**ACCIDENT**

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| **Aircraft Type:** | Paramotor (comprising a 'Revolution' wing and 'PAP1400AS' paramotor unit), no registration |
| **No & Type of Engines:** | 1 'SNAP100' two-stroke piston engine |
| **Year of Manufacture:** | Wing manufactured in 2006 |
| **Date & Time (UTC):** | 11 June 2007 at 1920 hrs |
| **Location:** | Chavenage Green Airstrip, near Tetbury, Gloucestershire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - 1 (Fatal) Passengers - N/A |
| **Nature of Damage:** | Paramotor unit extensively damaged |
| **Commander's Licence:** | N/A - licence not required |
| **Commander's Age:** | 24 years |
| **Commander's Flying Experience:** | In excess of 350 hrs hours paramotor<br>Last 90 days - Not known<br>Last 28 days - Not known |
| **Information Source:** | AAIB Field Investigation, with assistance from the BHPA and the BMAA |

**Synopsis**

The pilot of a paramotor aircraft was attempting a manoeuvre at a low height above the ground when the right-hand side of the wing 'collapsed', causing the aircraft to enter a sudden right-hand spiral dive. There was insufficient height for recovery and the aircraft struck the ground with a high vertical speed, causing fatal injuries to the pilot.

Contributory factors were the pilot's handling of the aircraft, combined with the low height at which the manoeuvre was attempted.

**History of the flight**

The pilot had been competing in the UK Paramotor National Championships, an annual event held over four days where the competitors perform a number of set tasks on which they are judged. The pilot had completed the final task of the day, on the penultimate day of the event, and was participating in some 'free flying' with approximately five others; this had been approved by the event organisers. These other flyers included the current paramotor world champion and the UK champion.

Having flown for several minutes practising various aerobatic manoeuvres, some of which were flown at very low level, the pilot climbed the paramotor to a height of approximately 150 ft agl before entering another manoeuvre. Soon after initiating this manoeuvre the right-hand side of the wing collapsed, causing the aircraft to enter a sudden right-hand spiral dive. There was insufficient height for recovery and the aircraft struck the ground with a high vertical speed causing fatal injuries to the pilot.

**Weather**

The Met Office provided an aftercast for the time of the accident. It stated that the visibility was 7 to 11 km and there was scattered cumulus cloud between 2,500 ft and 2,800 ft agl. The surface wind was variable at 3 kt and the wind at 500 ft agl was variable at 5 kt.

**Pilot's experience**

The pilot had been flying paramotors since April 2004 and had performed at numerous international events promoting the sport of paramotoring for the wing manufacturer. He was a member of the BMAA and held a BMAA FLM rating, as well as an FAI International Sporting Licence. He was described by those that knew him as a very capable pilot, who enjoyed performing aerobatic manoeuvres. He had had two previous accidents; in one he broke his right heel and in the other his right thigh bone. The causes of these accidents are not known.

The pilot held a Display Authorisation issued by the CAA and was familiar with this model and size of wing, having flown it on a number of occasions, and had reportedly chosen it because of its 'sportier' handling characteristics. He had also flown it previously on the day of the accident and had not reported any problems.

**Video evidence**

Several spectator videos of the accident were provided to the AAIB, one of which was analysed in detail. The footage was recorded by a spectator on the ground in front of, and to the right of, the flight path of the aircraft.

Examination of the video recording in slow motion showed that the aircraft was in a wings-level attitude, at a low height above the ground, immediately prior to the accident manoeuvre. The pilot was in a seated position, with his arms extended low down on either side of his torso. The wing was symmetrically inflated and the pilot appeared to be in full control of the aircraft. The sound of the engine was consistent with a high engine power setting.

In commencing the manoeuvre, the pilot reached above his head and grasped either the wing risers or the 'A' lines, causing the paramotor unit to tilt backwards momentarily. In one rapid, continuous motion, whilst apparently holding onto the risers or 'A' lines, he rotated forwards and extended his legs with his feet together. Concurrently, the engine sound decreased in volume. The wing and paramotor unit then began to pitch 'nose-down' and the pilot's body then turned to the right, with his weight biased to the right. The leading edge of right-hand side of the wing then deflected downwards, producing a visible kink in the leading edge at the mid-span location. The right-hand side of the wing rapidly collapsed from the tip inwards, causing the aircraft to enter a tight, descending right-hand spiral. Although the wing quickly re-inflated, there was insufficient height available for recovery and the aircraft struck the ground at high speed, in a steep 'nose-down' attitude. Initiation of the manoeuvre to ground impact took approximately 5 seconds.

A copy of the video footage was provided to the National Imagery Exploitation Centre for analysis. Estimates from this analysis placed the aircraft at a height of between 40 and 50 metres (130 - 165 ft) agl at the start of the manoeuvre.

Other video footage obtained showed the pilot confidently performing various aerobatic manoeuvres in this aircraft shortly before the accident. The aircraft appeared to be performing satisfactorily with no evidence of control difficulties.

**Medical examination**

A post-mortem was carried out by a Home Office pathologist. It showed that the forces in the impact were such that the accident was not survivable.

Toxicological analysis of the pilot's blood revealed the presence of a small amount of alcohol in his blood. This is believed to have been produced post-mortem. Had it been as a result of alcohol being consumed it is believed that as the concentration was so low it would be unlikely to have had a detrimental effect on the pilot's flying ability. The presence of paracetamol was also found at a concentration consistent with therapeutic use. There was no evidence of natural disease which could have contributed to the crash.

**Aircraft description**

*General*

The aircraft was a foot-launched, powered paraglider, comprising a non-rigid fabric 'Paramania Revolution' parafoil, red and white in colour, attached to a 'PAP1400AS' paramotor unit (Figure 1). The paramotor unit is worn in a similar manner to a backpack and consists of a stainless steel metal chassis, to which are attached the engine and the pilot's seat and harness assembly. The pilot must stand to launch and land the aircraft, but may adopt a seated position in flight.

The aircraft did not bear any registration mark (it is not required). However, it was identified with the number '20' in black adhesive tape on the underside of the wing for the purposes of the competition. The aircraft was not certified to a published standard and there was no requirement for it to be.

The pilot was using a borrowed paramotor unit on the accident flight as the one he had planned to use was unserviceable. This unit was generally similar to his own and he was familiar with its operation.

*Wing details*

General

The 'Revolution' series of parafoils entered production in 1996 and they are produced in various sizes, ranging from 21 to 30 square metres ($m^2$) in area.

The wing, bearing serial number 0306303, was manufactured in March 2006. It was labelled as a 'Revolution 23', but belonged to a batch of approximately 20 wings that were manufactured undersize and incorrectly labelled. This size of wing proved popular with advanced pilots, due to its higher speed and greater manoeuvrability and it is now marketed as the Revolution 21 model. The wing has a roughly elliptical planform, with a span and maximum chord of approximately 9.75 metres and 2.4 metres, respectively.

**Figure 1**

Photograph of paramotor aircraft

Wing construction

The wing is constructed primarily from a synthetic fabric and relies on air flowing into it at the leading edge to inflate it and give its aerofoil shape. The upper and lower surfaces are stitched together at the trailing edge and around the wing tips, but the leading edge is open, to allow air to enter the wing. Chordwise vertical ribs are attached to the upper and lower surfaces of the wing, dividing it into cells. Holes in the ribs permit the cross-flow of air, so that air pressure inside the wing is equalised. The air pressure inside the wing is dependent on airspeed and the direction of the relative airflow.

Four sets of cords or 'lines' are attached to the lower surface of the wing at specific chordwise locations. The lines are made of synthetic fibre and are grouped according to their chordwise location. The 'A' lines are attached to the leading edge of the wing, with the 'B' through 'D' lines being attached at progressively more rearward positions on the wing. Each set of lines is colour-coded for identification. The lower ends of the lines on each side of the wing are attached to straps or 'risers', which are connected to the paramotor unit by karabiners and shackles.

A further set of cords, the brake lines, are attached to the trailing edge of the wing and provide the primary means of controlling the aircraft. The brake lines are connected to hand loops located above and on either side of the pilot. Pulling the brake lines on one side of the wing lowers the wing trailing edge, increasing the drag, causing the aircraft to turn in that direction. Pulling on both brake lines simultaneously lowers the trailing edge on both sides of the wing, increasing its angle of attack and hence its lift and drag, which allows the aircraft to be slowed down in flight and flared for landing.

Wingtip steering

An optional wingtip steering kit may be fitted, which allows the pilot to steer the aircraft at higher speeds without using the brake lines. The kit comprises two straps, one on each side, which enable the pilot to pull on the wingtip lines in isolation and turn the aircraft without affecting either the trailing edge or the profile of the wing. The wing in this accident had been modified to add a wingtip steering strap on the right side, but none was fitted on the left side. The reason for this was not clear, but photographs taken earlier that day showed the pilot flying the wing with a tip steering strap fitted on the right side only.

Wing variable reflex

A key design feature of the 'Revolution' wing is that its profile can be varied in flight to provide reflex, so that the profile of the rear of the wing curves upwards. This allows the aircraft to be flown at a higher speed, which is desirable when flying longer distances. The introduction of reflex also moves the lifting forces further forward on the wing profile, so that the front of the wing is more heavily loaded. This has the reported benefit of making the wing more resistant to collapse.

The amount of reflex is controlled by the trimmer system, which comprises adjustable nylon straps looped through the C and D risers. Tightening the straps shortens the C and D risers, pulling the rear of the wing down and reducing the amount of reflex. The trimmed speed of the aircraft reduces as the trimmer straps are shortened and the aircraft becomes increasingly more manoeuvrable. Conversely, the degree of reflex increases as the trimmer straps are lengthened, resulting in a higher trim speed and reduced manoeuvrability.

*'Speed bar'*

The speed of the aircraft may also be controlled via a foot-operated 'speed bar', which hangs below the pilot's seat. It consists of two cords attached to a metal bar, onto which the pilot places his or her feet. The cords are routed upwards through a pair of pulleys on either side of the seat and are connected to straps looped through the A and B risers. The upper ends of the speed bar lines are terminated in 'quick disconnect' cleats so that they may be detached from the wing when de-rigging the aircraft. Application of the speed bar pulls down on the A and B risers, deflecting the front of the wing downwards, thus reducing its angle of attack and aerodynamic drag, allowing the aircraft to fly more quickly. The pulleys provide mechanical advantage to reduce the forces required to operate the speed bar.

*Paramotor unit details*

The paramotor unit comprised a stainless-steel frame with a seat assembly at the front and a 'SNAP100' model single-cylinder, two-stroke petrol engine mounted at the rear. The engine drives a two-bladed pusher propeller via a reduction gearbox and centrifugal clutch. Engine speed is controlled via a hand-held throttle.

Two pivot arms are attached to the main frame, extending forwards on either side of the pilot. The arms are pivoted at their attachment to the frame to allow them to be folded down during transportation. Each wing riser karabiner is clipped onto a shackle attached to its pivot arm. The pilot's seat is also attached to the pivot arms. The seat is flexible and can be folded down to allow the pilot to stand during takeoff and landing. The paramotor unit is equipped with a harness incorporating torso and leg restraints.

*Aircraft control*

The 'A' risers are used primarily to assist in launching a wing. The BHPA commented to the AAIB that, once airborne, the 'A' risers and lines should not be used unless purposely intending to induce a wing collapse, such as during wing testing. If the speed bar is applied, whilst pulling on the 'A' risers, it increases the probability of the wing collapsing.

The wing manufacturer promotes its reflex wings by highlighting its greatly improved stability over that of a non-reflex wing.

**Aircraft examination**

The wing was found to be in good condition and undamaged, with the exception of the right-hand brake line which appeared to have been cut. The integrity of the wing was verified by raising it and inflating it (Figure 2). Measurements taken by the AAIB showed that the lines were symmetrical on either side of the wing and that their lengths were close to the manufacturer's specified line lengths for this size of wing. Measurements of the wing upper surface area, with the wing laid out flat, gave an estimate of 18.98 m$^2$, close to the manufacturer's

**Figure 2**

Photograph showing test re-inflation of wing quoted figure of 19.06 $m^2$. This wing had, therefore, a relatively high wing loading, in comparison to others in the 'Revolution' series.

A paramotor pilot, who attended the scene immediately after the accident, reportedly found the trimmer settings adjusted towards the slowest (ie least reflex) setting. However, this could not be verified, as the aircraft was disturbed prior to the AAIB's arrival.

The paramotor unit was intact, but the chassis was damaged in the ground impact. The engine turned over freely and appeared to be capable of running. There was fuel remaining in the fuel tank, totalling approximately 1.2 litres in volume. The harness straps were in good condition, but had been cleanly cut in several places. All of the buckles operated correctly.

The speed bar mechanism was still attached to the paramotor unit, but was disconnected from the wing when the aircraft was moved from the accident site. The right-hand speed bar cord appeared to have been cut approximately 38 centimetres from its attachment to the foot bar and the upper section of cord was missing, whereas the left-hand cord was completely intact.

No evidence was found of any pre-accident mechanical failure of either the wing or the paramotor unit.

## Analysis

*Wreckage examination*

All the damage observed to the aircraft was found to be consistent with either ground impact or actions taken in order to free the pilot. Given that no evidence was found of any pre-accident material failures, the wing collapse and loss of control is considered unlikely to have been the result of mechanical failure.

*Pilot handling*

The pilot was familiar with the wing, having flown it on a number of occasions and had chosen it because of its sportier handling characteristics. He had also flown it previously on the day of the accident and had not reported any problems with it. The fact that video evidence showed him confidently performing aerobatic manoeuvres just before the accident suggests that he was unlikely to have had any control difficulties prior to the accident manoeuvre. Given his considerable experience, it is unlikely that he would have attempted these manoeuvres had there been a problem with the aircraft.

The video evidence showed that, immediately prior to the accident manoeuvre, the pilot had his hands low down on either side of his torso. This is consistent with the symmetrical application of the brake lines. This would suggest that the pilot was slowing down the aircraft prior to entering the manoeuvre. At the same time, the engine was heard to be at a high power setting. The pilot was then seen to let go of the brake lines and raise his arms to grasp the risers or 'A' lines, before standing up in his harness, with his feet held together, as if standing on the speed bar. Releasing the brake lines would have had the effect of reducing the drag of the wing, causing it to accelerate forwards. Standing on the speed bar would then pull down on the front of the wing, reducing its angle of attack, further reducing the drag. With the aircraft at a slow airspeed, the air pressure in the wing would be reduced, making it more susceptible to collapse. The pilot's rapid, full application of the speed bar at this critical point would have increased the probability of it collapsing. Once collapse had been induced, it was seen to progress very rapidly, probably due to the relatively high wing loading of this wing. The right-hand side of the wing collapsed first, possibly as a consequence of the pilot's weight, intentionally or unintentionally, being biased to the right side, or by a slightly asymmetric pull on the 'A' risers or lines, causing the right side of the wing to be deflected downwards to the point where the relative airflow initiated the collapse. The wing very quickly re-inflated, but, by attempting the manoeuvre at such a low height, the pilot had no margin available and there was insufficient height for him to recover.

It is not known what manoeuvre the pilot was attempting. Some pilots have suggested that he was likely to have been attempting a steep dive, after which he would flare the aircraft so as to fly a few feet above the ground before landing.

**Conclusions**

In summary, no evidence was found of any pre-accident material failure. The collapse of the wing was probably the direct result of the pilot's actions and the low height at which the manoeuvre was attempted did not provide sufficient height for a safe recovery.