ACCIDENT

Aircraft Type and Registration:	Pegasus Quik, G-CCPC	
No & Type of Engines:	1 Rotax 912ULS piston engine	
Year of Manufacture:	2003 (Serial no: 7994)	
Date & Time (UTC):	1 June 2022 at 0945 hrs	
Location:	East Fortune Airfield, East Lothian	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Fatal)	Passengers - N/A
Nature of Damage:	Destroyed	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	69 years	
Commander's Flying Experience:	155 hours (of which 6 were on type) Last 90 days - 6 hours Last 28 days - 3 hours	
Information Source:	AAIB Field Investigation	

Synopsis

During start up, the engine suddenly went to a high rpm. The aircraft accelerated over the ground and became airborne with the base bar attached to the front strut. It struck the ground in a field adjacent to the airfield and the pilot died from head injuries eight days later.

It is likely that the pilot started the engine with the hand throttle open and did not free the base bar, reduce the rpm or stop the engine before the aircraft became airborne. The pilot might have survived if he had been wearing his shoulder (diagonal) harness and his helmet had been designed to protect him from rotational head injuries.

Four Safety Recommendations are made in this report. Two to the CAA to mandate the embodiment of a starter inhibitor switch on the hand throttle, and to review the exception for a shoulder strap not to be worn. Two to the British Standards Institute regarding the design of helmets used for airborne sports. Safety Actions were also taken by the BMAA, Microlight Panel of Examiners and the pilot's flying club.

History of the flight

The accident pilot was a member of the flying club at East Fortune Airfield near North Berwick, where he kept his aircraft. On the day of the accident, he arrived at the airfield at approximately 0815 hrs and discussed with several members of staff his intended flight in the local area and cosmetic repairs he planned for his aircraft. There had been some lower

cloud earlier in the morning, but the bases had lifted and the weather was suitable for the planned flight, with light winds from the north-east.

The flying club has multiple CCTV cameras from which recordings show the pilot putting on a helmet and entering the aircraft, which was parked on a grass area immediately in front of the club hangar. The recordings, one of which included audio, showed four engine start cycles and on the fifth cycle the engine started and immediately accelerated to a high rpm. This was at approximately 0940 hrs. Club staff, who were alerted by the sudden "abnormal" sound of the engine, ran out of the hangar and saw the aircraft accelerating rapidly over the grass and collide with a runway marker sign. The collision caused the aircraft to bounce as it crossed the taxiway and become airborne (Figure 1).

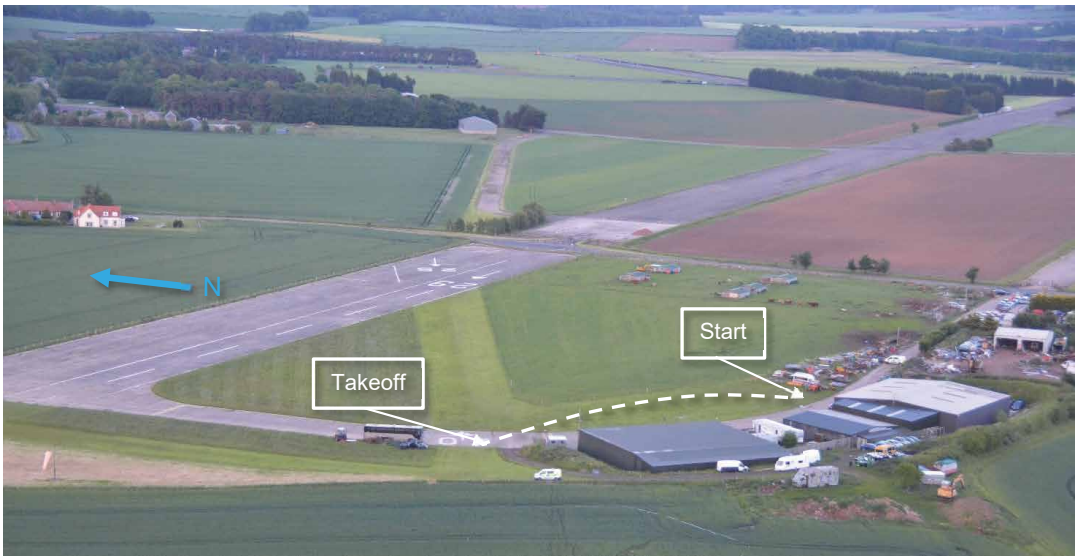


Figure 1

Approximate path of aircraft across the grass area (image used with permission)

The aircraft entered a wide left turn, climbing above the height of the hangars, before descending out of sight in a left-wing low attitude behind a hangar at the south-west corner of the airfield. Witnesses described hearing the engine "high revving" up to the point of impact with the ground and observed a "cartwheeling" wingtip just visible behind the hanger.

Flying club staff arrived quickly at the aircraft and found the pilot secured in his seat by the safety harness lap strap; he was not wearing the diagonal shoulder strap. The pilot's helmet was still fitted, although the face visor had become detached. He was breathing but unresponsive and apparently unconscious.

An ambulance and the fire service attended the scene, followed by a doctor and paramedic. The pilot was released from his lap strap and the wreckage moved in order to provide medical assistance. The pilot was transferred to hospital by ambulance but died eight days later as a result of his injuries.

Accident site

Ground marks

Marks made by the aircraft's wheels as they travelled across the grass stretched from where the aircraft was parked on the grass in front of the hangar to the edge of the concrete taxiway. The marks indicate that the aircraft travelled in a left arc, missing a wire fence approximately 30 m in front and perpendicular to the direction the aircraft was parked. As the aircraft travelled towards the concrete taxiway, its right main landing gear struck a runway stop sign concreted into the ground at the edge of the taxiway (Figure 2) before becoming airborne.

Figure 2

Runway stop sign struck by aircraft

Accident site

The aircraft came to rest in a field to the west of the airfield. Ground impact marks show that the aircraft's left wheel struck the ground first followed by the left-wing tip and the front of the trike. The aircraft cartwheeled and bounced before stopping approximately 28 m from the initial impact point. The trike came to rest on its right side with the pylon still attached to the wing (Figure 3).

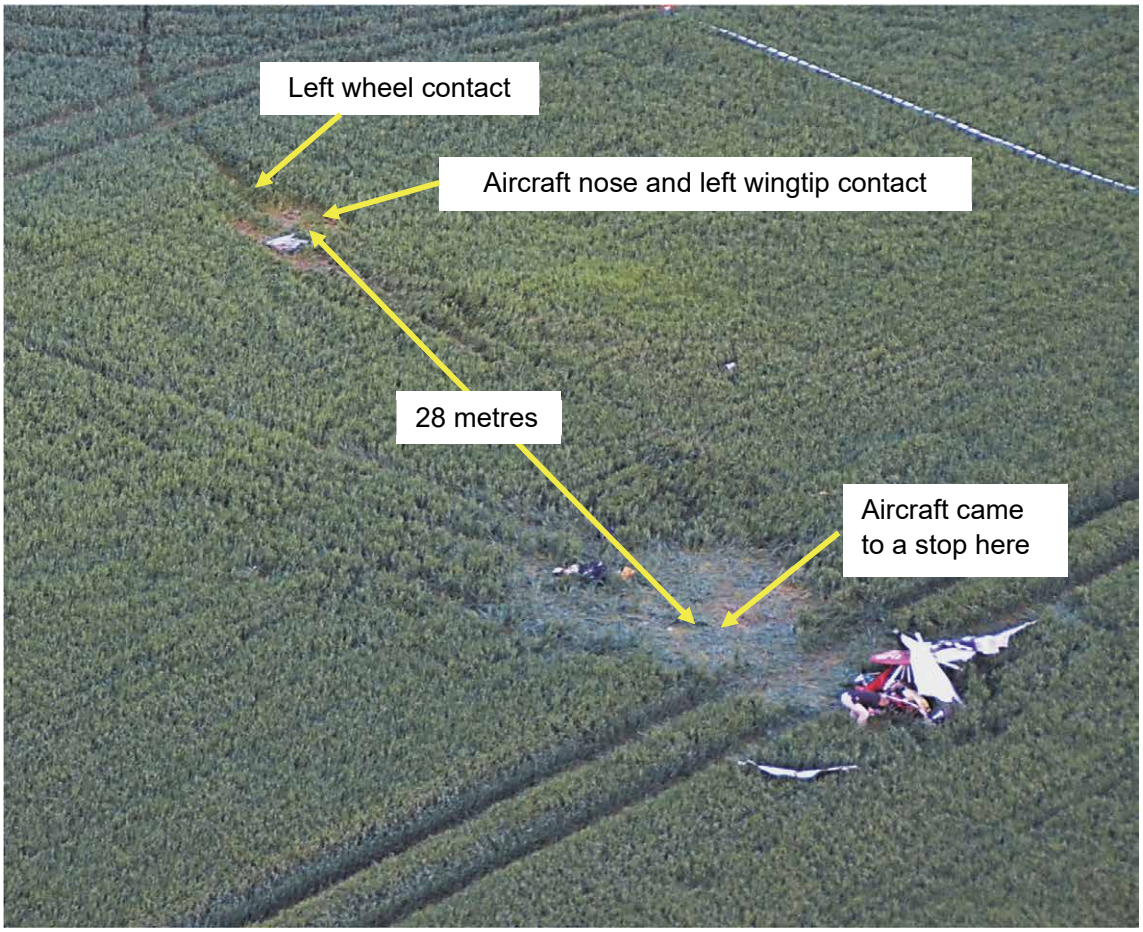


Figure 3
Accident site

Pilot information

The pilot held a UK National Private Pilot's Licence issued in 2018, and had flown 155 hours, of which 6 hours were in G-CCPC. His microlight rating was valid until the end of August 2022. He purchased G-CCPC in March 2022 and conducted differences training with an instructor on 20 March 2022.

Medical

Post-mortem report

The pathologist found that the pilot died from a severe rotational head injury sustained in the accident. There was no indication of medical impairment or incapacitation of the pilot before the aircraft struck the ground.

Pilot medical declaration

The pilot submitted a Pilot Medical Declaration on 1 August 2017, which was valid until May 2023.

Aircraft description

General

G-CCPC was a Pegasus[1] Quik flexwing microlight powered by a Rotax 912 ULS piston engine, which has a maximum rpm of 5,800. Significant features of the aircraft are shown in Figure 4.

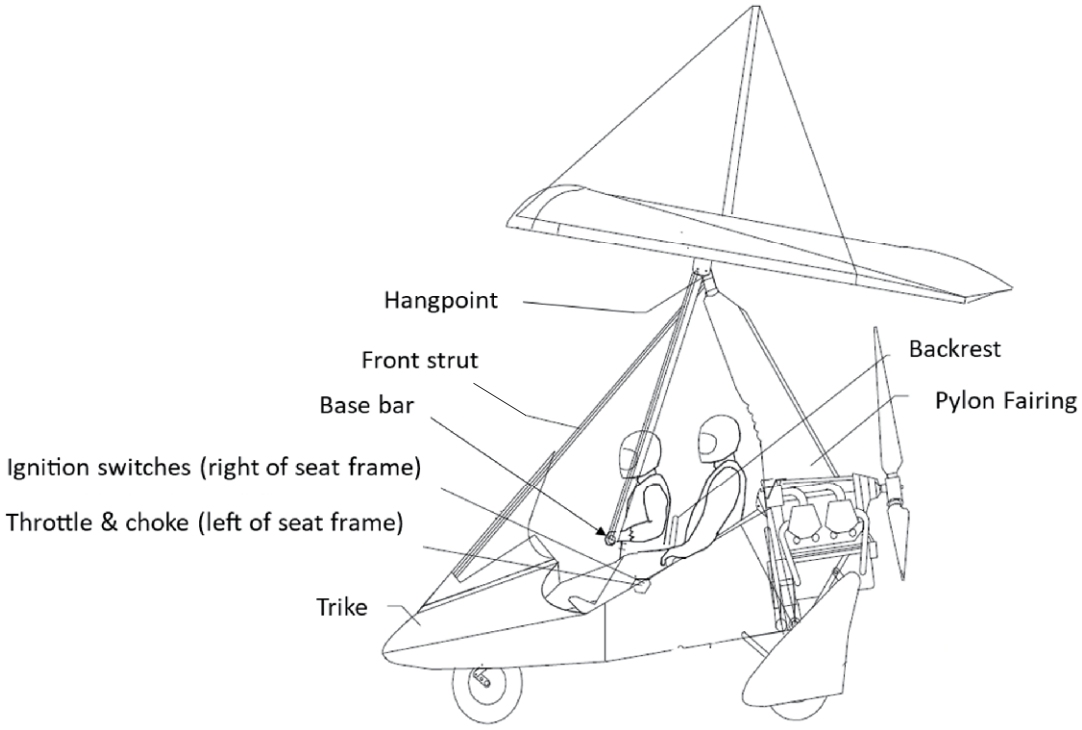


Figure 4
Significant features of the Pegasus Quik aircraft

Certification

The Pegasus Quik was certified by the CAA against British Civil Airworthiness Requirements (BCAR) Section S, Issue 3, '*Small Light Aeroplanes*', on 6 December 2002. The CAA Microlight Type Approval Data Sheet (TADS) Number BM66 applies.

Aircraft brakes

The aircraft is fitted with disc brakes on the two mainwheels, which can be operated by a hand lever located in the left footwell or a brake pedal located above the left footrest on the nosewheel steering bar (Figure 5). The aircraft does not have differential braking.

Footnote

[1] The current manufacturer is P&M Aviation, formed from Pegasus Aviation and Mainair Sports in 2003.

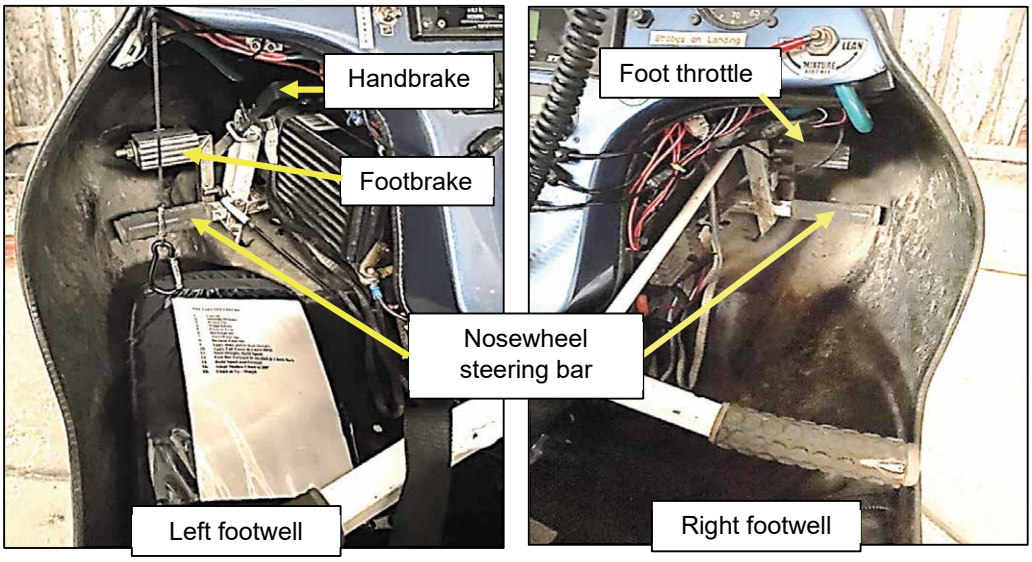


Figure 5

Location of footbrake, handbrake, foot throttle and nosewheel steering bar

Engine controls

The engine rpm is controlled by either a hand or foot throttle. The hand throttle is located on the left of the seat frame, and the foot throttle above the right nosewheel steering bar. Each of the controls are attached by Bowden cables, through a 'splitter box' to each of the two carburettor throttle linkages. The splitter box is designed to allow either the hand or foot throttle control to adjust the engine speed. If one of the controls is moved to fully open (maximum rpm), movement of the other control will have no effect as the engine is already operating at its maximum speed.

The foot throttle is the primary engine speed control and when foot pressure is removed the engine reverts to idle. The hand throttle, however, is a friction damped lever which allows the pilot to adjust the engine rpm. Unlike the foot throttle, once set the hand throttle will remain in this position until readjusted.

Manufacturer's hand throttle modification M112

There have been reported instances of the engine on the Pegasus Quik suddenly increasing to maximum rpm during engine start. At a high rpm, the aircraft brakes are not capable of holding the aircraft stationary and without the pilot taking immediate action the aircraft can quickly accelerate and reach flying speed. In 2003, the manufacturer issued optional modification M112[2] - '*Safety starter switch in hand throttle,'* that introduced a microswitch in the hand throttle housing to prevent the engine from starting if the throttle lever is not in the OFF (closed) position. The modification was installed as standard on all Quik aircraft manufactured from 2003 unless the owner chose not to have it installed.

Footnote

[2] CAA Microlight Type Approval Data Sheet (TADS) No: BM 66 Issue 9 Annex B '*Approved Optional Modifications*'.

Seat safety harnesses

The rear seat was equipped with a 4-point safety harness consisting of two shoulder straps and a lap strap. The front seat was fitted with a 3-point safety harness consisting of a lap strap and one manually adjustable diagonal shoulder strap.

Pilot's helmet

The pilot's helmet was marked with the British Standard Institute (BSI) Standard, BS EN 966:1996 '*Helmets for Airborne Sports.'*

The helmet had a hard outer shell of Glass Reinforced Plastic with an inner trauma lining[3] and a foam backed nylon comfort layer. It was equipped with integrated ear shells containing earphones and had a microphone boom attached to the left shell. Attached to the front of the helmet was a clear visor that could be locked in the up or down position. On the bottom edge of the visor was a neoprene draft-proof chin guard.

Last aircraft and engine maintenance

The aircraft had been extensively repaired following an accident on 31 July 2020, and both the aircraft and the engine had passed their post-repair Permit to Fly inspections on 28 February 2022. This was followed by a successful check flight on 1 March 2022. The owner had flown the aircraft five times between 20 March 2022 and the date of the accident without incident.

Recorded information

Engine monitoring device

The microlight was not fitted with any devices that recorded the flight path and there was no active transponder on board. It was fitted with an engine monitoring device which monitors the engine parameters, recording the maximums reached in successive six-minute periods. It also captures any parameter exceedances. The unit's data was downloaded and indicated that the engine had operated for a total of 756.5 hours. As the accident flight was under six minutes there was only one entry, which showed that the maximum engine speed reached was 4,880 rpm and no exceedances had been triggered during the short flight.

The unit also retains the last time an alarm level for each parameter was reached; the last alarm was more than 150 operating hours prior to the accident flight and not considered relevant to this investigation.

CCTV

There were a number of CCTV cameras installed at the airfield and one at a neighbouring business premises. Between them they recorded the flight from the initial attempted starts though to the final impact. The accident site was captured from a camera where a building obscured the ground contact of the aircraft. One of the on-airfield cameras included audio,

Footnote

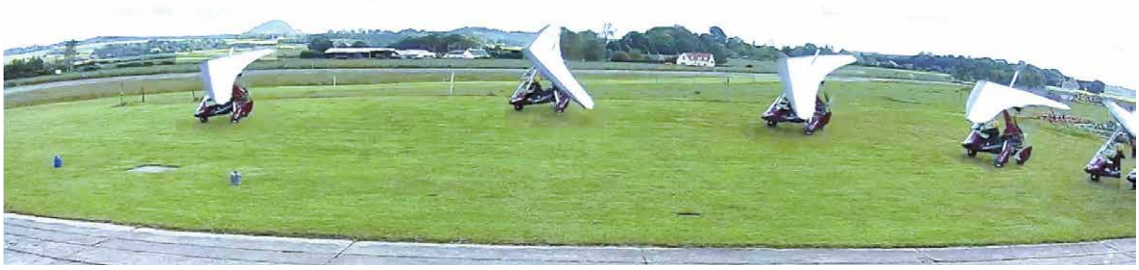
[3] The trauma liner was designed to absorb forces caused by direct blows to the helmet thereby providing protection from skull fracture injuries.

which corroborated the maximum engine speed recorded by the engine monitoring unit. The peak was reached on startup and dropped to approximately 4,630 rpm over the next few seconds.

The CCTV shows the base bar against the front strut when the aircraft was parked and it remained in this position in all the subsequent CCTV images as it travelled over the ground. After entering the cockpit, the pilot made various adjustments and then attempted to start the engine. The start was not successful on the first attempt. The quality of the recordings was not sufficient to accurately track the movement of the pilot's hands on the engine controls. However, when the engine started on the fifth attempt, it appears that the pilot moved his left hand from the instrument panel to the left side of the pod in the vicinity of the hand throttle and choke. The aircraft immediately started to move. The pilot then moved his left hand to the base bar within two seconds of the aircraft starting to move, followed about a second later by his right hand. The microlight accelerated in a curved path with the base bar against the front strut and the wing at a high angle of attack. The microlight struck a runway marker sign at the edge of the taxiway, bounced and became airborne with the wing displaced to the left.

Figure 6 shows cropped snapshots from the CCTV footage overlaid to show the aircraft position at one second intervals in each camera view. The time from the engine starting to the aircraft becoming airborne was approximately nine seconds

a) Start



b) Curved ground track

c) Takeoff

Figure 6

Cropped CCTV snapshots, overlaid to show the aircraft position at one second intervals in each camera view. There is overlap between the period covered by image b) and the other two sequences.

After taking off, the microlight flew in a low-level, tight, left turn (Figure 7). The images are not clear enough to determine whether the base bar was against the front strut after takeoff.

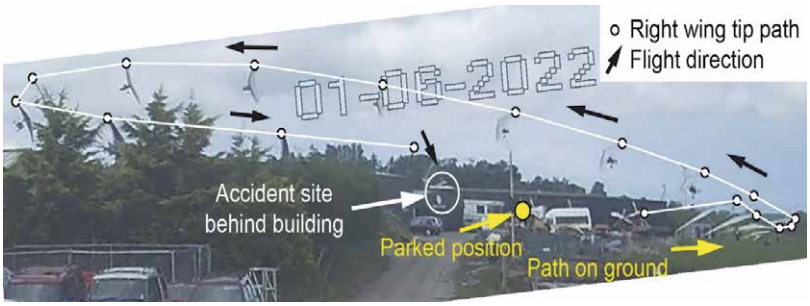


Figure 7

Cropped CCTV snapshots, rotated to horizontal,
and overlaid to show the aircraft position at one second intervals

The CCTV indicates that a few seconds prior to the final impact, the aircraft had a groundspeed of between 54 kt and 63 kt. The audio recording on the CCTV of the engine noise before impact was analysed. After taking into account the increased tone of the audio due to the aircraft travelling towards the microphone, the engine speed was slightly higher than during the ground run, which would be expected with a higher airspeed.

Prior to impact the microlight had a significant left bank angle.

Aircraft examination

On site examination of wreckage

Both ignition switches located on the right side of the seat frame were found in the ON position with the switch guard bent over the switches preventing them from being moved. The friction-damped hand throttle lever located on the left side of the seat frame was positioned slightly forward of OFF. Located directly below the hand throttle was the choke lever which was selected to OFF (Figure 8).

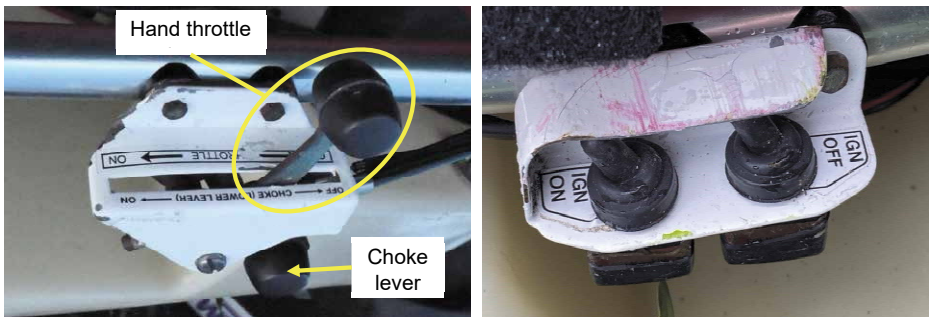


Figure 8

Hand throttle and choke levers (left), ignition switches (right)

The front of the trike's base tube had been disrupted at the rear steering bar attachment point. The nosewheel, front steering fork, foot throttle, and foot brake were intact and connected to the broken section of the base tube by pipes, wiring and cables.

The throttle and brake cables remained connected to their respective foot pedals and routed to their systems in the aft section of the trike. When pressure was applied to the footbrake, both main disk brakes operated and the footbrake returned to the OFF position when pressure was released.

A nylon strap was attached to the front strut which was used to tether the base bar when the aircraft was parked. The strap was found to be hanging loose from the strut and not tethered to the base bar.

Hand and foot throttle operation

When the hand throttle and the foot throttle were operated in turn, each one correctly and simultaneously operated both carburettors' throttle linkages. The manufacturer's optional modification M112 was not installed.

Seat harnesses

The rear seat shoulder straps were found disconnected from their lap strap and tied around the pylon. The rear seat lap strap had been adjusted so that it was tight against the rear seat cushion. The front seat diagonal shoulder strap had been tightened between the pylon and the base tube and routed under the seat cushion to prevent it from fouling the propeller during flight (Figure 9). In this configuration, the shoulder strap could not have been worn by the pilot during the flight.

Figure 9

Front seat diagonal shoulder strap positioned as found at the accident site

Requirements for the fitment and use of safety harnesses

British Civil Airworthiness Requirements Section S - Small Light Aeroplanes

BCAR Section S[4] contains the following requirements for the fitment of safety harnesses:

> ***'Emergency Landing Conditions***
>
> ***S 561 General***
>
> *a) The aeroplane, although it may be damaged in emergency landing conditions, must be designed as prescribed in this paragraph to protect each occupant under those conditions.*
>
> *b) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a crash landing when proper use is made of belts and harnesses provided for in the design, in the following conditions:*
>
> ***S 785 Seats and safety harnesses***
>
> *d) Each safety harness must be attached so that the pilot is safely retained in his initial sitting or reclining position under flight and emergency landing accelerations. (See AMC S 785 d).'*

Acceptable Means of Compliance and Interpretive Material (AMC) S 785 d) refers to Section S 1307, which contains what the CAA described as a 'configuration specific provision' for weight-shift controlled aircraft to be provided with only a lap strap for front seat occupants:

> ***'S 1307 Miscellaneous equipment***
>
> *a) All occupants must be provided with a lap strap and upper torso restraint, capable of restraining the wearer against the forces resulting from the accelerations prescribed for emergency landing conditions in S 561, and AMC S 1307 a), except that only a lap strap need be provided for front seat occupants of a weight-shift controlled aircraft.'*

The CAA informed the AAIB that the 'configuration specific provision' was first introduced in Issue 4 of BCAR Section S, dated 21 December 2007. The CAA could not positively determine why the configuration specific provision had been added but reported that it was:

> *'…highly likely that it was introduced to reflect the fact that in order to effectively control a weight-shift microlight, the pilot(s) need adequate upper body movement. There may also be consideration towards being able to operate the control bar from both seating positions if there was a student under instruction'.*

Footnote

[4] CAP 482: British Civil Airworthiness Requirements Section S – Small Light Aeroplanes, Issue 7, dated 19/12/2018 [accessed June 2023]

The CAA added that proposed amendments to Section S would have gone through the Section S Working Group comprised of industry experts and CAA specialists for approval. The CAA further stated that:

> *'We believe the key word in this requirement* [S 561] *is 'reasonable chance' and believe that when you consider the need for the pilot to effectively control the aircraft in normal operation, a properly worn lap belt is a logical solution in combination with guidance and advice for occupants to consider the use of safety helmets.'*

Previous AAIB Safety Recommendation on use of shoulder harnesses

In the report into the fatal accident involving the flexwing microlight G-STYX[5] in 2004, where neither the pilot nor the passenger were wearing the upper torso restraints fitted to the aircraft, the AAIB made the following Safety Recommendation on 15 November 2005:

> **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.

The CAA responded that:

> *'The CAA have reviewed the regulatory policies in both these areas as they apply to microlight aircraft. The requirements for seat belts and harnesses, and for briefings and instructions for passengers regarding their use, are contained in the Air Navigation Order and are believed to be sufficiently robust.'*

The G-STYX report also referenced a previous accident, G-MZCN in 2001[6], where the pilot was fatally injured because the passenger was not wearing an upper body restraint.

Air Navigation Order requirements

A Part 21 aircraft is defined by the CAA as an aircraft that was previously managed by EASA and considered as EASA Types. They are regulated under UK Regulation (EU) 2018/1139, also known as the UK Basic Regulation, and its implementing regulations cover airworthiness, operations and flight crew licensing. Aircraft operating on BMAA and LAA Permits to Fly are classified as non-Part 21 aircraft and are managed nationally under the Air Navigation Order[7] (ANO).

Schedule 5 of the ANO applies to equipment required to be fitted to non-Part 21 aircraft and pre-dates the configuration specific provision in BCAR S 1307. Schedule 5 provides

Footnote

5 Aircraft Accident Report 2/2005 - Pegasus Quik, G-STYX 21 August 2004 - GOV.UK (www.gov.uk). [Accessed June 2023]

6 Aircraft Accident Report 6/2001 - Mainair Blade 582, G-MZCN 13 January 2001 - GOV.UK (www.gov.uk). [Accessed June 2023]

7 The Air Navigation Order. UK Statutory Instruments 2016 No 765.

the legislative basis for the incorporation of the 'configuration specific provision' into BCAR Section S, issue 4. With regards to safety harnesses, it states:

> *'… a flying machine must be equipped with a seat belt with an upper torso restraint system on each flight crew seat, having a single point of release.'*

However, Schedule 5 also states that '*the CAA may permit a flying machine not to be equipped'* with this item of equipment.

The CAA informed the AAIB that in addition to flexwing microlights, examples of aircraft where the flight crew seats were permitted to be provided with only a lap strap included two types of fixed wing aircraft that ceased being manufactured before 1980.

Operator's Manual

The manufacturer's Operator's Manual[8] contains the following notes and warnings regarding the use of safety harnesses and seat belts:

> ***'1.5. SAFETY HARNESSES***
>
> *P&M aircraft are equipped with a 3 point harness for the pilot, and a four point harness for the passenger. These should be worn at all times.*
>
> ***2.7. SECONDARY STRUCTURES AND SYSTEMS - SEAT BELTS***
>
> *Lap straps are provided for both occupants. In addition, a single diagonal shoulder restraint is provided for the front seat and twin shoulder restraints for the rear.*

> ***7.2. STRAPPING IN***
>
> *Lap straps should be adjusted snugly across the hips to reduce tendency for either occupant to slide forwards under the strap. Shoulder straps should be adjusted with a little slack to allow any necessary movement during flight and to ensure that the lap straps remain in place without slipping upwards in the event of accident.'*

Footnote

[8] Quik Range of Aircraft Operating Instructions Issue 3 dated 4 October 2012.

Use of the safety harness shoulder strap during training

Instructors did not actively encourage the pilot to wear the shoulder strap of the safety harness during his training for two reasons. Firstly, they believed that wearing the shoulder strap could restrict the movement of the pilot's body and prevent him from exercising full control of the base bar. It was believed that if the strap was adjusted to leave a little slack, in accordance with the manufacturer's guidance, it was prone to slip off the shoulder and could present a snagging hazard for the pilot's arms. Secondly, it could prevent the instructor in the rear seat from exercising full control of the base bar by restricting their reach during demonstrations or in the event of having to take control.

Use of the safety harness shoulder strap in the wider flexwing community

Interviews conducted with flexwing pilots, research and consultation with the BMAA revealed that not using the shoulder strap appeared to be a common operating culture in the flexwing community. This was based on a general belief that the perceived inconvenience of wearing the strap and the potential for restricting upper body movement presented a greater hazard than not wearing it. The fact that BCAR Section S contained a 'configuration specific provision' allowing flexwing microlights to be fitted with only a lap strap for front seat occupants was stated as contributory to this culture: if it was not mandated that shoulder straps should be fitted, pilots did not feel obliged to use them even when they were. Videos and images of flexwing microlights, freely available on the internet, showed some occupants not wearing the installed shoulder strap for the 3-point harness in the front seat and the 4-point harness in the rear seat. These images included flexwing aircraft equipped with inertia reel shoulder straps.

Guidance provided to flexwing instructors on the use of safety harnesses

At the time of the accident, there was no guidance provided to flexwing instructors on the recommended use of safety harnesses for the occupant of the front seat during training flights. To address this issue, the Microlight Panel of Examiners[9] published the following guidance in their Instructor and Examiner Bulletin (01/2022), dated December 2022. The full document is at Appendix A.

> ***'2. USE OF DIAGONAL RESTRAINTS IN FLEXWINGS***
>
> *There is a worrying trend developing of pilots not wearing diagonal restraints when fitted to flexwing aircraft.*
>
> *This may be because students see instructors not wearing them and therefore consider them not important.*
>
> *A reminder that any restraints fitted to an aircraft must be worn by a pilot in accordance with the requirements in the aircraft's POH and whatever restraints are fitted must be used.*

Footnote

[9] The Microlight Panel of Examiners are appointed and overseen by the CAA. The Panel, in turn, appoint flight examiners.

Instructors do not have to wear the diagonal harness if they assess it will interfere with their ability to remain safely and effectively in control.

Student's must be left in no doubt that this is an exception purely for instructors whilst conducting flying training, and examiners whilst conducting GST[10]s.

Whilst conducting GSTs the candidate must demonstrate to the examiner the correct use of these restraints, even if the examiner is not wearing them for safety considerations.'

Safety Actions taken by the BMAA

Following this accident, the BMAA took the following Safety Actions:

a) The guidance published in the Microlight Panel of Examiners' bulletin on the use of diagonal restraints in flexwings will be incorporated into the '*Instructor and Examiner Guide'* published by the BMAA at the next appropriate amendment.

b) A 'Belt-Up' safety campaign was launched in May 2023[11] promoting the safe use of safety harnesses in microlight aircraft, including a campaign poster, an article in the membership magazine. A video demonstrating correct inspection and fitting techniques is planned to be released in early 2024.

Royal Air Force Centre of Aviation Medicine analysis

The RAF Centre of Aviation Medicine (RAFCAM) assisted the investigation in understanding the relationship between the aircraft impact forces and the injuries sustained by the pilot. As part of this analysis, impact testing was carried out on the same type and model of helmet worn by the pilot. RAFCAM reported that:

'The evidence from the helmet damage coupled with the post-mortem findings indicated that the pilot had sustained a severe blow to the right side of his head which ultimately resulted in his demise.'

In describing the pilot's use of only the lap strap:

'The lack of upper torso restraint, provided by just the lap straps being connected, would have permitted the pilot's upper torso and head to flail forward excessively. This increased flailing would have resulted in the pilot more likely contacting the ground and cockpit structures during the impact, thereby increasing the severity of his head injuries. If the pilot had had his shoulder strap fitted it is likely that his forward and sideward flailing would have been lessened. It is then possible that this reduction in flailing could

Footnote

[10] General Skills Test.
[11] The British Microlight Aircraft Association/belt-up-safety-campaign [accessed June 2023]

have reduced the severity of the head injury as the impact velocity of his head with the ground and cockpit structures would have been reduced. As a consequence of a reduction in the head impact velocity the outcome of the accident may have been altered such that he may have survived. However, it is difficult to quantify the magnitude of the reduction in impact velocity achieved by limiting flailing of his upper torso.'

With regard to the helmet worn by the pilot:

'Although the pilot was wearing a helmet which was designed and conformed to the appropriate helmet standard: CSN EN 966 - Helmets for Airborne Sports, it is highly likely that the head impact energy and velocity were far in excess of those which the EN Standard dictates airborne sports helmets should attenuate.'

Survivability

Over the previous six years, the AAIB investigated seven flexwing accidents where the use of seat harnesses had been recorded in the accident reports. Where the full seat harness was worn, the occupants were more likely to sustain minor or no injuries. In three of the accidents where the front seat pilots were not wearing the shoulder strap, the pilots suffered serious or fatal injuries. The results of the level of injuries sustained in these seven accidents is summarised in Table 1.

Number of accidents	Harness worn by occupants	Injuries
1	All occupants wearing harness	None
2	All occupants wearing harness	Minor
1	All occupants wearing harness	Serious
2	No harness worn	Serious
1	**No harness worn**	**Fatal**

Table 1

Flexwing accidents over a six-year period where the use of seat harnesses had been recorded in AAIB reports

Comparison of head injuries sustained in two similar flexwing accidents

The AAIB investigated two similar accidents to Pegasus Quik aircraft that both occurred at Harringe Court Farm airstrip; one occurred on 6 August 2022 (G-CGRR) and the second on 14 May 2023 (G-CDPD)[12]. In both accidents the aircraft veered on landing and rolled onto their side (Figure 10).

Despite the similarities between the accidents, the injuries sustained by the pilots were substantially different. The pilot of G-CGRR, who was only wearing the lap strap and not

Footnote

[12] Pegasus Quik, G-CGRR 04-23 published 3 May 2023 and Pegasus Quik G-CDPD published 10 August 2023.

the shoulder strap, received serious facial injuries when his head contacted parts of the structure and the ground. Whereas the pilot of G-CDPD, who was wearing the full three-point harness, received only minor injuries.

Figure 10

Pictorial comparison of G-CGRR (left) and G-CDPD (right)

Safety Helmets

The CAA makes no requirement for sports aviation pilots to wear safety helmets, nor do they set standards for airborne sports helmets. Standards for airborne helmets are published by the BSI and the European Conformité Européenne (CE).

The pilot's helmet was marked with the BSI Standard BS EN 966:1996[13] '*Helmets for Airborne Sports.'* BS EN 996:1996 had two sub-categories: '*Helmets for paragliding and hang gliding (HPG)';* and '*Helmets for flying in ultra-light aeroplanes (UL)*.' The pilot's helmet was marked with UL. However, within the UK there is no defined ultra-light aeroplane category, instead sports aircraft such as G-CCPC are defined in Schedule 1 of the ANO as microlights, which are aircraft that can have a Maximum Takeoff Mass (MTOM) up to 600 kg with a stall speed, or minimum steady flight speed, not exceeding 35 kt CAS at MTOM.

Accidents that involve an oblique impact to the head can cause rotational motion of the head and brain. Existing research into brain injuries suffered during transport accidents, shows that rotational motion of the head produces a significantly greater risk of brain damage than the injuries sustained from direct frontal, vertical or lateral impacts. Currently the European

Footnote

[13] This Standard has been superseded by BS EN 966: 2012 '*Helmets for Airborne Sports*' which still contains the HPG and UL categories and the same test criteria.

and British standards for airborne sports helmet testing does not include the helmet's response to oblique impacts. Rotation protection systems are available for helmets used for cycling, climbing, construction, horse riding, motorsports and winter sports[14]. RAFCAM's assessment of the pilot's helmet was that it did not incorporate protection from rotational head injuries.

Compass location

On G-CCPC, the compass had been relocated from the top of the cockpit coaming and mounted on the front strut directly in front of the pilot. This location made the compass easy to read and provided space to mount additional avionic units on the cockpit coaming. It was noted that on other similar flexwing aircraft at the flying club, the compass was also mounted on the front strut.

Where equipment is mounted on the front strut of flexwing aircraft, and the shoulder strap is not worn, there is an increased risk of the front seat occupant sustaining head injuries in an accident.

Microlight training

Obtaining a National Private Pilot Licence

To obtain a National Private Pilot Licence (NPPL) with a microlight class rating a pilot must complete a training course with a CAA certified flight instructor entitled to instruct on microlights. Training must follow the UK NPPL microlight syllabus published by the BMAA. Once qualified, pilots must undertake at least one hour of flying training in a 24-month period to revalidate their licence.

The pilot of G-CCPC completed his NPPL training in August 2018 and had flown with a CAA certified instructor in September 2020 and March 2022.

Starting the engine

To start a Pegasus Quik engine, instructors at the club taught the following technique:

- Maintain the right hand close to the ignition switches on the right side of the cockpit, ready to select them OFF to shut down the engine.
- The left hand operates the starter button on the left side of the instrument console and can be used to adjust the choke on the left side of the cockpit if required.
- The Quik wing is too short to rest on the ground and can be moved by the wind, potentially overturning the trike. To prevent this, the left arm can support the base bar while operating the starter. Alternatively, to free the left arm the base bar can be tethered to the front strut using a nylon strap.

Footnote

[14] Mips - Safety for helmets at https://mipsprotection.com [accessed 29 June 2023].

The pre-start checklist includes a step to check that the hand throttle is fully closed and that the right foot is clear of the foot throttle. When starting an engine from cold, students are taught to increase the engine oil pressure by turning the engine over twice, in five second bursts, with the ignition switches turned OFF and the choke closed. The choke is then opened as required for subsequent engine start cycles.

This start procedure and the guidance taught by the club was the same as provided in the manufacturer's Operator's Manual.

Starting with a flooded engine

If during the start cycle the engine has been fed with an excessively rich air-fuel mixture, the engine will not start and is considered to be 'flooded'. The BMAA advised that the following technique can be used to clear a 'flooded' engine prior to starting:

- Close the choke.
- Open the hand throttle to a high setting (or use the foot throttle in types where a safety starter microswitch is fitted in the throttle quadrant).
- Press the starter button.
- Be prepared to close the hand or foot throttle when the engine catches and turns over.

This technique to start a flooded engine was recognised, but not taught by the instructors at the club as they did not consider opening the hand throttle to a high setting to be a safe action. They taught that the engine should be cranked with the choke fully closed and some foot throttle applied until the engine cleared and started. This way the throttle setting could be easily reduced by lifting the foot off the foot throttle. It could not be determined if the pilot was aware of the technique described by the BMAA

Neither the engine manufacturer, nor the aircraft manufacturer's Operator's Manual contained specific advice on clearing a flooded engine.

Training for aircraft systems failures

The microlight training syllabus covers various system failures, including a stuck throttle and brake failure which is taught in lesson 16e[15], before a student is sent solo. Instructors at the club conducted these failure scenarios as a 'discussion' with students and did not simulate the malfunctions in an aircraft. The '*Microlight Instructor and Examiner Guide',* published by the BMAA, did not provide guidance on how instructors should conduct this lesson.

To assist microlight instructors and examiners in the conduct of training and testing for system failures, the Microlight Panel of Examiners published guidance on the following topics in their Instructor and Examiner Bulletin (01/2022), dated December 2022. This will

Footnote

[15] '*Syllabus of Training for the National Private Pilot's Licence for Microlights',* approved by the CAA and published by the BMAA,

be incorporated into the '*Instructor and Examiner Guide*', Section 4, Lesson 16e – System Failures:

> Microlight instructors and examiners will include the following content in flying training and testing:
>
> - Preparation for unexpected situations and emergencies.
> - Conduct of aircraft checks.
> - Student response to unintentional mishaps and emergencies while on the ground and in flight.
> - Preventative actions which must be incorporated into daily checks and routines, including aircraft daily inspections, advice on the positioning of the base bar, and aircraft starting.

Safety actions taken by the flying club

To provide realistic training for pilots in the handling of system malfunctions, the flying club took the following Safety Actions:

> The flying club:
>
> - Published a 'Procedures Reminder' to club members, emphasising the following:
>   - The importance of the engine start checks to ensure the aircraft is configured correctly.
>   - Keeping fingers on the ignition switches during start to ensure the engine can be stopped immediately if it runs away.
>   - The importance of checking the hand and foot throttles during the daily inspection to ensure correct function.
> - Require, prior to first solo, students to complete the following training:
>   - Simulate an engine runaway during startup. To be conducted on the runway requiring the student to switch off the ignition switches to shut down the engine.
>   - Simulate a stuck throttle and a brake failure. Both scenarios to be conducted independently on either the runway or taxiway and require the student to steer the aircraft in a safe direction before switching off the ignition switches to shut down the engine.
> - Require the engine runaway, stuck throttle and brake failure, exercises to be included in biennial training flights for licence renewal.

Aircraft manufacturer's Service Bulletin Number 159

As a result of this accident the aircraft manufacturer issued Service Bulletin (SB) Number 159[16] that reclassified the starter inhibitor switch as a manufacturer's compulsory modification and provided instructions for it to be embodied on existing aircraft.

The SB recommended a start procedure which included the following step before the engine is turned over:

> *'Undo any parking strap, pull the control bar in.'*

With regard to the use of the harness, the SB stated:

> *'A pilot diagonal strap and passenger twin shoulder harness has been provided on all P&M aircraft since 1990. Correctly adjusted, the harness does not compromise full and free control inputs.'*

Analysis

Overview

The accident sequence began when the engine started and went immediately to a high rpm, causing the aircraft to accelerate across the ground and become airborne while the base bar was still tethered to the front strut. The pilot, who was not wearing the diagonal shoulder strap that formed part of his harness, died from a rotational head injury sustained when the aircraft struck the ground.

Medical

The post-mortem examination determined that there was no indication of medical impairment or incapacitation of the pilot before the aircraft struck the ground.

Base bar tethering

It is common practice on the Quik for the base bar to be tethered to the front strut when the aircraft is parked. CCTV evidence shows the base bar on G-CCPC located against the front strut as the aircraft accelerated over the ground and became airborne. The attitude and track of the aircraft during the short flight are also consistent with the base bar remaining in this position.

Whilst the nylon strap, that is fixed to the front strut, was not looped around the base bar when examined by the AAIB at the accident site, it was possible that the emergency services had unstrapped it while attending to the casualty.

The investigation concluded that the base bar was tethered to the front strut during the flight and was a factor in this accident.

Footnote

[16] Pegasus Sport Aviation Ltd Service Bulletin Number 159, issued on 22 September 2023.

Engine starting

The first two engine turnovers were likely to have been carried out to increase the engine's oil pressure before attempting to start the engine from cold. The following two attempts were unsuccessful and may have convinced the pilot that the engine was flooded.

It is probable that in attempting to clear the flooded engine, on the fifth turnover the pilot set the hand throttle to a high rpm setting. Once the engine started and suddenly went to a high rpm, he did not reduce the throttle to idle nor switch off the ignition switches.

The engine start procedure in the manufacturer's Operating Manual advises pilots to keep their right hand close to the ignition switches to enable them to quickly cut the engine power if necessary. Had the pilot selected the switches to OFF he could have arrested the forward motion with the aircraft brakes. This was the procedure taught to the pilot by the club instructors as part of a stuck throttle scenario. However, the procedure was only discussed and not practised in the aircraft. There was no opportunity for him to experience the action of locating and switching off the ignition switches with the aircraft in forward motion. There was also no requirement for this skill to be demonstrated during biennial training, nor during instructor validation and revalidation training. This lack of practical experience in responding to a stuck throttle is considered to be a factor in this accident.

Since this accident, the Microlight Panel of Examiners has taken action to improve training and testing of pilot's response to system failures.

Hand throttle modification

As a result of reported instances of the engine on the Pegasus Quik suddenly increasing to maximum rpm during engine start, in 2003 the manufacturer introduced optional modification M112, which prevents the engine starting if the hand throttle is not in the OFF position. Had the modification been fitted to G-CCPC then this accident would not have happened.

Following this accident, the aircraft manufacturer prepared SB 159 to classify the starter inhibitor switch as a compulsory modification on their range of flexwing aircraft equipped with an electric starter. To prevent a reoccurrence of this type of accident, the following Safety Recommendation is made to the CAA to require the starter inhibitor switch to be fitted to all electric start, in-service Pegasus Sport Aviation Ltd flexwing aircraft:

Safety Recommendation 2023-037

It is recommended that the UK Civil Aviation Authority issue a Mandatory Permit Directive to mandate Pegasus Sport Aviation Ltd Service Bulletin 159, to embody a Starter Inhibitor Switch on all electric start, in-service Pegasus Sport Aviation Ltd flexwing aircraft.

Use of shoulder straps

The 'configuration specific provision' in BCAR Section S that allowed only a lap strap to be fitted on flexwing aircraft had resulted from representation from the flexwing community, who were concerned that the shoulder strap could limit the pilot's ability to control the aircraft.

As there was no regulatory requirement to fit or use a shoulder strap in flexwing aircraft, the BMAA did not provide guidance on the potential benefits of their use, despite a number of accident reports citing the lack of upper body restraints as a potential cause of injury or death. Similarly, the Microlight Panel of Examiners did not provide guidance to flexwing instructors on the recommended use of safety harnesses for the occupant of the front seat during training flights.

Over time this situation led to the emergence of a culture in the flexwing community that despite clear manufacturer's warnings to always wear both parts of the seat harness assembly, there was a perception that wearing the shoulder strap presented a greater hazard than using the lap strap alone. A mark of the strength of this culture was that even where flexwing aircraft were fitted with inertia reel shoulder straps, which were designed to overcome the perceived restrictions in movement, shoulder straps were not always worn.

Instructors at the flying club where the pilot conducted his training for a NPPL, did not actively encourage the wearing of the shoulder strap as they believed it restricted their ability to fly from the rear seat and the pilot to operate the flying controls from the front seat. The pilot routinely saw instructors and other pilots not wearing the shoulder harness which likely reinforced his belief that it was safe to do the same. Once he completed his training and purchased his own aircraft, it was therefore probable that he would continue with this established practice.

Following this accident, the Microlight Panel of Examiners addressed this safety issue by issuing guidance to examiners and instructors on the wearing of shoulder harnesses.

Survivability

The RAFCAM described excessive flailing of the pilot's upper torso and head during the accident sequence as a consequence of only using the lap strap as a restraint. It was likely that not using the diagonal shoulder strap resulted in the pilot's head striking the ground and cockpit structure with significant force, thereby increasing the severity of his head injury. The RAFCAM assessment postulates that the potential reduction in the impact velocity of the pilot's head when it struck the ground if he had been wearing his shoulder strap, may have made the outcome of the accident survivable.

The finding from RAFCAM and the experience of the AAIB that there is a greater risk of serious and fatal injury when a shoulder strap is not worn during an accident, is contrary to the CAA's position that a properly worn lap strap, in combination with a safety helmet, provides adequate protection.

The aircraft manufacturer warns that the full harness should be worn and if correctly adjusted does not compromise full and free control inputs. However, pilots of the Pegasus Quik who expressed concern at wearing the shoulder harness quoted the exception in BCAR Section S 1307 as justification not to wear it. To ensure that the exception in BCAR Section S1307 is still appropriate, the following Safety Recommendation is made to the CAA:

Safety Recommendation 2023-038

It is recommended that the UK Civil Aviation Authority review the suitability of the Configuration Specific Provision in British Civil Airworthiness Requirements, Section S 1307 (a) Miscellaneous equipment which states, 'except that only a lap strap need be provided for front seat occupants of a weight-shift controlled aircraft'.

Airborne helmet safety standards

Whilst there was no regulatory requirement for microlight pilots to wear a safety helmet, the pilot wore a helmet designed to conform to BS EN 966: 2012 '*Helmets for airborne sports'*. However, this Standard does not protect wearers from the most likely cause of serious and fatal head injuries in aircraft accidents that result from rotational motion of the head when it is subject to an oblique impact. In this accident, the pilot died from a severe rotational head injury which his helmet was not designed to protect him from. Therefore, to ensure that BS EN 966: 2012 provides protection from oblique impacts that are likely to occur in aircraft accidents, the following Safety Recommendation is made to the BSI:

Safety Recommendation 2023-039

It is recommended that the British Standards Institute introduce a requirement in BS EN 966 'Helmets for Airborne Sports' to protect wearers from rotational head injuries

The helmet worn by the pilot was categorised for use in ultralight aircraft; however, this term has not been defined by either the BSI or the CAA. To ensure microlight pilots select helmets suitable for their airborne activity, the following Safety Recommendation is made to the BSI:

Safety Recommendation 2023-040

It is recommended that the British Standards Institute adopts the definition of a microlight from Schedule 1 of the Air Navigation Order (UK Statutory Instruments No. 765) in BS EN 966 'Helmets for Airborne Sports'.

Conclusion

The accident happened as a result of the aircraft becoming airborne with the base bar tethered to the front strut. The pilot might have survived had he worn a shoulder harness to restrain his upper torso and a helmet that offered protection from rotational head injuries.

During the start procedure, the engine went to a high rpm causing the aircraft to accelerate over the ground and become airborne. As a result of previous similar occurrences, the

aircraft manufacturer had introduced an optional modification to prevent this from happening; however, this modification had not been embodied on G-CCPC.

The training in dealing with system failures, such as a stuck throttle, was conducted as a discussion and not as practical training in the aircraft. Consequently, the pilot had never practised locating and turning off the ignition switches while the aircraft was in forward motion.

While shoulder straps were fitted to the aircraft, there was a general concern within the microlight community that wearing them potentially restricted the pilot's ability to control the aircraft. Consequently, a culture had emerged of only wearing a lap strap; this practice significantly increased the risk of head injuries during an accident.

While protection from rotational head injuries is already available in safety helmets for other sports and transport users, the BSI standard for the airborne sports helmet worn by the pilot did not include this requirement.

Safety Actions

The Microlight Panel of Examiners published the following guidance in their Instructor and Examiner Bulletin (01/2022), dated December 2022.

> ***2. USE OF DIAGONAL RESTRAINTS IN FLEXWINGS***
>
> *There is a worrying trend developing of pilots not wearing diagonal restraints when fitted to flexwing aircraft.*
>
> *This may be because students see instructors not wearing them and therefore consider them not important.*
>
> *A reminder that any restraints fitted to an aircraft must be worn by a pilot in accordance with the requirements in the aircraft's POH and whatever restraints are fitted must be used.*
>
> *Instructors do not have to wear the diagonal harness if they assess it will interfere with their ability to remain safely and effectively in control.*
>
> *Student's must be left in no doubt that this is an exception purely for instructors whilst conducting flying training, and examiners whilst conducting GSTs.*
>
> *Whilst conducting GSTs the candidate must demonstrate to the examiner the correct use of these restraints, even if the examiner is not wearing them for safety considerations.*
>
> Microlight instructors and examiners will include the following content in flying training and testing:
>
> ○ Preparation for unexpected situations and emergencies.

- Conduct of aircraft checks.
- Student response to unintentional mishaps and emergencies while on the ground and in flight.
- Preventative actions which must be incorporated into daily checks and routines, including aircraft daily inspections, advice on the positioning of the base bar, and aircraft starting.

The following Safety Actions were taken by the BMAA:

a) The guidance published in the Microlight Panel of Examiners' bulletin on the use of diagonal restraints in flexwing aircraft will be incorporated into the '*Instructor and Examiner Guide'* published by the BMAA at the next appropriate amendment.

b) A 'Belt-Up' safety campaign was launched in May 2023[17] promoting the safe use of safety harnesses in microlight aircraft, including a campaign poster, an article in the membership magazine. A video demonstrating correct inspection and fitting techniques is planned to be released in early 2024.

The pilot's flying club flying club took the following Safety Actions:

The flying club:

- Published a 'Procedures Reminder' to club members, emphasising the following:
  - The importance of the engine start checks to ensure the aircraft is configured correctly.
  - Keeping fingers on the ignition switches during start to ensure the engine can be stopped immediately if it runs away.
  - The importance of checking the hand and foot throttles during the daily inspection to ensure correct function.
- Require, prior to first solo, students to complete the following training:
  - Simulate an engine runaway during startup. To be conducted on the runway requiring the student to switch off the ignition switches to shut down the engine.
  - Simulate a stuck throttle and a brake failure. Both scenarios to be conducted independently on either the runway or taxiway and require the student to steer the aircraft in a safe direction before switching off the ignition switches to shut down the engine.
- Require the engine runaway, stuck throttle and brake failure, exercises to be included in biennial training flights for licence renewal.

Footnote

[17] The British Microlight Aircraft Association/belt-up-safety-campaign [accessed June 2023]

Safety Recommendations

The following Safety Recommendation was made on 15 November 2005.

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.

The CAA responded that:

'The CAA have reviewed the regulatory policies in both these areas as they apply to microlight aircraft. The requirements for seat belts and harnesses, and for briefings and instructions for passengers regarding their use, are contained in the Air Navigation Order and are believed to be sufficiently robust.'

The following Safety Recommendations are made in this report:

Safety Recommendation 2023-037

It is recommended that the UK Civil Aviation Authority issue a Mandatory Permit Directive to mandate Pegasus Sport Aviation Ltd Service Bulletin 159 to embody a Starter Inhibitor Switch on all in-service Pegasus Sport Aviation Ltd aircraft .

Safety Recommendation 2023-038

It is recommended that the UK Civil Aviation Authority *review the suitability of the Configuration Specific Provision* in British Civil Airworthiness Requirements, Section S 1307 (a) Miscellaneous equipment *which states,* '*except that only a lap strap need be provided for front seat occupants of a weight-shift controlled aircraft*'.

Safety Recommendation 2023-039

It is recommended that the British Standards Institute introduce a requirement in BS EN 966 'Helmets for Airborne Sports' to protect wearers from rotational head injuries.

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It is recommended that the British Standards Institute adopts the definition of a microlight from Schedule 1 of the Air Navigation Order (UK Statutory Instruments No. 765) in BS EN 966 'Helmets for Airborne Sports'.

Published: 7 December 2023.

APPENDIX A

INSTRUCTOR AND EXAMINER BULLETIN 01/2022

INSTRUCTOR AND EXAMINER BULLETIN 01/2022

How to use checks efficiently

Reinforce the understanding that checks are not just to be read from a list but to be part of a procedure that must incorporate both the check list and the actions together. Too often checks are just seen as a list to complete rather than a physical action.

Stress the need to practice **touch checks**, and the instinctive knowledge of position of the controls. This will help to prevent fumbling and losing time when things go wrong and actions need to be swift.

Remind students that touch checks mean physically touching, but **not** engaging/ activating systems such as ignition switches, fuel on/off, throttle, brake, parachute release mechanism for example.

Students should be taught to practice responses to various unintentional mishaps/ emergencies whilst on the ground, taxiing and in flight.

Examples include, but are not limited to the following:

1) Brake failure on start up
2) Starting unintentionally with full throttle
3) Failed or stuck throttle causing aircraft to go to full power on start-up and taxiing.
4) Throttle failure in flight for those aircraft with throttles that will fail 'safe,' i.e., go to full power. (What could happen? How will the engine perform with only one carb operating? What are the consequences? What to do?)

Preventative actions which must be incorporated into daily checks and routine:

- Aircraft should be stopped with the nose wheel straight. In any case, this should be checked before start up then, if the unexpected should happen the aircraft would go straight ahead to the pre-planned open area. There has been more than a one accident due to the aircraft not moving in the same direction as intended on start up!
- Wherever possible, have one hand on the throttle as the engine is started.
- Daily Inspection on aircraft to include throttle checks at carbs, on and off, and in the case of Flexwings, hand and foot throttle check.
- Additionally in the case of flexwings the control bar should be under armpits or at least untied at start up.
- Take note of and teach the aircraft manufacturer's instructions for dealing with emergencies in that aircraft, they may be specific and additional instructions.

The Instructor and Examiner Guide Section 4, Ex 16e - Systems Failures, will be updated for this.

I & E Bulletin 01-2022

INSTRUCTOR AND EXAMINER BULLETIN 01/2022

20/12/2022

All Instructors and Examiners,

The Panel has decided there is a need for more guidance to be given to Instructors and Examiners on 1) Eventualities, checks and the POH and 2) Diagonal restraints in Flexwings.

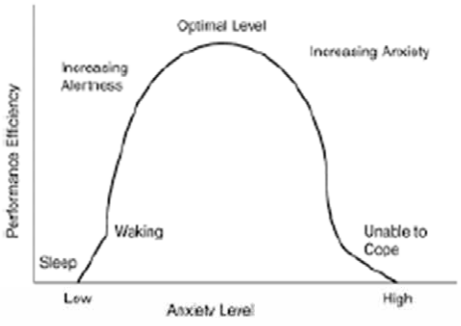
Until the Guide is amended to incorporate the points covered in this Instructor Bulletin please make sure this content is included, where appropriate, in your flying training/testing.

1. **The following points are a list of reminders on the importance of teaching EVENTUALITIES, thorough CHECKS and referring to the aircraft's POH**

Eventualities

When confronted with an unexpected situation/emergency one will typically freeze momentarily. The first reaction is usually 'What happened?' followed by 'I can't believe this is happening.' This is the *'startle'* effect. Until this is under control you cannot function effectively to deal with the crisis.

See below the Yerkes Dodson Law with the bell shaped graph of *performance versus anxiety/ stress*. Note the need to remain on the upslope of the curve to be able to act effectively.



Discuss with students the importance of preparing beforehand by practising/ considering what can go wrong to be able to react with minimum delay to reduce the *'startle'* effect should the unexpected/emergency occur.

For example: prior to take-off, considering contingencies for an engine failure on take-off.

I & E Bulletin 01-2022

INSTRUCTOR AND EXAMINER BULLETIN 01/2022

2. USE OF DIAGONAL RESTRAINTS IN FLEXWINGS

There is a worrying trend developing of pilots not wearing diagonal restraints when fitted to flexwing aircraft.

This may be because students see instructors not wearing them and therefore consider them not important.

A reminder that any restraints fitted to an aircraft must be worn by a pilot in accordance with the requirements in the aircraft's POH and whatever restraints are fitted must be used.

Instructors do not have to wear the diagonal harness if they assess it will interfere with their ability to remain safely and effectively in control.

Student's must be left in no doubt that this is an exception purely for instructors whilst conducting flying training, and examiners whilst conducting GSTs.

Whilst conducting GSTs the candidate must demonstrate to the examiner the correct use of these restraints, even if the examiner is not wearing them for safety considerations.

This guidance will be added to the Instructor and Examiner Guide.

Should you need advice on any of the content of this Instructor Bulletin get in touch with one of the Panel members/ FIEs.