidence of any turbulence or severe updraughts; however the surface temperature of 18°C may possibly have resulted in some thermal activity of unknown severity.

1.8 Aids to navigation

Not applicable.

1.9 Communications

The aircraft was equipped with a ICOM IC-A3E handheld VHF airband transceiver. Inter-helmet communication was also fitted.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

1.11.1 Introduction

The microlight was equipped with a 'FLYdat' engine data recorder. The recorder provides the pilot with a digital display of the engine speed, cylinder head temperature, exhaust gas temperature, ambient air temperature, oil temperature and pressure. It monitors each of the parameters and every 6 minutes the maximum value reached during the previous 6 minute period is stored in the non-volatile memory. The recorder can store up to 2 hours of information. Despite the recorder being extensively damaged, the memory chip was removed and fitted to a host unit where the data was downloaded.

1.11.2 Recorded data

The memory contained information on two flights that were undertaken on the day of the accident. The data for the accident flight revealed that the engine ran for 42 minutes and shut down whilst there was still electrical power at the recorder. All the engine parameters were found to be within the maximum permitted limits and no warnings had been activated.

The rpm on the last flight was significantly higher than the previous flight, 4,580 to 4,740 rpm compared with 3,800 to 4,610 rpm during the earlier flight. It is possible that the pilot had blipped the throttle during each of the 6 minute periods; however the cylinder head and oil temperatures were also significantly higher, which indicates that during the second flight the engine was operating at a higher power setting.

Data from the manufacturer indicates that the engine parameters, recorded over the last 3 readings, corresponding to the 12 to 18 minutes before loss of electrical power, are consistent with the engine operating at maximum rpm. Maximum RPM in straight and level flight, with two persons on board and the propeller pitch set at 27º, would give a speed of approximately 100 mph.

1.12 Wreckage and impact information

1.12.1 Accident site

The microlight had been flying in a westerly direction between the shoreline and 30 m high cliffs when the wing separated from the trike. The trike landed a third of the way down the cliff in an upright attitude, slightly nose-down and tilted to the right. The lack of forward throw of the soft earth and the location of the majority of the wreckage, within 2 m of the trike, indicated that at the point of impact the trike had negligible forward velocity. The wing was found two thirds down the cliff, lying nose down with the lower surface facing upwards, approximately 150 m to the west of the trike. The fairing for the monopole, which connects the trike to the wing, was found 8 m to the east of the trike. A crash helmet was found 3 m to the west of the trike; however, a witness stated that it had been moved from its original position half way between the trike and the wing. A witness also stated that prior to the arrival of the police, individuals had moved the wing approximately 30 m up the cliff and had attempted to make the trike safe by turning off the fuel and disconnecting the battery.

1.12.2 On-site examination of the wreckage

Apart from the failure of the monopole and forward strut, the damage to the trike was consistent with a vertical impact with the ground. Ground marks, and lack of damage to the propeller blades, indicated that the engine was not turning when the trike struck the ground. There was no fuel in the tank, which had ruptured on impact, though fuel was found in the right carburettor fuel bowl. The fuel bowl on the left carburettor, which had become detached from the engine, was empty.

With the exception of the left hand forward lower rigging cable, which had failed, all the rigging cables on the wing were in tension. The front of the wing keel tube was bent to the right and the front right leading edge spar had failed adjacent to the keel tube. There was a bend in the basebar and the left rubber grip had rolled back. The upper joint in the right 'A' frame upright had become disconnected from the aerofoil extrusion. The Monel rivets in the upper joint in the left upright had failed and the joint had rotated rearwards in the extrusion by approximately 50º. The trim cable, that runs inside the right upright, was still intact and had been wound fully off the trim wheel. The luff lines were all in the fully shortened position.

The wreckage was removed the following day to the AAIB’s facility at Farnborough for a detailed examination.

1.12.3 Detailed examination of wreckage

1.12.3.1 Engine and propeller

Apart from a slight delamination of the tip on one of the blades, the propeller was undamaged. The pitch of the blades that had contacted the ground, were 26º and 25º. The pitch of the third blade was 27º. The recommended pitch setting for this propeller is 27º. Given the accuracy of measuring the blade pitch, and the fact that the pitch might have changed when the blades contacted the ground, it is assessed that prior to the incident the propeller pitch was probably set in accordance with the manufacturer's specification of 27º.

The engine was examined under AAIB supervision at the UK distributor's premises. The engine turned freely on the starter motor, the valves operated normally and there was a strong compression in each cylinder. The spark plug electrodes were in good condition and light grey in colour indicating that the engine mixture was correct. The magneto drive was intact and a strong spark was observed at each of the spark plug connectors. There was fuel in the mechanical fuel pump, which produced a significant head of pressure. Whilst oil had leaked out of the reservoir, which had been punctured in the crash, clean oil was found in the engine galleries. The oil filter was also clean. Although the water pump housing had been extensively damaged, the drive was intact and the impeller rotated with the engine.

All the damage to the engine was consistent with it having impacted the ground. The lack of damage to the propeller blades and the intact water pump drive indicates that the engine was not turning when the trike hit the ground. Overall the engine was assessed as being in good condition with no evidence of a fault that would cause it to fail prior to the incident.

1.12.3.2 Trike

With the exception of the monopole and front strut, the damage to the trike was consistent with it having impacted the ground. The front strut had failed approximately 32 cm from the keel tube attachment bracket. The failure was consistent with the basebar having burst through the front strut causing it to fail in overload bending.

The monopole failed 61 cm above the trike keel. There were signs that the front and rear faces of the monopole had been subject to plastic deformation before it failed in overload. This damage indicates that the monopole had been subjected to high loads causing it to flex forward and aft before failure of the front face of the monopole occurred. The nose of the trike would then have rotated away from the wing until the rear face of the monopole failed, resulting in the separation of the trike from the wing.

Two observations were made regarding the trike:

> Firstly, information on the limitation placard, which was positioned on the keel in front of the front seat, was worn and illegible. The front occupant has to stand on this part of the keel when entering and leaving his seat.

Secondly, the Air Navigation Order Article 9A(6) and British Microlight Aircraft Association guidelines require the fitting of a placard stating: *Occupant Warning. This aircraft has not been certified to an international requirement.* No such placard was fitted to G-STYX. Furthermore, this placard was missing from other two seat microlight aircraft examined during the investigation.

1.12.3.3 Wing

The damage to the portions of the front strut and monopole that had remained attached to the wing, matched the damage on the parts attached to the trike. The wing was still in tension, although several of the battens were bent and the port tip stick had failed at the attachment point. The left forward flying wire had failed and the end connectors on the remaining fore and aft flying wires were stretched indicating that they had been subjected to unusually high loads.

1.12.3.4 Upright upper joints

Inspection of the failed upper joints revealed that whilst the original 'Monel' rivets fitted in the upright had failed, the additional 'Avdel' rivets, introduced by Service Bulletin 116, were still intact. Significantly, not only had the additional rivets been fitted in the wrong position, but two of the additional rivets were of the incorrect type. There was also evidence of fretting between the top edge of both upright extrusions and the lower face of the upper fittings (Figure 3).

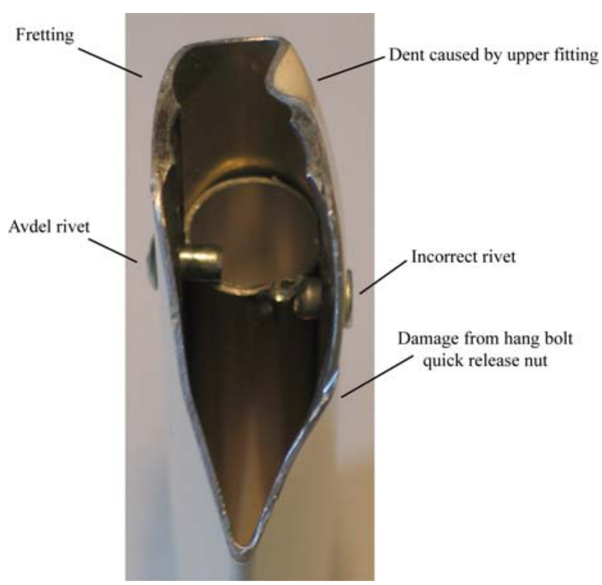


Figure 3 Right upright

The Service Bulletin (at Annex B) called for the additional steel Avdel rivets to be fitted either side of the upright, 7 mm below the top of the extrusion and above the existing Monel rivets. However, on both uprights the additional rivets were fitted below the Monel rivets. On the left upright the additional rivets had been fitted at 38 mm from the top of the extrusion and on the right they had been fitted at 36 mm and 42 mm from the top of the extrusion. The distance between the rivet holes on each side of the extrusion was 13 mm, 12.7 mm, 11.5 mm and 17 mm. What appeared to be an aluminium pop rivet had been fitted on the outboard position on both uprights instead of the Avdel rivets supplied by the manufacturer. On the right upright the hole for the outboard rivet had missed the shank on the upper fitting. The other three holes for the additional rivets had been drilled such that the holes only partially cut into the shank (Figure 4).

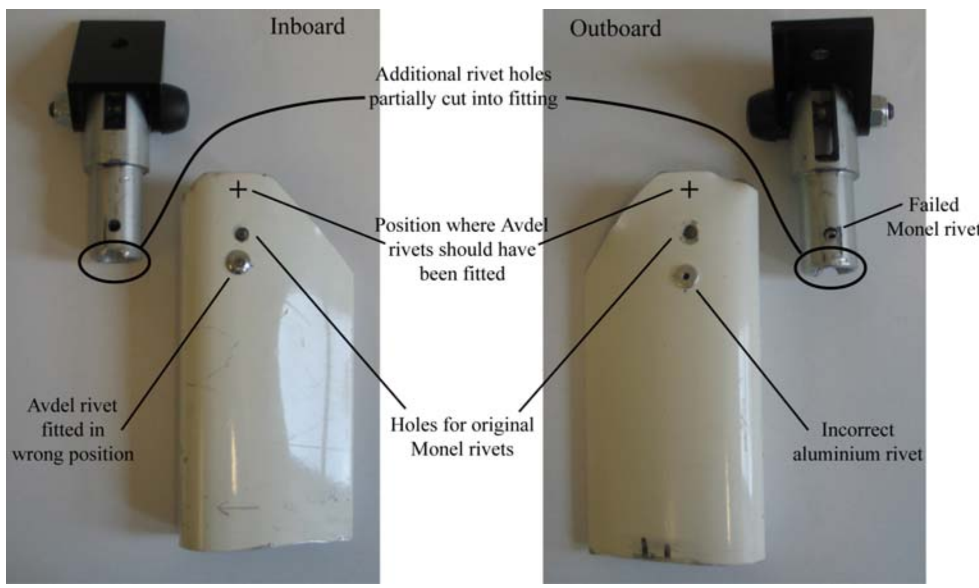


Figure 4 Positioning of rivet holes in right upright

To determine if the uprights failed before or during the tumble, the front strut was fitted to a new Pegasus Quik and the contact point between the basebar and front strut was compared. It was found that on the intact aircraft the basebar contacted the front strut at a position 1.5 cm lower than the failure position on the accident aircraft (Figure 5). There were also scratch marks on the basebar caused by the broken end of the front strut. All the marks could be made to line up by moving the right upright fitting slightly backwards and upwards. This indicated that the right upright upper fitting had failed prior to the basebar hitting the front strut. Consideration was given to the possibility that the upper fittings failed when the basebar made contact with the pilot, which would result in the upper fitting rolling towards the leading edge of the extrusion; however there were no witness marks to indicate that this had happened. The likelihood that the discrepancy of the position of the basebar was the result of flight loads distorting the structure was considered and discounted, as any resulting movement was likely to be negligible in comparison with the amount the basebar had moved up the front strut.

Figure 5 Contact point between basebar and front strut

Once the joint had failed the compressive forces in the upright would push it upward into the wing. Whilst there was no damage to the wing, there was a dent on the outside of the extrusion that matched the profile of the fitting. Other marks on the extrusion, fitting and hang bolt indicated that when the basebar hit the ground the top of the extrusion was jammed between the fitting and hang bolt quick release fastener (Figure 3). The trim cable, which was intact, had been bent in two places at right angles. This was consistent with it being pulled sharply over the top edge of the extrusion and the bottom edge of the fitting.

The left upright had been subjected to a force from the left sufficient to cause the original rivets and the inboard side of the extrusion to fail. The damage to the wing and 'A' frame, and the penetration of mud into several areas on the left side of the wing, indicated that the wing struck the ground in a nose down, left wing low attitude with sufficient force to cause the failure of this fitting.

1.13 Medical and pathological information

The pilot and passenger received fatal injuries as a result of ground impact. There was no evidence of any physiological factors or incapacitation that would have affected the pilot's performance or contributed to the accident.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 General

The pilot and passenger had both been wearing lap straps. The lap strap of the pilot, who was wearing a crash helmet, had failed at the quick release connector allowing his head to make contact with the front strut and instrument panel. The passenger, whose helmet had come off in the accident, was still strapped to his seat.

1.15.2 Safety observations

Although the failure of the monopole meant that the accident was not survivable, there were a number of safety observations:

(a) The passenger's helmet, with the chin strap still fastened, was found approximately 75 m from the trike. The helmet was a size XL (62 cm); however, the passenger's head size was S (56 cm). It is probable that the passenger's helmet came off during the tumble because it was too large.

The Quik manual states, under the heading Passenger Briefing, '*Helmet: A protective helmet must be worn, fit correctly and be secured'*. There are no regulations in the ANO or other CAA publications that mandate the wearing of protective helmets.

(b) The Quik is equipped with a 3-point harness for the pilot and a 4-point harness for the passenger. The aircraft manual states that these harnesses should be worn at all times and contains the following warning. '*If you do not wear a harness it could be hazardous and failure to do so may result in injury or death'*. Both the passenger and pilot were secured by their lap straps. The pilot's shoulder strap, however, had been removed and was stowed in the equipment bag and the passenger’s shoulder straps had been tied in a knot and secured behind his seat.

ANO Article 44(1) (a) requires the commander of an aircraft to take all reasonable steps to ensure that before the aircraft takes off on any flight that the passengers are made familiar with the position and method of use of the harnesses.

1.15.3 Use of helmets and upper body restraints

On 24 May 2001 the AAIB, as a result of a number of accidents where the front seat occupant of a microlight was fatally injured by being struck by the rear seat occupant, made Safety Recommendation No 2001-52 that stated:

It is recommended that the Civil Aviation Authority require manufacturers of UK registered aircraft to provide upper body restraint to the rear seats of aircraft where forward movement of a passenger could cause injury to the pilot.

Subsequently the CAA issued a Mandatory Permit Directive: (MPD) No 2001-010 requiring the introduction of passenger shoulder straps in microlight aircraft.

In the course of this investigation a number of microlight pilots expressed concern that static shoulder straps might prevent the pilot obtaining the full range of movement of the basebar. Moreover, if the harness is fitted loosely, as recommended in the Quik manual, it could unknowingly slip off the shoulder and restrict movement at a critical point in the flight. Concern was also expressed that inertia-reel harnesses might jam when the aircraft is subject to turbulence during the landing phase when large control movements are required. In this accident the passenger was sitting in the rear seat and would not have been expected to fly the aircraft.

Previous accidents have clearly demonstrated that the use of shoulder harnesses and correctly fitted helmets saves lives and reduces serious injury. The Safety Regulation Group Safety Plan for 2005/2006 includes an action plan item to conduct a study into developing a suitable helmet for use by general aviation pilots.

1.16 Tests and research

1.16.1 Microlight Tumbling

The tumble is a departure from controlled flight whereby the angular momentum of the aircraft causes the microlight to rotate about its pitch axis with a very high angular velocity and acceleration; angular velocities of one revolution per second and transient accelerations of 8g are not unknown. During the tumble the forces are so great that the basebar normally hits the front strut with sufficient force to cause either the basebar or front strut to fail. A tumble normally results in the break up of the aircraft and the occupants to be fatally injured.

For a microlight to tumble the trike must swing with sufficient momentum to overcome the aerodynamic damping forces from the wing and allow the establishment of a pitch autorotation. This is possible if the pilot mishandles the aircraft, severe turbulence is encountered at low speed, or the microlight enters a stall from a high climb angle. Mishandling or a steep stall normally result in the microlight tumbling nose down.

1.16.2 Aircraft handling characteristics

The manufacturer demonstrated the effect on the handling of the aircraft following an engine failure, mishandling or pilot incapacitation. When the aircraft was stalled at a maximum nose pitch-up angle of 45º and the engine was set to idle, the response was very benign with the nose gently pitching down to the trim position. When the pilot simulated loss of consciousness in trimmed flight, his body slumped backward into the seat and the aircraft continued to fly straight and level for a short period until it slowly entered a spiral dive.

The manufacturer subsequently undertook further tests, which were not observed by the AAIB, to determine the effect of the pilot losing consciousness with the aircraft flying at maximum straight and level speed with the luff lines slack. With 2 persons on board the test pilot incrementally increased the speed from 80 mph to 100 mph and at each speed increment the pilot let go of the basebar and observed the effect. The maximum level speed of 100 mph was achieved by the pilot applying a rearward force of 18 kgf to hold the basebar close to his chest. On releasing the bar at 100 mph the aircraft pitched swiftly upwards reaching an angle of 45º in 2 seconds before the nose dropped and the aircraft settled at the trim speed of 75 mph to 80 mph after 1.5 cycles. It was not possible to safely undertake the last exercise with one occupant on board, as the pitch rate would have resulted in the aircraft exceeding the maximum pitch up limits.

1.16.3 Previous incident of a failure of the upright upper fitting

In April 2004 a Pegasus Quik was being flown dual at 70 mph. Whilst making a 180º turn the pilot found that he had to move the basebar further than normal to stop the turn. The basebar did not appear to be in the correct position and was slightly crooked across the aircraft. The pilot returned to the airfield at 60 mph where it was discovered that the upper fitting had rotated rearwards about the two rivets in the extrusion. The fitting was returned to the manufacturer who established that the original rivets, which were still intact, were loose and that it was probable that compressive loads in the upright had caused the fitting to rotate approximately 55º. Consequently, on the 11 May 2004 the manufacturer issued Service Bulletin 116 which required an inspection of the joint and the fitting of an additional two Avdel rivets 7 mm from the top of the upright. The Service Bulletin called for the work to be recorded in the aircraft logbook and be signed by an inspector.

1.16.4 Testing

1.16.4.1 Upright fittings

Both the original two rivet configuration upright fitting, and that of the failed upright on the accident aircraft, were tested by the manufacturer, under the supervision of the AAIB, to establish the mode of failure. Because of the limited material available, the end fittings were manufactured from 25 mm stock, which was 3 mm narrower in diameter than the production fittings. The impact of using a smaller stock size is that the supporting face between the top of the upright and fitting would be narrower, thereby making the joint more susceptible to splaying. However, this would only be relevant to the original two-rivet configuration and would have no impact on the mode of failure.

The Certification Requirements for the Quik are specified in the British Civil Airworthiness Requirements (BCAR) Section S, which requires the microlight to be designed to a minimum manoeuvring limit load of +4g. A safety factor of 1.5g is applied to this limit which means that the structure must be capable of withstanding a static load of +6g. The uprights were designed for a 1g compressive load of 150 kg.

A compressive load was applied to the original two-rivet configuration. At 500 kg (3.3g) the fitting started to rotate around the rivets until at 600 kg (4g) it had rotated by approximately 40º. At this point, the compressive load was being reacted by the rivets and the contact between the fitting and the trailing edge of the extrusion (Figure 6).

Figure 6 Rotation of upper fitting

The load was removed and the original rivets were found to be loose; there was also noticeable movement in the joint. To replicate the addition of the Avdel rivets, as per the Service Bulletin under field conditions, a handheld cordless drill and ruler were used to position and drill the holes. The additional Avdel rivets were fitted and a load was incrementally applied up to 3,000 kg (20g). At each increment the load was removed and the joint checked for looseness. Whilst the gap between the top of the extrusion and the fitting closed when the load was applied, the joint remained firm with no evidence of the rivets working loose. The joint did not fail even when the extrusion was hit repeatedly in both directions with a soft face hammer whilst under a compressive load of 3,000 kg. This test indicated that the addition of two correctly formed Avdel rivets 7 mm from the top edge of the extrusion is sufficient to stabilise the joint even when the original Monel rivets are loose. The test however, did not prove the long-term airworthiness of the joint.

The second test fitting had Service Bulletin 116 embodied with the rivets fitted, using a handheld cordless drill, in the same position as the right upright on the accident aircraft. A Monel rivet was used to replicate the incorrect rivet; this ensured that the stem did not contact the sleeve. As the drill bit went through the fitting it could be felt biting into the sleeve and fitting. On the inboard hole the drill constantly juddered and made unusual noises as the bit tried to cut through the fitting and sleeve. As the bit broke through the gap it caused the fitting to jump upwards and rotate slightly forwards. Looking through the hole, it could be clearly seen that the drill had gone through the gap between the sleeve and fitting. It was even clearer, when looking through the trailing edge of the extrusion, that both holes had been drilled in the wrong place and the outboard hole had missed the inner fitting. The outboard rivet was fitted first and had no effect. When the Avdel rivet was pushed into the hole it took up a slightly cocked alignment. As the Avdel rivet was formed it caused the inboard side of the fitting to move upwards and at the same time the extrusion started to splay. Whilst the joint felt secure, with no movement, the inboard gap between the top of the extrusion and fitting increased from 0.8 to 1.35 mm. A vertical gap of 0.3 mm also appeared between the fitting and side of the extrusion. Looking into the extrusion from the trailing edge, it could be clearly seen that the rivets had not secured the extrusion to the fitting (Figure 3).

The test fitting was subjected to compressive loads in 150 kg (1g) steps up to 1,000 kg (6.7g) and the rivets and joint were checked for looseness. At 300 kg (2g) the vertical gap opened to 0.5 mm and it was noticeable that the fitting was rotating outboard and slightly backwards. At 1,000 kg (6.7g) the joint appeared to be going unstable by starting to roll to the right and backwards; this was a different failure mode to the first sample. The load was removed and 6 cycles from 30 to 300 kg (2g) were applied. The vertical splaying occurred earlier on each cycle until after the fifth cycle the splaying started to occur at 125 kg (0.8g) (Figure 7).

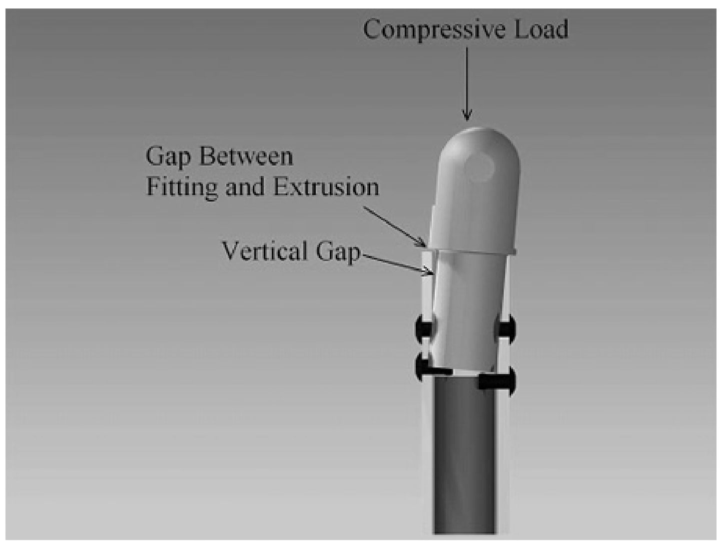


Figure 7 Effect of applying a comprehensive load on right upright with incorrectly fitted rivets

There was no evidence of looseness of the joint, or rivets throughout this test. A load of 1,500 kg was reapplied and the joint was encouraged to fail by pushing the leading edge forward. The original Monel rivets failed as the joint rotated. Inspection of the joint revealed that rotation of the fitting around the existing rivets had resulted in damage to the top of the sleeve, Avdel rivets and the interior of the extrusion. Further tests supported the finding that rotation of the fitting around the Monel rivets resulted in damage to the inner sleeve, Avdel rivets and inside of the extrusion (Figure 6). No such damage was found on the right upright on the accident aircraft. This lack of damage to the inner sleeve and Avdel rivet indicates that on the upright fitted to the accident aircraft the Monel rivets failed first leaving the fitting perched on the Avdel rivet. The fitting would then be held in place by the side forces from the extrusion, which had been splayed, and the compressive force that would push the fitting against the top edge of the extrusion.

1.16.4.2 Trim cable

The trim cable is made from 2 mm Type 316 Bright Stainless Steel Rope with a quoted strength of 240 kg. A sample was tested and found to fail at 312 kg. The steel rope is connected to the luff lines via a 3 mm Excel Pro polyester cord with strength of 189 kg. A sample of the cord was tested using the same type of knot used on the Quik. In three separate tests the cord failed at 90, 112 and 120 kg. It is likely that during the tumble the compressive loads in the upright would have exceeded the ultimate strength of the steel rope and polyester cord. This meant that following the failure of the right upper fitting, it is unlikely that the trim cable alone could have taken the load in the upright.

1.16.5 Independent testing of uprights

1.16.5.1 Design loads

An independent review of the design loads and failure of the upright was undertaken by the QinetiQ Forensic Engineering Group. The load required to either buckle or break each element in a structure is compared with the ultimate load and the ratio of these loads, which is called the reserve factor, must be greater than or equal to 1. In the case of the upright, the reserve factor is stated by the manufacturer as 1.02 and was calculated using a number of assumptions, not all of which appeared to have been verified by testing. QinetiQ used slightly different values in their calculations and obtained a reserve factor of 0.93 corresponding to a maximum safe design load of 3.74g. This was similar to the maximum safe design load of 3.8g calculated by the designer for the Pegasus Q2 wing, which was used as the basis of the design for the Quik wing. BCAR S AMC 337 (2)(b) recognises that the distortion of flexwings might mean that the required manoeuvre limit load of 4g is not achievable and, therefore, a lower limit load, corresponding to the maximum load that the aircraft can achieve, is permitted. As a result of the design review, the CAA and Manufacturer agree that the Quik would not be able to achieve a load greater than +3.5g; therefore a limit load of 3.74/3.8g is acceptable. However, these figures did not correspond with the 4g load quoted in the Quik Type Approval Data Sheet (TADS) and the Flight Limitations Placard.

As a result of these findings the manufacturer carried out flight tests on a Quik fitted with an instrumented upright. The test confirmed that the wing twists as the wing load increases, thereby causing the centre of pressure to move inboards. Extrapolation of the load data obtained at 2g indicated that at 4g the reserve factor is greater than 1. This means that the construction of a correctly assembled upright is strong enough to take the required 4g load. The CAA supported the findings of the manufacturer and asked the manufacturer to take action to amend the certification documentation.

1.16.5.2 Examination of uprights

The uprights and rivets were examined using Optical Microscopy, Scanning Electron Microscope (SEM) and Energy Dispersive X-rays (EDX) techniques. The examination agreed with the AAIB examination in that the additional rivets had been fitted in the incorrect position and an incorrect aluminium alloy rivet had been fitted in each of the uprights instead of the specified Avdel rivets. Damage to the right fitting indicated that it had rotated around the Monel rivets during the drilling operation. The SEM examination also revealed that the oval hole at the bottom of the shank on the upper fitting was caused by the double drilling of the hole. The EDX assessment revealed that the correct Monel rivets had been fitted. The incorrect rivet in each upright was identified as being composed of approximately 97% aluminium and 2.8% magnesium with a shear strength between 12% to 25%, and a tensile strength of 20% to 50% of the correct Avdel rivet. Therefore, even if the additional rivets had been fitted in the correct position the use of the wrong rivet would have severely compromised the structural integrity of the 'A' frame.

1.16.5.3 Fitment of additional rivets

Test pieces were manufactured and following the fitment of the Monel rivets the joint was worked until the rivets became loose. The Avdel rivets were then fitted in the same place as in the accident aircraft. During the drilling of the hole the fitting started to rotate, which subsequently required one hole to be re-drilled. The subsequent damage to the hole was very similar to the oval hole on the accident aircraft. A hand riveting tool was used to fit the rivets and during this operation difficulty was experienced in breaking the rivet core in tension; therefore the core was broken by applying a sideways bending force. Whilst the head of the rivet appeared to be correctly formed, there was a risk that bending of the rivet core would result in the rivet tail not expanding sufficiently. A SEM examination of the rivet cores on the test and accident uprights established that the additional rivets on the accident aircraft had been correctly fitted.

1.16.5.4 Testing of uprights

In order to establish the integrity of the riveted joint, it was decided to subject the test pieces to a cyclic load that would be broadly representative of the range of loads the microlight would expect to see in flight. This was not a fatigue test, nor was it intended to replicate the flight profile of the aircraft in the hours leading up to the accident. Following discussions with the CAA, Manufacturer and BMAA Technical Office it was decided to carry out the test using a cyclic load between 0.3 and 2.5 of the 1g load, corresponding to 459 N and 3,825 N.

The results of the test were similar to those found by the manufacturer. There was sideways movement of the fitting, splaying of the extrusion and loosing of the rivets. As in the first test, deformation of the rivets resulted in the fitting settling on the extrusion, which acted to stabilise the joint. As in the previous test, the joint would not rotate when subject to a compressive load.

1.16.5.5 Outcome of testing

The results of the test by both the manufacturer and QinetiQ indicate that the fitting is stable when subject to a simple compressive load. This suggests that for the joint to rotate the loads in the upright must be more complex and the joint must have already been weakened possibly as a result of loose rivets and a splayed extrusion. The tests also showed that with the rivets fitted in the same position as in the accident aircraft the application of a compressive load will cause the extrusion to splay. A Finite Element model of the extrusion, produced by QinetiQ, indicated that splaying of the extrusion, far enough to allow the fitting to rotate, would cause parts of the extrusion side wall to exceed the yield strength of the material. Consequently, when the load was removed the extrusion would not spring back to its original shape. This model is consistent with the testing undertaken by the manufacturer and the AAIB, where splaying of the extrusion started at progressively lower loads.

In Service Bulletin 116 Issue 1, the reason given for the splaying of the extrusion and loosing of the rivets was the load resulting from the contact of the upright with the hang bracket when the Quik is parked wing down in windy conditions. Tests on another Quik showed that in the fully rigged condition the upright will contact the front strut before contact is made between the hang bracket and upright. It is therefore, unlikely that parking the wing down in a strong wind was the mechanism by which the joint was originally weakened. It is probable that the most likely mechanism was when the wing was rigged and sat on the ground with the original Monel rivet on the upright contacting the edge of the hang bracket (Figure 8). A load applied to the wing would be transmitted through the kingpost which, if large enough, could cause the extrusion to splay and a tensile load to be applied to the rivet. Calculations subsequently carried out by the manufacturer indicated that in this position a strong gust of wind on the wing would result in a load sufficient to splay the extrusion and weaken the Monel rivets. The manufacturer also calculated that the modified design, with four correctly fitted rivets, would be strong enough to cope with such a load. The CAA reviewed the manufacturer's calculations and considered that the four rivet configuration is an acceptable solution to prevent the extrusion from splaying.

Figure 8 Contact between hang bracket and upright

1.17 Organisational and management information

1.17.1 British Microlight Aircraft Association (BMAA) inspectorate

1.17.1.1 Role of BMAA inspectors

BMAA inspectors carry out the 12 monthly inspection of microlight aeroplanes required for the revalidation of the Permit to Fly. The inspectors also undertake duplicate independent inspections and stage inspections on home built microlights. The inspectors report to a full time Chief Inspector who can authorise them to inspect flexwing and three axis aircraft.

1.17.1.2 Experience level of BMAA inspectors

The BMAA has a pool of suitably qualified and experienced volunteers, who are capable at undertaking the duties of an inspector; albeit they might not always be in the parts of the country where they are most needed. In the course of this investigation the AAIB worked closely with one such inspector who was very knowledgeable and familiar with the construction of the Quik. He also had a very good understanding of the necessary airworthiness and maintenance issues.

The BMAA Technical Office is also staffed with professional engineers who assisted in the early stages of the investigation and played a significant role in the drafting of the reissue of Service Bulletin 116. They also responded quickly to the early findings on the inadequate recording of maintenance and lack of a duplicate inspection by publishing a very clear article on the subject in the November-December 2004 issue of the BMAA magazine Microlight Flying (MF).

1.17.1.3 Criteria for the selection of BMAA inspectors

Inspectors are selected and appointed by the Chief Inspector in accordance with criteria specified in the Chief Inspector’s responsibilities detailed in the BMAA Technical Procedures Manual and 'Guide to Airworthiness Procedures'. The engineering competence required to be appointed as an inspector is specified as: '*at least 3 years experience as an engineer/technician with an engineering Ordinary National Certificate (ONC) or equivalent'*.

Regarding engineering competence; whilst the BMAA Chief Inspector can waive the minimum requirements the appeal procedures for unsuccessful candidates is less clear. The Chief Inspector believed that individuals could appeal to the BMAA Council, and the Chief Executive believed that he could over turn the decision of its Chief Inspector.

The development and implementation of the inspector criteria began in 1985 and inspectors appointed prior to this date were granted grandfather rights, thereby effectively exempting them from the minimum engineering criteria. Historical records within the BMAA are incomplete and shortly after the accident the Chief Inspector was unable to ascertain the criteria by which some of the current inspectors were appointed, or the number of records that needed updating. The BMAA subsequently identified six inspectors whose records showed no clear basis for their appointment as inspectors. Whilst three of the inspectors resubmitted their qualifications with their annual renewal, it was difficult to determine from the updated records if the individuals had the necessary technical knowledge. The inspector involved in this accident was one of the individuals for which there were incomplete records. The individual was appointed as a BMAA inspector in July 1994 and had no formal engineering qualifications, or experience, beyond that which he had obtained through his involvement with microlight aircraft. Whilst the BMAA Chief Inspector does not possess an engineering ONC or recognised equivalent he has an extensive engineering background in aircraft maintenance and has satisfied the CAA that he has the necessary competencies for the appointment.

1.17.1.4 Training of BMAA inspectors

New inspectors undergo a period of on-the-job training and after undertaking a number of supervised inspections, required for the revalidation of the Permit to Fly, are formally appointed by the Chief Inspector. Inspectors then reapply on an annual basis and re-authorization is normally granted unless the Chief Inspector has received any adverse comments or complaints about an individual's performance; attendance at training courses and seminars is not taken into account.

1.17.1.5 Continuation training and guidelines for inspecting microlights

New inspectors are provided with documents including '*Guidelines for the Inspection and Maintenance of Microlight Aircraft*', dated January 1993, current copies of the Chief Inspector's General Notices, recent Defect Reports and Type Approval Data sheets (TADS). They can also access the BMAA Guide to Airworthiness Procedures via the BMAA web site and are given the opportunity to attend manufacturers' training courses and BMAA seminars. The Guidelines give advice on checking rivets for looseness and use the expression 'pop-rivets', though they do not explain that there are many different types of fasteners, suitable for different applications and it is essential that the manufacturers instructions for their use is strictly adhered to. With regard to the drilling of holes, the BMAA Guidelines state:

> *..where components are bolted to tubes…as a general guide the centre distance of any drilled hole should never be less than two to three of the hole diameters from the end of the tube.*

Using this general criterion the minimum distance of the hole for the additional rivet from the edge of the extrusion should have been between 9.8 mm and 14.7 mm. The Service Bulletin required the hole to be drilled 7 mm from the edge of the extrusion. The Guidelines also make no mention of the type of construction used on the Quik uprights. The TAD for the Pegasus Quik does not list the essential warning placard as one that is required to be fitted to this aircraft.

The BMAA has stated that the inspector concerned would have received copies of General Notices containing guidance on duplicate inspections of primary structure, aircraft inspections and limitations on work undertaken by owners. This information is also included in the 'Guide to Airworthiness Procedures'. During discussions, the BMAA Chief Inspector indicated that due to the location of the training courses and the part time nature of the inspectors, many of them do not attend the training courses.

1.17.1.6 Audit of BMAA inspectorate

In 1995 the CAA mandated that the BMAA should undertake regular audits of their inspectors. Consequently a system of audits undertaken every five years by Senior BMAA inspectors was carried out in 1996 and 2000.

The Inspector involved in the accident was last audited on 13 October 2000 by a Senior Inspector who had completed a four year aircraft apprenticeship, approximately 27 years ago. During the apprenticeship the Senior Inspector was employed in the maintenance of light aircraft and gained a City and Guild Certificate in mechanical engineering. His employment in aircraft maintenance ceased at the end of his apprenticeship when he moved away from the industry to become a service engineer. Nevertheless, the Senior Inspector maintained his interest in aviation by flying a range of different aircraft, including hang gliders and light aircraft, and building a number of aircraft from plans. He was appointed as a BMAA inspector approximately 20 years ago. In carrying out the audit, the Senior Inspector signed the following statement:

> *I have interviewed the above named Inspector and I am satisfied that he has sufficient knowledge of the above microlight aircraft subjects to examine safely, within the restrictions of their authorised aircraft type and inspection categorisations, microlight aircraft presented to them for inspection purposes.*

The subjects included construction; independent inspections; fasteners, including rivets; and recording of data.

Production of the Pegasus Quik, which does not use the traditional method of attaching the uprights to the hang bracket, began three years after the inspector had last been audited. The aircraft inspection aspect of the audit was undertaken on a Medway Hybred 44XLR, which was first approved in 1985, eighteen years before production of the Pegasus Quik started.

1.17.1.7 Possible future changes that might have an impact on the BMAA inspectorate

The CAA are currently considering a proposal from the BMAA, on behalf of the Department for Transport, for the de-regulation of single seat microlights weighing less than 115 kg by passing the full responsibility for safety to the owner. The BMAA have also balloted their members to seek approval from the CAA to handle the Very Light Aeroplane (VLA) category of aircraft, which would increase the size and weight of aircraft handled by the BMAA from the current 450 kg to 740 kg Maximum Take-off Weight. The VLA category would include modern aircraft that are more complex with a higher level of technology than which the BMAA inspectors might be familiar.

1.17.1.8 BMAA review of the appointment of inspectors

As a result of a BMAA Council meeting, held on 7 July 2004, a decision was made to set up a sub-committee to review the BMAA inspectorate system with a view to making recommendations to the BMAA Council on how it might be improved. Additionally, the standard of inspectors and the introduction of new technology and processes were discussed at a BMAA airworthiness meeting, attended by the CAA, on 10 August 2004. The CAA was informed about the proposed sub-committee and they offered to appoint an advisor/observer to that committee but, by August 2005, one year after the accident, no request from the BMAA had been received by the CAA and the sub-committee had not met. Internal discussions however, have taken place involving BMAA engineering staff regarding the criteria for appointing, training and auditing inspectors in the future. Furthermore, the BMAA has received written advice from the CAA about the selection and appointment of a new BMAA Chief Inspector that has influenced their recruiting effort and led to a revised job description for the post.

1.17.2 Civil Aviation Authority (CAA) oversight

1.17.2.1 CAA approval

The CAA granted approval in September 1984 for the BMAA to establish that microlight aircraft conform to acceptable standards/specifications in compliance with British Civil Airworthiness Requirements. A condition of the approval is that the BMAA furnish the CAA with an Exposition and Technical Procedures Manual (TPM) that provides a description of the organisation, list of nominated personnel and description of procedures. The TPM specifies the log books that are to be used, the minimum qualifications and experience required by inspectors and the internal auditing procedures for the BMAA Inspectorate.

1.17.2.2 CAA audits

The CAA exercises their oversight of the BMAA Inspector system by undertaking biannual audits. Historically these audits have been purely documentary reviews of sampled aircraft and the files of the inspector who had carried out the Permit to Fly revalidation audit. However, it was agreed at a BMAA airworthiness review meeting held on 10 August 2004 that the CAA would conduct sample aircraft surveys to validate the BMAA process. The first survey of an aircraft was undertaken on 2 June 2005 with a further four surveys planned for the end of the 2005 flying season.

1.17.2.3 Waving of specified criteria for BMAA inspectors

It is the Chief Inspector alone who is responsible for waiving the minimum qualifications and experience of new inspectors with no independent BMAA or CAA auditing process to check the basis on which this decision is made. In the inspector chain involved in this accident the inspector did not have the minimum experience and neither the inspector his auditor or the Chief Inspector possessed an ONC, or obvious equivalent. The BMAA was also unable to provide sufficient auditable evidence to establish if the inspector had the necessary knowledge and skills to fulfil his required responsibilities. However, both the Chief Inspector and auditor had completed aircraft apprenticeships and were employed as engineers prior to being selected and appointed as inspectors in the BMAA.

In comparison, the Popular Flying Association, which has the same aims as the BMAA, requires its potential inspectors to pass a two hour written exam covering aircraft engineering, maintenance, operation and certification.

1.17.2.4 BMAA inspector records

In February 2002 the CAA wrote to the BMAA Chief Executive expressing their concern that the inspector records were the minimum required to demonstrate the basis on which an inspection approval was granted. The Chief Executive responded in April 2002 stating that the matter was in hand and would be reviewed at their June 2002 meeting. In subsequent audits the CAA found the records of the inspectors sampled to be satisfactory. Nevertheless, shortly after the accident it was discovered that the record for the inspector involved in this accident was missing and the Chief Inspector confirmed that records for a number of other inspectors were incomplete. Each of these inspectors would have been re-authorized twice since the Chief Executive responded to the CAA in April 2002.

1.18 Additional Information

1.18.1 Duplicate inspections

Whilst not specifying that a duplicate inspection was required, the Service Bulletin did call for the work to be inspected by a BMAA inspector. The BMAA Guide to Airworthiness states:

> *'the use of duplicate inspections is a safety technique used throughout aviation. This is the practice of an inspection being made by one person and a subsequent independent inspection being made by a*

> *different person, once all the work is complete. Duplicate inspections should be made on all changes to primary structure or powerplant (including regular maintenance), and both inspections recorded in the logbook. For modifications and repairs, one of these inspections must be made by a BMAA inspector.'*

The 'A frame' is part of the primary structure and, therefore, the addition of the extra rivets required a duplicate, independent, inspection to be carried out. However, the only entry in the logbook, regarding this modification, was signed by the BMAA inspector who helped fit the rivets and could not, therefore, have carried out the required independent inspection. It is probable that the incorrect fitting of the additional rivets would have been noted if a duplicate inspection had been carried out by a competent, independent individual. The BMAA have stated that the inspector involved in this accident was considered to be conscientious with a reputation for being safety conscious.

1.18.2 Review of Service Bulletins by the BMAA

Manufacturers can issue Service Bulletins (SB) and the CAA can issue the associated Mandatory Permit Directive (MPD) with the recommendation that the work should be checked by an inspector without drafts of the SB being passed to the BMAA for their comment. In this instance the manufacturer released the SB on 11 May 2004 and the CAA released the MPD a day later on 12 May 2004. By allowing the BMAA to review SBs before they are published, the BMAA can provide appropriate advice as to the suitability of the SB being satisfactorily completed by their members. The BMAA would also have sufficient time to provide their inspectors with any necessary training or guidance.

1.18.3 Incorrectly modified Pegasus Quik aircraft

The manufacturer has stated that to their knowledge, of the seventy two Quiks that Service Bulletin 116 was satisfied by their owners, this aircraft was the only one that had the rivets fitted in the wrong place.

1.18.4 Permit to Fly

The Permit to Fly for a microlight aircraft is a non-expiring document that needs to be revalidated by the BMAA at 12 monthly intervals following an inspection report to ascertain that the aircraft is in an airworthy condition. The last inspection for recommending the re-issue of the Certificate of Validity was signed on the 10 January 2004 at 227 hours by the same BMAA inspector who signed as having inspected Service Bulletin 116. The inspector wrote '*SAT*' against entry 1.1 on the BMAA Flexwing Microlight Inspection Schedule that detailed: '*Logbook entries checked, including all maintenance and repairs'*.

A 200 hour servicing had been carried out at 188 hours 50 minutes, which would effectively have base-lined the aircraft for the aircraft maintenance for which there is no record of having been carried out up to that time. However, there is no entry to indicate whether all the required engine maintenance or the 100 hour inspection and test flight by a Pegasus aviation inspector had been carried out. The manufacturer subsequently clarified this last requirement by stating that it was intended for the USA market and that the 100 hour inspection and test flight could be undertaken by a BMAA inspector and check pilot; however the Inspector who undertook the Permit to Fly audit had not received any specific training on inspecting and test flying the Quik.

The owner also continued to fly the aircraft, with the inspector's knowledge, following the embodiment of Service Bulletin 116 without the work having been certified in the log book. Without this certification the owner would not have been able to demonstrate that the mandatory modification had been satisfactorily completed and that the aircraft was in an airworthy condition.

The BMAA General Notice to Inspectors GN-(99)-04 states:

> *'If Inspectors are asked to inspect an aircraft and they find that there is no record of regular inspection or manufacturers recommended maintenance being carried (out) then …: they walk away from it until the owner has completed and signed for the maintenance …; make an entry in the aircraft log book requiring the owner/operator to complete the maintenance and inspection work in a specified time or hours*

The inspector made no entry in the log book concerning the missed maintenance and claims that as he did not have any detailed knowledge of this aircraft, he relied on the owner to tell him the maintenance standard.

1.18.5 Cultural issues

Documentary evidence, in the form of Chief Inspectors General Notes going back to 1989, show that the BMAA has an ongoing concern at the standard of maintenance and Permit to Fly inspections undertaken by some of their members. At the time of the accident, which occurred at 342.7 hours, the engine maintenance had been brought back in line, however, there is no evidence that the last 50 hour and 100 hour aircraft servicing, or the 300 hour wing strip and inspection had been carried out.

It has also become apparent that there is a minority of individuals within the BMAA membership who believe that microlights are over regulated and are highly critical of the CAA. Whilst some of these individuals might be very capable engineers, with a sound grasp of the airworthiness issues, their attitude may influence other members of the BMAA, who do not possess the knowledge to fully assess the risk that they are exposing themselves to by deviating from the current regulations. It was not possible to determine if the views of the aforementioned minority had influenced the actions of the owner or the decision of the Inspector involved in this accident who chose to act on the advice of a colleague rather than follow the Service Bulletin when he modified the uprights.

2 Analysis

2.1 Introduction

The investigation considered a number of aspects that could have caused the initial pitch up that led to the aircraft entering an irrevocable tumbling manoeuvre.

2.1.1 Pilot incapacitation

There was no medical evidence from the pathological examination to indicate that the pilot was incapacitated prior to the microlight tumbling. Moreover, the aircraft handling characteristics are such that pilot incapacitation would result in the aircraft adopting the trim attitude before slowly entering a spiral dive. Had the pilot become unconscious and the passenger attempted to take control, then the passenger would have had to apply a force of 15 kgf to 18 kgf to hold the basebar in the fully forward position in order for the aircraft to pitch up at a high enough rate to enter the tumble. From the available medical evidence and aircraft handling characteristics it is considered unlikely that the aircraft entered the tumble as a result of the pilot becoming incapacitated.

2.1.2 Engine Failure

The claims by the witnesses that the engine stopped during the tumble is consistent with the lack of damage to the propellers and intact coolant pump drive. All the damage to the engine was consistent with it having struck the ground. Moreover, the data from the FLYdat recorder indicated that during the last flight the engine had been running normally and no parameters had been exceeded. Fuel starvation would most likely occur if the aircraft exceeded its maximum pitch attitude, or if it experienced a negative acceleration greater than –0.5g for more than 5 seconds. Both these limits would have been exceeded during the tumble and therefore this is the most likely reason for the engine stopping. Nevertheless, failure of the engine in normal flight conditions is a benign event that would not cause the aircraft to pitch up and enter a tumble.

2.1.3 Mishandling

The pilot had started flying microlights in July 2001 since which time he had accumulated a considerable number of hours. In February 2003 he bought the Pegasus Quik G-STYX and so was used to the aircraft and its relatively high performance. The pilot then underwent training to become an instructor and passed his assessment in May 2004 with an examiner known to demand high standards. Having successfully qualified as an instructor he then worked on a part-time basis instructing for the microlight club at Rochester Airfield. This included taking people on trial lessons such as that involved in this accident. Contact with past passengers on trial lessons undertaken by the pilot, have not revealed any sort of extreme manoeuvring during their flights such as the pitch up described by witnesses to this accident. Indeed the general comments were that the flights were all conducted in a very professional manner. Whilst it cannot be ruled out that the pilot deliberately pitched the nose of the aircraft up just prior to it entering the tumble, from the evidence gathered it seems most unlikely.

2.1.4 Weather

The aftercast showed that there was no significant weather at the time of the accident. However, the aircraft was flying at around 100 mph and 500 ft along the cliffs and may have encountered an updraft. Whilst this updraft may, in normal circumstances, have been insufficient to cause structural failure it is possible that on this occasion the change in load in the right upright was sufficient to cause the already weakened Monel rivets to fail and the fitting to rotate out of the extrusion.

2.1.5 Structural Failure

The failure of the upright fittings is the only structural damage that might have occurred prior to the aircraft tumbling. It is likely that the Monel rivets were already weakened and the joint was loose prior to the embodiment of Service Bulletin 116. The incorrect positioning of the Avdel rivet on the right upper upright fitting would have changed the load path such that under normal loads the existing Monel rivets would weaken and further loosen the joint. The fact that the pilot appeared to make no attempt to land or reduce his speed indicates that he was either unaware of the failure, or the aircraft's response to the failure was so quick and dramatic that he could do nothing. During the previous incident, when the upper fitting rotated, the pilot was sufficiently aware that the basebar and aircraft handling felt different that he slowed down and made a precautionary landing. It is difficult to imagine that this pilot would have done anything different; therefore, it is highly probable that the sudden failure of the right upright was the precursor for the aircraft pitching up and entering the tumble.

The most likely sequence of events is that the incorrect fitting of the Avdel rivet in the right upright changed the load path such that during the following 59 hours the Monel rivets weakened, then failed, leaving the upper fitting resting on the single Avdel rivet. Turbulence, or movement of the basebar, would then have changed the loading on the joint sufficiently to cause the fitting to roll backwards out of the extrusion. Driven by the wing loads pulling on the flying wires, the extrusion would move upwards causing the trim cable to fully unwind off the trim wheel and at the same time shorten the luff lines. As the upright moved upwards, the tightening trim cable would cause the top of the extrusion to jam beneath the fitting and the hang bolt quick release fastener. The wing reflex would increase as the luff lines shortened, causing a high wing pitch up moment.

Up to this point the pilot would have been exerting a force of around 18 kgf on the basebar in order to keep the aircraft flying straight and level at around 500 ft agl and 100 mph. As the luff lines tightened the force on the basebar would increase to approximately 45 kgf resulting in the basebar being snatched from the unsuspecting pilot's hand and the microlight would then enter a steep pitch up attitude. With a high angle of attack and maximum reflex the wing would continue to rotate nose-up and after approximately three seconds the microlight would be in a vertical attitude. The microlight would then enter a tumble during which the basebar burst through the front strut, and the resulting disruption to the fuel and airflow would cause the engine to stop. The trike would swing violently backwards and forwards between its limit of travel, with the resulting high angular acceleration and associated g loads disorientating and possibly resulting in the passenger and pilot loosing consciousness. The microlight would loose height as it tumbled and after a further three seconds, and two to three rotations, the monopole would fail resulting in the separation of the trike from the wing.

2.2 Discussion

2.2.1 Most probable cause

Whilst other causes can not be totally ruled out, it is most probable that the accident occurred when the microlight became uncontrollable as a result of a failure of the right upright upper fitting. This failure caused the microlight to pitch towards the near vertical and enter a series of tumbling manoeuvres resulting in the separation of the trike and wing.

2.2.2 Manufacturer's response to previous failure of upright

Once it became apparent that the upper fitting on the 'A' frame was susceptible to working loose, the manufacturer took timely action to modify the original design and issue Service Bulletin 116. Whilst this investigation has raised several long term airworthiness and safety issues it was the fitment of the fasteners in the incorrect position that resulted in the failure of the upright causing the aircraft to enter an irrecoverable tumble.

2.2.3 Flight loads

Even with the weakened rivets and splayed joint, tests indicated that with a simple compressive load the fitting should not rotate. However, the physical evidence from the accident aircraft and the previous incident, which resulted in the issue of Service Bulletin 116, proves that this is not the case.

Manoeuvre loads in the upright appear more complex than the original design predicted and it is likely that normal flight loads, and possibly inertia loads during landing resulting from the relative position of the wing and trike, are introducing complex non-axial loads into the uprights. Whilst the manufacturer's calculations indicated that four correctly fitted Avdel and Monel rivets are sufficient to take the loads in the upright, around 72 Quik microlights have been modified by owners and it is possible that the extrusions on these aircraft may have splayed and the Monel rivets may have been weakened prior to the embodiment of Service Bulletin 116. Moreover, the type of tools available to owners may have resulted in the cores of the Avdel rivets having been broken by bending with the result that, whilst externally they might appear to have been formed correctly, some rivets may not have expanded fully and therefore will be susceptible to working loose. There is also a risk that some of the holes may have been double drilled. Given these concerns it is recommended that the CAA and Manufacturer take appropriate action to ensure that uprights that have been modified by owners are replaced with factory modified items.

2.2.4 Opportunities to detect incorrect fitment of rivets

There were three possible opportunities for the incorrect fitment of the Avdel rivets to be detected: on initial fit, during the duplicate inspection and during the 100 hour servicing and wing overhaul that was due 42 hours before the aircraft accident. The opportunities were all missed because: the pilot and inspector did not follow the instructions in the Service Bulletin and did not ensure that an independent duplicate inspection had been carried out; the pilot did not appear to have maintained the aircraft in accordance with the maintenance schedule, which the inspector did not appear to notice when he undertook the Permit to Fly revalidation inspection and, therefore, did not advise the pilot on the importance of adhering to the maintenance schedule.

2.2.5 Competence of BMAA inspectors

The safety of microlight aviation is dependent on the BMAA inspectors undertaking the airworthiness audit required prior to the issue of the Certificate of Validity, which forms part of the Permit to Fly, and the inspection of modifications and implementation of Service Bulletins. The engineering nature of this role means that it is essential that inspectors have appropriate engineering knowledge and experience. It would appear, however, that the minimum qualifications, detailed in the Technical Procedures Manual, is little more than an aspiration and that the system relies on the Chief Inspector alone exercising his judgement as to who is suitable.

Furthermore it is a concern that the BMAA Council and Chief Executive could possibly overturn the Chief Inspector's decision not to appoint individuals who lack the appropriate engineering experience and qualifications. The present system whereby there is little auditable process to demonstrate that individuals have the necessary level of knowledge may have played a part in this accident as it enabled an individual, who did not appear to have the necessary competencies, to inspect work and undertake the inspection required for the revalidation of the Permit to Fly on a high performance microlight. Rather than specifying the need for a formal engineering qualification it might have been more appropriate for the BMAA and CAA to agree on the engineering skills and knowledge required by inspectors. The advantages of such a system are that it could increase the potential pool of inspectors within the BMAA, make the system more visible and enable the CAA, during their audits, to establish if an inspector is appropriately qualified.

2.2.6 Training and guidance for BMAA inspectors

All the Sports Flying Associations rely on the integrity and skills of their enthusiastic amateur inspectors to maintain the required standards of airworthiness across their fleets. It is therefore incumbent on the Associations to ensure that their inspectors are suitably trained, provided with up-to-date guidelines and are kept abreast of developments in technology used on the aircraft that they are required to inspect. The BMAA Guidelines for the Inspection and Maintenance of Microlight Aircraft, which is provided to all BMAA inspectors, is over 10 years old and is considered to be inadequate to cover the latest generation of high performance microlight aircraft. Moreover, once an inspector has been appointed, there is no requirement for him to undergo any further training. The present system, whereby manufacturers rely on the inspectors to check the work undertaken by owners with little opportunity for the BMAA to review and comment on the suitability of the work requested from their inspectors, is considered unsatisfactory as it could result in inspectors undertaking tasks for which they have not been suitably trained, or which fall outside their level of competence.

Furthermore the use of old aircraft to audit inspectors who are required to work on the latest generation of microlights, the incomplete maintenance record on G-STYX and the lack of basic engineering knowledge and appreciation of the need to follow airworthiness instructions demonstrated by the inspector involved in this accident, brings into question the effectiveness of the BMAA internal audit system.

2.2.7 Microlight operations

The microlight sport has changed considerably over the last 25 years from the early single-seat low performance to the current twin-seat high performance microlight aircraft. The BMAA is also on the verge of seeking approval to handle the Very Light Aeroplane category, bringing the challenges associated with more complex aircraft with a higher level of technology. But in addition to the advances in aircraft design there has also been significant changes in how microlight aircraft operate such that there are now essentially two different areas of microlight operations, which perhaps require different levels of oversight. Namely the self owned single-seat and the quasi public transport operation.

In the first category the owner is a qualified microlight pilot, who maintains his own aircraft and has sufficient knowledge to assess the degree of risk to which he is exposed. In the second category revenue is earned by hiring out aircraft, flying members of the public and operating flying training schools. This category also includes passengers flown on non-revenue flights. In the second category individuals will not generally possess sufficient knowledge to understand the level of risk that they are exposed to and, therefore, rely on the regulatory authorities to ensure that the risk is kept as low as reasonably practicable.

2.2.8 Safety and cultural issues

The BMAA has played a significant role in the improvement of flight safety by their involvement in the introduction of pilot training and the design standards detailed in BCAR Section S. However, it would appear that a minority of their members are inadvertently undermining the positive safety culture being promoted by the BMAA. This minority resent what they perceive to be interference and over regulation by the CAA and it is possible that in openly expressing their views they might have influenced some individuals into believing that it is acceptable to deviate from the regulations concerning the maintenance and modification of microlight aircraft. This non-conformance is often undertaken without individuals fully understanding the associated impact on the airworthiness of their aircraft and ultimately their safety. BMAA documentation supports this as at least two BMAA Chief Inspectors have in the past expressed concern at the standard of maintenance and inspections carried out by some of the owners and their inspectors.

In this accident the owner, who earned revenue by using his aircraft for flying training and air experience flights, did not appear to have maintained the aircraft in accordance with the manufacturer's recommendations. Despite the apparent erratic maintenance, and a missing essential placard, a BMAA inspector had signed the inspector's declaration on the Permit to Fly revalidation paperwork and subsequently modified primary structure, on the advice of colleagues, without reference to the Service Bulletin. He also did not ensure that the work had been signed for prior to the aircraft flying. Furthermore, even when finally reading the Service Bulletin he still considered his positioning of the additional rivets to be an improvement over the instructions provided by the manufacturer and CAA.

Despite his apparent lack of engineering qualifications and experience the BMAA had, through their selection, training and internal audit and annual reauthorisation procedures, possibly given the inspector the confidence to believe that he was a competent inspector. He should have been able to inspect modifications, including the use of fasteners, on the range of aircraft he was authorised to inspect. Yet in fitting the incorrect rivets he did not appear to notice that 2 of the 4 rivets used looked significantly different, the forces involved in forming the correct rivets as opposed to the incorrect ones would have been significantly different and the formed rivets would have looked different (see Figure 4). He did not appear to realise that the double drilling of holes and the incorrect positioning of rivets would affect the stress concentration within the structure and he did not appear to appreciate that it was essential that the additional rivets needed to be fitted above the pivot point, formed by the contact between the hang bracket and upright, in order to prevent the extrusion from splaying (Figure 8). The appreciation and detection of these discrepancies all required a basic level of engineering knowledge that this inspector appeared not to possess.

The lack of the essential warning placard on BMAA permitted aircraft, the missing pilot's and passenger's shoulder harnesses, the use of unapproved log books and poor maintenance records shows that strict adherence to the regulations is not always followed. Moreover, it appears that some inspectors will sign the documentation for the re-issue of the Certification of Validity, for aircraft used to earn revenue, without ensuring that the aircraft comply with all the required regulations. It has been suggested by some that missing placards and the use of unapproved log books are trivial and relatively unimportant. This attitude however, has allowed some individuals to believe that they can selectively deviate from the regulations. In this accident a potentially life saving shoulder harness was not used and an inspector believed that it was acceptable to deviate from an essential modification on primary structure. The fact that the inspector took advice from another individual prior to modifying the structure suggests that he was not alone in believing that it was acceptable to deviate from the instructions detailed in a mandatory modification.

Whilst this accident appears to be an isolated occurrence, the available evidence suggests that there are systemic weaknesses in the BMAA inspector system.

3. Conclusions

(a) Findings

1 With the exception of the 'A' frame uprights the engine, trike and wing were serviceable prior to the aircraft entering the tumble.

2 Whilst flying at approximately 100 mph, the microlight entered a series of tumbling manoeuvres, which resulted in the failure of the monopole and front strut allowing the trike to separate from the wing.

3 The accident was not survivable.

4 Failure of the right upper fitting resulted in the tightening of the trim cable, which increased the wing reflex causing the microlight to exceed the pitch limit and enter the tumble.

5 The upper fitting failed because the additional rivets, introduced by Service Bulletin 116, were fitted in the wrong place.

6 An independent duplicate inspection was not carried out following the embodiment of Service Bulletin 116.

7 The BMAA inspector who undertook the modification on G-STYX did not refer to the Service Bulletin.

8 Where individuals referred to the Service Bulletin the modification was correctly embodied.

9 The aircraft did not appear to have been maintained in accordance with the manufacturer's recommend maintenance schedule.

10 There was no record that the 100 hour inspection, due at 300 hours, and wing overhaul had been carried out, thus the opportunity to discover the incorrect fitment of the Avdel rivets was missed.

11 The BMAA inspector who signed as having inspected the modification did not have the minimum engineering qualifications and experience specified by the BMAA.

12 The BMAA inspector did not understand how the upright was constructed, the different type of rivets available and the airworthiness issues resulting from incorrectly fitting fasteners in primary structure.

13 The BMAA Guidelines for the Inspection and Maintenance of Microlight Aircraft made no reference to the different types of rivets available and the locations where they should or should not be used.

14 The BMAA specify the minimum engineering qualifications and experience required of an inspector.

15 The BMAA's policy for the waiving of the minimum engineering qualifications and experience for inspectors is not objectively based.

16 Continuation training for BMAA inspectors is not compulsory and not a requirement for revalidation.

17 The records held by the BMAA on inspectors were incomplete.

18 The CAA audit of the BMAA did not identify all the shortcomings in the BMAA's inspectorate.

(b) Causal factors

The investigation identified the following causal factors:

1 Failure of the right upright upper fitting caused the microlight to enter a tumble manoeuvre from which it was not possible to recover.

2 Service Bulletin 116, which introduced additional rivets in the upper fitting, was not correctly embodied.

4 Safety Recommendations

4.1 The following safety recommendations were made on 16 September 2004:

Safety Recommendation 2004-080: It is recommended that the British Microlight Aircraft Association, take the necessary immediate steps to ensure the continued safe operation of the Pegasus Quik microlight aircraft with regard to the application of Service Bulletin 116.

Response to recommendation:

Mandatory Permit Directive 2004-009 R2, requiring Service Bulletin 116 Issue 2 to be undertaken before the next flight, was issued by the CAA on 29 September 2004.

Safety Recommendation 2004-081: It is recommended that the British Microlight Aircraft Association consider reviewing its policy, procedures and standards with regard the implementation and inspection of 'field fitted' modifications and service bulletins.

Response to recommendation:

The BMAA advised the AAIB on the 21 October 2004 that they would consult widely and produce a Code of Practice, which would be published as a BMAA Technical Information Leaflet.

4.2 The following additional Safety Recommendations are made:

Safety Recommendation 2005-082: It is recommended that the Civil Aviation Authority review its policy on the use of crash helmets and shoulder harnesses on microlight aircraft.

Safety Recommendation 2005-083: It is recommended that the Civil Aviation Authority conduct a review of the British Microlight Aircraft Association (BMAA) policy on the selection, training and revalidation of inspectors with a view to establishing; the minimum engineering skills and knowledge; appeal procedures and the individuals within the BMAA who should authorise a reduction in the minimum engineering standards.

Safety Recommendation 2005-084: It is recommended that the Civil Aviation Authority review their audit procedures of the British Microlight Aircraft Association.

Safety Recommendation 2005-085: It is recommended that the Civil Aviation Authority ensure that Service Bulletins involving work conducted on primary aircraft structure include a statement that duplicate independent inspections are required, and that both inspections are to be recorded in the aircraft logbook.

Safety Recommendation 2005-086: It is recommended that the Civil Aviation Authority and Mainair Sports Limited take appropriate action to ensure that Pegasus Quik uprights that have been modified by owners are replaced with factory modified items.

Safety Recommendation 2005-087: It is recommended that the British Microlight Aircraft Association (BMAA) liaise with industry to ensure that advanced copies of Service Bulletins are passed to the BMAA so that comments can be made on their owner/members' and inspectors' ability to competently satisfy the instructions.

Safety Recommendation 2005-088: It is recommended that the British Microlight Aircraft Association (BMAA) ensure, through the issue of the Permit to Fly, that microlight aircraft are fitted with the correct placards and are maintained in accordance with either the manufacturer's or BMAA recommended maintenance schedule and that all maintenance is recorded in a Civil Aviation Authority approved log book.

Safety Recommendation 2005-089: It is recommended that the British Microlight Aircraft Association review and regularly update their document entitled '*Guidelines for the Inspection and Maintenance of Microlight Aircraft*'.

Safety Recommendation 2005-090: It is recommended that Mainair Sports Ltd takes action to ensure that the limitation placard on the Pegasus Quik is protected, or relocated, so that the data remains clearly visible to the pilot.

D S Miller
Deputy Chief Inspector of Air Accidents
Air Accidents Investigation Branch
Department for Transport
October 2005

United Kingdom
Civil Aviation Authority

MPD No: 2004-009

Issue Date: 12 May 2004

MANDATORY PERMIT DIRECTIVE

In accordance with Article 9A(5)(b) of the Air Navigation Order 2000 as amended, the following action required by this Mandatory Permit Directive (MPD) is mandatory for applicable aircraft registered in the United Kingdom operating on a UK CAA Permit to Fly.

MPD: 2004-009 MAINAIR SPORTS

Subject: Control frame top rivets

Applicability: Pegasus Quik microlight aeroplanes up to serial number 8037.

Reason: During flight of a Pegasus Quik microlight aircraft, the top control frame knuckle on the hang bolt side rotated rearwards about the attachment rivets.

Compliance:

i) Before further flight, inspect the control frame top knuckle fitting in accordance with Mainair Service Bulletin 116 and modify in accordance with Modification 124 if necessary.

ii) Within 5 flying hours from the effective date of this MPD, modify the control frame top knuckle fitting in accordance with Modification 124 of Mainair Service Bulletin 116.

A copy of Mainair Service Bulletin 116 can be obtained from:

Mainair Sports Ltd
Unit B
Crawford Street
Rochdale
Lancashire
OL16 5NU

Tel: 01706 655134
Fax: 01706 631561
Email: flying@mainairsports.co.uk

Record compliance with this MPD in the aircraft log book.

This MPD becomes effective on 13 May 2004.

Enquiries regarding this MPD should be referred to Mrs Barratt, Certification and Approvals Department, Civil Aviation Authority, Safety Regulation Group, Aviation House, Gatwick Airport South, West Sussex, RH6 0YR. Phone: 01293 573945 Fax: 01293 573976 E-mail: jane.barratt@srg.caa.co.uk

PEGASUS AVIATION   mainair sports

SERVICE BULLETIN NUMBER 116	ISSUE 1	PAGE 1 of 2

TITLE	Quik control frame top rivets
CLASSIFICATION	The CAA have classified this bulletin as Mandatory.
COMPLIANCE	Inspection before further flight, install rivets within 5 hours
APPLICABILITY	All Pegasus Quik up to serial number 8037

INTRODUCTION -

The top control frame knuckle on the hangbolt nut side rotated rearwards about the attachment rivets in flight. The structure remained intact and a safe landing was made.

INVESTIGATION-

If the aircraft is parked wing down in windy weather, the control frame top rivets may tend to work loose, eventually allowing the knuckle to rotate rearwards by spreading the walls of the streamlined upright apart. It is better to park the aircraft into wind with the control bar tied back to the seat, as detailed in the operator's manual.

If the hangbolt is ever re-installed in the hang bracket and the control frame folded rearwards, a very large rotation load can be applied to the knuckle. The hang bolt must always be removed before folding the control frame, as detailed in the rigging instructions.

This service bulletin introduces modification M124, which is to install a second pair of identical rivets as shown in assembly drawing YQC-040 issue B overleaf near the top of the uprights which prevent the possibility of rotation of the knuckle fitting.

ACTION –

Inspection before further flight:

Grasp the top of the upright and move it forwards and rearwards, feeling for rocking movement of the top knuckle fitting in the aerofoil tube. If any movement is apparent, the assembly must be modified as detailed below before further flight.

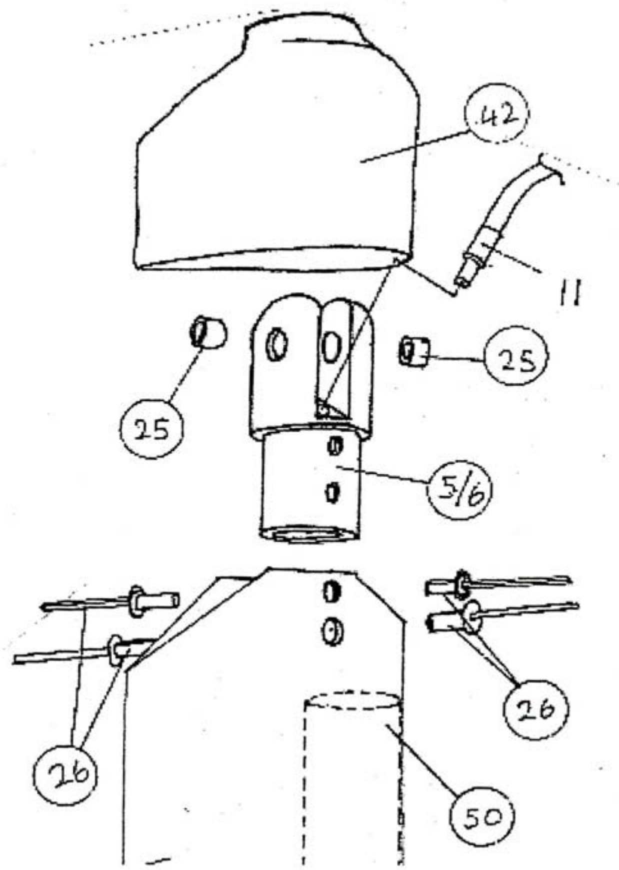
Modification 124 implementation:

Remove the wing from the trike. Remove the RH upright at the top knuckle to channel bolt. Slide off the PVC boot. Drill 4.9mm holes each side of the upright into the top fitting, 7mm below the upright top edge. Ensure the drill does not damage the trim cable. Fit 2 suppplimentary 3/16" Avdel rivets part no. FR-6-12-002. Check the rivets are properly set and that the assembly is secure. Slide the boot over the fitting and refit the uprights using new nyloc nuts. Do not over tighten the assembly. Repeat the procedure for the LH upright. Check trimmer operation and roll bracket articulation before re-rigging for flight.

DOCUMENTATION

The above actions must be entered in the aircraft technical log and "Service Bulletin 116, top knuckle rivets inspection" and "Service bulletin 116, modification 124, additional top knuckle upright rivets installed" signed by the inspector.

PEGASUS AVIATION mainair sports



Assembly drawing YQC-040 issue B showing Avdel FR-6-12-002 rivets part 26

ISSUED BY: Chief Engineer W.G.Brooks	**DATE** 11/5/04.

Contact 01672 861350 or 01706 655134
email technical@pegasusaviation.co.uk or flying@mainairsports.co.uk

Unless otherwise indicated, recommendations in this report are addressed to the regulatory authorities of the State having responsibility for the matters with which the recommendation is concerned. It is for those authorities to decide what action is taken. In the United Kingdom the responsible authority is the Civil Aviation Authority, CAA House, 45-49 Kingsway, London WC2B 6TE or the European Aviation Safety Agency, Postfach 10 12 53, D-50452 Koeln, Germany.