Air Accident Investigation Unit Ireland

SYNOPTIC REPORT

ACCIDENT
Ozone, Speedster 28, Paramotor
Gormanston Beach, Co. Meath

4 June 2016

An Roinn Iompair Turasóireachta agus Spóirt
Department of Transport, Tourism and Sport

Foreword

This safety investigation is exclusively of a technical nature and the Final Report reflects the determination of the AAIU regarding the circumstances of this occurrence and its probable causes.

In accordance with the provisions of Annex 13[1] to the Convention on International Civil Aviation, Regulation (EU) No 996/2010[2] and Statutory Instrument No. 460 of 2009[3], safety investigations are in no case concerned with apportioning blame or liability. They are independent of, separate from and without prejudice to any judicial or administrative proceedings to apportion blame or liability. The sole objective of this safety investigation and Final Report is the prevention of accidents and incidents.

Accordingly, it is inappropriate that AAIU Reports should be used to assign fault or blame or determine liability, since neither the safety investigation nor the reporting process has been undertaken for that purpose.

Extracts from this Report may be published providing that the source is acknowledged, the material is accurately reproduced and that it is not used in a derogatory or misleading context.

[1] **Annex 13**: International Civil Aviation Organization (ICAO), Annex 13, Aircraft Accident and Incident Investigation.
[2] **Regulation (EU) No 996/2010** of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation.
[3] **Statutory Instrument (SI) No. 460 of 2009**: Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulations 2009.

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In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No 996/2010 and the provisions of SI 460 of 2009, the Chief Inspector of Air Accidents on 4 June 2016, appointed Mr Howard Hughes as the Investigator-in-Charge to carry out an Investigation into this Accident and prepare a Report.

Aircraft Type and Registration:	Ozone, Speedster 28, un-registered	
No. and Type of Engines:	1 x P.AP. 125, 2-stroke piston engine	
Aircraft Serial Number:	SP28-0-02E-010	
Year of Manufacture:	2013	
Date and Time (UTC)[4]:	4 June 2016 @ 16.55 hrs	
Location:	Gormanston Beach, Co. Meath	
Type of Operation:	General Aviation	
Persons on Board:	Crew - 1	Passengers - 0
Injuries:	Crew - 1 (Fatal)	Passengers - 0
Nature of Damage:	Substantial	
Commander's Licence:	N/A	
Commander's Details:	Male, aged 45 years	
Commander's Flying Experience:	Approximately 25 hours (unverified) on Paramotor	
Notification Source:	An Garda Síochána	
Information Source:	AAIU Field Investigation	

[4] **UTC**: Co-ordinated Universal Time. All timings in this report are quoted in UTC; to obtain the local time add one hour.

SYNOPSIS

The paramotor was foot-launched by the Pilot from Gormanston Beach. Witnesses observed it climbing out over the sea where it was seen performing a number of orbits and steep turns during which the paramotor would descend to the surface and climb back to its original altitude. It was then observed entering a rapid spiralling descent. It impacted in shallow water approximately 150 metres (m) from the shoreline. The Pilot was fatally injured.

NOTIFICATION

The AAIU was notified by An Garda Síochána. Two Inspectors from the AAIU deployed to the accident site and commenced an Investigation.

1. FACTUAL INFORMATION

1.1 History of Flight

When the Pilot first arrived at Gormanston Beach he encountered a vehicle that was stuck in soft sand and delayed the commencement of his flight in order to render assistance to the stranded vehicle and its driver.

The Pilot was observed preparing for flight in the paramotor, which he had brought onto the beach in the back of his 4-wheel drive vehicle. He had set up the equipment close to his vehicle and the paramotor was foot-launched at approximately 16.20 hrs. It maintained an easterly direction as it climbed over the water. It was then observed turning in a southerly direction, initially maintaining altitude. The paramotor then flew north and south a number of times, over the water and parallel to the shoreline, before it was seen to commence a number of manoeuvres, including steeply banked turns and steep figure-of-eight turns. During these manoeuvres the engine was heard revving up and down and the paramotor was observed descending close to the surface before climbing back to its original altitude.

Just prior to the accident, a witness observed the paramotor climbing away from the surface in a northerly direction before turning south over the water and maintaining altitude. Engine power was then heard to reduce significantly and the paramotor commenced a series of right hand turns. The paramotor then began to descend rapidly whilst continuing to turn to the right. During this descent the forward speed and rate of descent of the paramotor were observed by the witness to increase. The paramotor continued the spiral dive[5] until impact. Just prior to impact the engine sound was heard to increase.

1.1.1 Witnesses

There were a number of persons on Gormanston Beach on the afternoon of the accident. The Investigation interviewed several witnesses. Their accounts are given below.

[5]**Spiral Dive:** A configuration in which the paraglider or paramotor descends rapidly in a steep banked turn. The wing's path in a spiral dive can be described as a corkscrew.

1.1.1.1 Witness No. 1

Witness No. 1 stated that he arrived at approximately 16.30 hrs and parked on a lane leading to the beach close to an adjacent motocross track. As he walked onto the beach he saw the Pilot commencing what appeared to be a take-off run. He saw the paramotor take-off from beside a vehicle (which he later learned was the Pilot's vehicle) and climb in an easterly direction towards the sea.

The witness informed the Investigation that is was difficult to judge the height[6] of the paramotor, but estimated it to be "*between 30 and 40 metres,* [130 ft], *or maybe higher"*. It then turned in a southerly direction. The witness stated that he had seen paramotors before and was familiar with the sight and sound of these aircraft. He stated that the launch appeared normal and that the engine sounded normal throughout the flight.

The witness continued his walk along the beach towards Benn Head. The witness stated that the paramotor then flew back in a northerly direction, at which point he saw it commencing a number of manoeuvres including "*doing … many turns, spinning the paramotor"* and performing a series of "*steep figure-of-eight turns"*. The witness noted that occasionally during these manoeuvres the paramotor would descend and then climb back up to its original height.

The witness did not see the impact, but heard the sound of the paramotor hitting the water.

1.1.1.2 Witness No. 2

Witness No. 2 arrived at the beach at approximately 14.00 hrs. He told the Investigation that he did not see any flying activity when he arrived on the beach.

The witness was located close to the shoreline at the time the Pilot launched the paramotor. He saw it launch from close to the Pilot's vehicle, which was parked near to the sand dunes, and take-off towards him.

The witness saw the paramotor climb as it routed out over the water, and then turned south. The paramotor then flew "*back and forth in large orbits"*, over the water. The witness did not observe the paramotor throughout its flight but noted that he occasionally heard the engine tone changing frequently as if it was *"revving up and down"*.

The witness told the Investigation that he saw the aircraft performing very steep turns. The witness said he then turned his attention away from the aircraft and did not see the accident, but he heard the sound of the impact. He told the Investigation that he also heard the engine "*revving up"* just before impact.

The witness estimated the total flight time to be between 30 and 40 minutes.

[6] The Investigation was informed by paramotor experts that it is very difficult for members of the public to estimate the height of paramotors above the surface and may often be higher than they seem.

1.1.1.3 Witness No. 3

Witness No. 3 arrived by car at approximately 16.30 hrs, and drove down onto the northern end of the beach and parked at a location close to Benn Head. He was accompanied by his wife who was using a video camera at the time of the accident. The Investigation obtained a copy of a video recording which was made at the time of the accident flight.

The witness was walking his two dogs in shallow water close to Benn Head when he saw what he believed was the paramotor taking off from close to the shoreline and climbing in a northerly direction towards him. It then turned right in a southerly direction, and climbed to a height that the witness estimated was approximately 150 ft. The witness told the Investigation that he thought the engine had stopped, as he could no longer hear it, but the witness assumed the Pilot would be able to maintain height for a while, or come in and land.

A few seconds later the witness observed the paramotor start what he termed a spiral descent. He assumed that the Pilot "*was performing some sort of trick, or stunt"* and that the engine would start up and the paramotor would climb back up again.

The witness stated *"he spiralled, and as he descended down, the spirals got wider and wider, and he got faster and faster and then he was getting really close to the water …. And just moments before impact the engine started up again".*

The witness went out to where the accident happened to try to assist the Pilot, who appeared to be unconscious. He informed the Investigation that the water at the accident scene was approximately *'two and a half feet deep'* and the sand was soft under foot with no visible rocks or other hard objects. He signalled to his wife to call the emergency services. Details from the National Maritime Operations Centre log for the event show that this call was received at 16.55 hrs.

The witness was joined in the water by a number of other people who assisted in bringing the Pilot ashore. As the Pilot was still attached to the canopy by his harness, the witness went to his vehicle where he had a utility knife, which was used in an attempt to cut the Pilot from the harness. The witness noted that another rescuer had a fishing knife that was also used to cut the Pilot free. Once ashore CPR[7] was administered to the Pilot.

1.1.1.4 Witness No. 4

Witness No. 4 told the Investigation that he was attending a social gathering on Gormanston Beach. He arrived at approximately 16.30 hrs from the access lane at the southern end of the beach, and walked north approximately 600 m to the gathering. He noted that the paramotor was already airborne when he arrived.

The witness stated that the paramotor was flying over the sea, approximately 800 m northwest of his location and at a height of between 30 and 40 m above the sea surface. The paramotor was flying what appeared to be orbits that took it towards the shoreline and then out to sea.

[7] **CPR:** Cardiopulmonary resuscitation

Just before the accident the witness stated that he saw what appeared to be a change in shape to the right side of the paramotor's wing. The witness said it "*looked like he got a wind blow which fattened his parachute",* and almost immediately he saw the paramotor begin a rapid descent with turns to the right. The paramotor was flying towards the witness at the time, in a southerly direction.

As soon as the witness saw the paramotor impact the water, he and a number of other people ran to the scene where they joined witness No. 3 and assisted in recovering the Pilot to the shore. Witness No. 4 stated that he commenced CPR when the Pilot was brought ashore.

1.1.1.5 Witness No. 5

Witness No. 5 described what she saw to the Investigation through a translator.

Witness No. 5 was attending the same social gathering as witness No. 4. When she arrived at approximately 16.00 hrs there was no flying activity. She told the Investigation that she saw the paramotor launch and fly for approximately 40 minutes prior to the accident.

The witness noted that when the Pilot was flying, he would fly up but come back down. The witness said that the Pilot appeared to be climbing and descending as if he had difficulty controlling the paramotor.

Witness No. 5 told the Investigation that fifteen minutes before the accident the Pilot started to spin around, he descended, but then he managed to control it. Then he did it again, but this time he lost control and he got into a spinning motion and then he fell into the sea.

1.2 Pilot Information and Flight Experience

Information supplied by the Pilot's family and paragliding acquaintances indicated that the Pilot had taken up paragliding in 1997 whilst residing in the UK, where he would fly two to three times per year. He joined the British Hang Gliding and Paragliding Association (BHPA) in 2002. The BHPA informed the Investigation that unless a pilot intended flying as an instructor, or tandem pilot, there was no requirement in the UK for paraglider pilots, or paramotor pilots, to retain records of their flight times. Thus, an exact level of flying experience for the accident Pilot was unavailable.

In 2002, the Pilot gained his '*Club Pilot Rating*' followed by his '*Pilot Rating'* which he gained in 2003. According to the BHPA, the Pilot Rating involves "*passing exams in Air Law, Meteorology, and Cross Country Flying"*. As his flying at this stage involved foot launched gliding from slopes or hills only, his Rating carried a '*Hill Environment'* endorsement.

The Pilot returned to Ireland in 2008, and continued to be a member of the BHPA. The Investigation was informed that he continued to fly as a paraglider pilot, two to three times per year. In May 2015, the Pilot attended a BHPA-approved paraglider/paramotor flight training facility in Spain for one week, where he attained his '*Power Environment'* endorsement using a wing and power unit supplied by the training facility.

Later in 2015, the Pilot acquired the paramotor wing and power unit that were involved in the accident. In May of 2016, two weeks prior to the accident, he attended the same flight school in Spain. The course attended involved SIV[8] training, also known as stability training and it was carried out using the wing involved in this accident.

The BHPA syllabus for SIV training includes, but is not limited to, steep 360 degree turns, weight-shift turns, wing-overs, wing collapses (tucks) and spiral dives. The Investigation was informed that the Pilot carried out the SIV training in May 2016. This was undertaken without the addition of a motor and its associated equipment. The Investigation understands from the flight school, that between acquiring the paramotor in 2015 and attending the SIV course in May 2016, the Pilot did approximately 25 hours flying.

A number of paramotoring/paragliding acquaintances of the Pilot described him as an experienced paraglider pilot practiced in stall and wing-collapse recovery techniques. They also informed the Investigation that the Pilot would practice more extreme manoeuvres such as wing-overs[9], but that they would not have expected him to attempt such manoeuvres unless at a suitable altitude.

The Pilot had approximately one year of experience using a paramotor. Acquaintances who had seen the Pilot flying under power, noted that when flying with the additional weight of a power unit, the Pilot occasionally appeared to have difficulty executing manoeuvres such as wing-overs. One opinion expressed, was that the additional weight was causing the Pilot to *"swing ahead of the wing".*

1.3 Medical and Pathology Information

The pathologist's report stated that the cause of death was '*a severe head injury in keeping with a paraglider accident and a fall from a height*'. According to the Toxicology Test Report provided to the Investigation, neither ethanol nor drugs were detected.

1.4 Aircraft Information

1.4.1 General

Naming and classification of a paramotor is determined by the wing or canopy that is used. In this case the wing was an Ozone Speedster 28. The 'aircraft' in this case consisted of:

- The wing and suspension lines
- The engine, engine cage, propeller and fuel tank
- The harness (which incorporated a reserve chute)

[8] **SIV**: (French) *Simulation d'Incident en Vol,* (Simulated Incident in Flight). A BHPA information sheet states that SIV '*means simulating unstable situations in flight*'.

[9] Wing-Overs consist of a series of dynamic turns, during which the pilot swings laterally side to side to the extent that he/she is above, or 'over the wing'

Photo No. 1: An example of a similar paramotor in flight

The wing Manufacturer's Pilot's Manual for the Speedster gave no wind limit information. However, a subject matter expert[10] informed the Investigation that the normal wind speed for foot launching a paramotor was in the region of 0-8 kts, but experienced pilots could launch in winds up to approximately 13 kts.

1.4.2 Wing

The wing consists of fabric with no rigid structure. The fabric wing comprises a large number of interconnected baffled cells. It is attached by suspension lines to a harness below the wing. The wing's aerodynamic shape is maintained by the suspension lines, the flow of air entering the baffled cells via vents along the leading edge of the wing, and the air flowing over the outside surfaces of the wing.

The wing had a data panel stitched into the centre of the leading edge fabric. It gave details of, *inter alia*; serial number, date of manufacture, classification and maximum total flying weight. The wing was classified as 'C' and the maximum total flying weight stated on the data panel was 125 kg.

1.4.2.1 Wing Classification

The European Standards document, EN 926-2, *'Paragliding equipment-Paragliders-Part 2: Requirements and test methods for classifying flight safety characteristics'*, describes methods for classifying the flight safety characteristics of paraglider wings in terms of the demands on pilot flying skills.

[10] **A subject-matter expert** is a person who displays a comprehensive knowledge in a particular area or topic.

The test standard covers a wide range of manoeuvres and flight characteristics and the results of the test criteria allow for behaviour of the wing to be classified from A - D (and F - fail), with A being the most passive safety classification, and D the most demanding classification. Table 1 from this document gives the flight characteristics and pilot flying skills required for each category; this table is reproduced in full in **Appendix A**.

A paramotor wing will behave differently when flown under power compared to under gliding conditions. The Investigation understands that at the time that the Ozone Speedster wing design was being tested under EN 926-2, the wing design was only classified using paraglider criteria and the Investigation found no evidence of a test standard for this wing design under powered conditions.

1.4.2.2 Ozone Speedster 28 Flight Test Report

The flight test report carried out under EN 926-2 for this wing type states the total in-flight weight range for which the wing was certified. The maximum total flying weight was stated as 125 kg. The flight test report notes that when flown at the maximum total flying weight, the wing was found to descend at a rate in excess of 14 m/s[11] (2,722 fpm[12]) during steeply banked turns.

The Ozone Speedster 28 wing is classified as ‘C’ under the criteria set out in EN 926-2: 2013. The flight characteristics and pilot flying skills for Category C paraglider wings are given as follows:

> *Paragliders with moderate passive safety and with potentially dynamic reactions to turbulence and pilot errors. Recovery to normal flight may require precise pilot input.*
>
> *Designed for pilots familiar with recovery techniques, who fly ‘actively’ and regularly, and understand the implications of flying a glider with reduced passive safety.*

1.4.3 Power Unit

Paramotoring, also known as Powered Paragliding, makes use of a propulsion unit attached to the rear of the pilot’s harness to provide forward thrust. This usually consists of a light-weight 2-stroke petrol engine, turning a small fixed pitch pusher propeller, mounted within a protective cage.

In this case the power unit was a P.AP. PA125 engine. This was a 125 cm^3, 2-stroke, single cylinder engine, driving a two-bladed 130 cm carbon fibre propeller through a centrifugal clutch and reduction gearbox, producing approximately 65 kg of thrust. The engine was combined with a P.AP. 1450 harness, chassis and cage.

[11] **m/s**: Metres per second.
[12] **fpm**: Feet per minute.

1.4.4 Harness, Chassis and Cage

The harness, chassis and cage used was a P.AP. 1450 PA3, indicating the cage diameter was 1450 mm. It was designed to incorporate the PA 125 engine and used a 3-part cage assembly. The P.AP. 1450 also makes use of '*active system arms'*. These are metal pivot arms that connect the harness to the chassis and permit the pilot to achieve an optimum balance point.

1.5 Damage to Aircraft

1.5.1 Wing

The fabric wing sustained damage that consisted of a number of rips and tears. However, it was noted by AAIU Inspectors who recovered the wing from the beach that the interconnected baffled cells of the wing had filled with large quantities of wet sand which made the wing extremely heavy and difficult to lift. The damage to the wing was consistent with efforts by members of the public to rescue the Pilot and move his equipment onto the shore.

A number of the suspension lines were found to have been cut, as stated by witnesses, in their efforts to rescue the Pilot.

1.5.2 Power Unit

The engine was found intact, but had suffered seawater ingestion. When this was drained the engine could be turned over using the starter pull-cord, and compression was found on the cylinder.

1.5.2.1 Engine Mounting Bolts

The engine was mounted to the frame and harness using four mounting bolts. Each of the four bolts was found bent in a manner consistent with the engine and frame having been subjected to significant impact forces.

1.5.3 Propeller

Thrust was provided by a carbon fibre 2-bladed, fixed pitch, propeller that originally measured 130 cm in length. The propeller from the accident aircraft was found to measure approximately 90 cm, with approximately 20 cm missing from each tip, **Photo No. 2**. No propeller strike damage was found on the propeller cage, harness, or pilot's helmet. The damage to the propeller was consistent with contact with the surface of the water and/or wet sand, whilst under significant engine power.

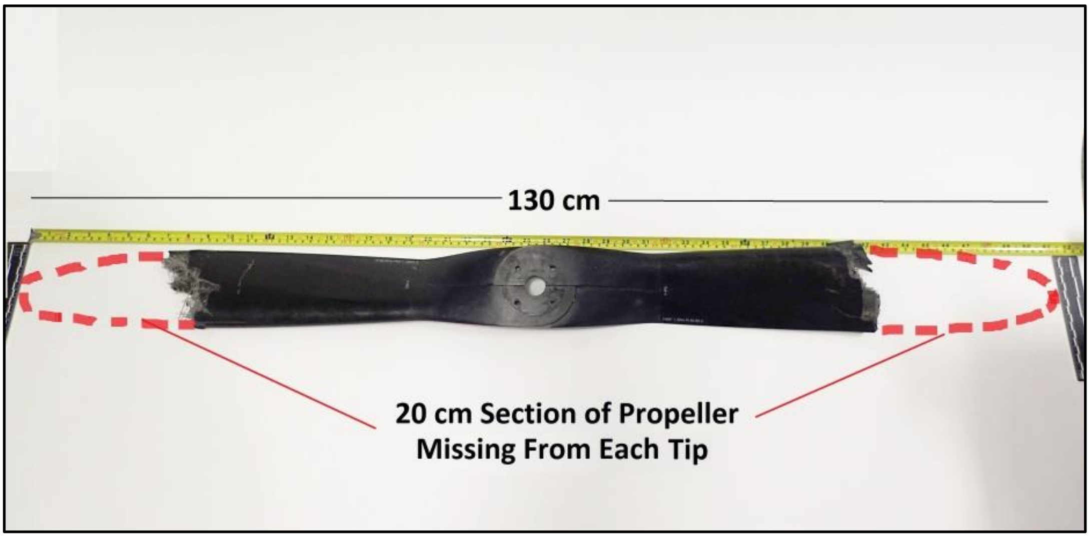

Photo No. 2: Damaged carbon fibre propeller

1.5.4 Harness Chassis and Cage

The Investigation found no evidence of pre-impact damage or failure of the harness or pivot arms. The pivot arms were found intact, undamaged and attached to the chassis. Damage to the harness was found to be consistent with attempts by members of the public to cut the pilot free from the harness to bring him ashore. Following reassembly, the cage exhibited evidence of minor distortion consistent with impact forces and recovery to shore. There was no evidence of the cage having made contact with the pilot's helmet.

1.6 Meteorology

Met Éireann, the Irish meteorological service, provided an aftercast for the Gormanston beach area for the time of the accident. The aftercast indicates that conditions on Gormanston beach at the time of the accident were:

Wind:	Between surface and 2000 ft, easterly at 5 kts
Visibility:	20 km
Cloud:	No significant cloud
Air Temperature:	Approximately 18 degrees Celsius

1.7 Weight and Balance

The total all-up weight of the paramotor, including fuel, Pilot and all equipment was estimated to be 140 kg.

The P.AP. 1450 cage and harness incorporates two pivot arms, called '*Active System Arms*'. Each arm has six holes along its length used to attach the harness and the paramotor riser lines using D-shackles and carabiners. By varying the attachment point used, the pilot can obtain the optimum balance position when seated in the harness, based upon his/her weight. The Manufacturer's manual suggests carrying out a static balance check before the first flight and adjusting the attachment point accordingly.

The Investigation could not determine if this was done, but the carabiners were found attached to point 'E' on the Active System Arms. This was within the weight range for the Pilot. An extract from the user manual for the '*Active System Arms*,' is given in **Appendix B**.

1.7.1 Wing Loading

The Investigation was informed by a number of subject matter experts that pilots flying paramotors have a preference to *"fly heavy"*. This is because a greater weight slung under a fabric wing may reduce the chances of a wing collapse due to a higher wing loading. However, the Investigation also found anecdotal evidence that paramotor pilots may fly above the certified weight for a particular wing in the belief that this improves safety and wing handling. Subject matter experts informed the Investigation that one effect of additional weight slung below the wing is an increased pendulum effect, whereby the pilot may swing further forward or backwards during certain manoeuvres. This can be further exacerbated by the addition of thrust during manoeuvres.

1.8 Paragliding and Paramotoring Published Material

The Investigation noted a number of references to spinning, spiral dives, and steep turns, in published material it reviewed.

1.8.1 Ozone Speedster 28 Flight Manual

The following guidance and cautions are given in the Flight Manual for the wing.

> ***Spiral Dives***
>
> *If you turn your Speedster in a series of tightening 360's it will enter a spiral dive. This will result in rapid height loss. To initiate a spiral, look and lean in to the direction you want to go, then smoothly pull down on the inside brake. The Speedster will first turn almost 360 degrees before it drops into the spiral. Once in the spiral you must apply a little outside brake to keep the outer wing tip pressured and inflated.*
>
> *Safe descent rates of 8m/s (1500 ft/min approx.) are possible in a spiral dive, but at these rates the associated high speeds and G-forces can be disorientating, so pay particular attention to your altitude.*
>
> *To exit the spiral dive, return your weight shift to a central position and then slowly release the inside brake. As the Speedster decelerates allow it to continue to turn until enough energy is lost for it to return to level flight without an excessive climb and surge*[13]*.*
>
> *The Speedster shows no tendency to remain locked in a spiral dive; however some parameters could interfere with its behaviour. These might include: wrong settings of the chest strap (too wide); total weight in flight outside of the certified weight range, or being in a very deep spiral at a very high sink rate. You should always be prepared to pilot the wing out of such a spiral dive. To do so smoothly use opposite weight shift and apply a small amount of outside brake and the glider will start to resume normal flight.*

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[13]**Surge**: An energetic reaction by a paraglider/paramotor, in which the wing travels forward, in front of the pilot.

Never attempt to recover from a spiral with hard or quick opposite inputs as this will result in an aggressive climb and surge. IMPORTANT: Spiral dives with sink rates over 8 m/s are possible, but should be avoided. They are dangerous and put unnecessary strain on the glider. Spiral dives cause disorientation and need time and height to recover. Do not perform this manoeuvre near the ground.

1.8.2 General Paraglider and Paramotor Articles

The Investigation noted a number of articles on the hazards associated with steep turns and spiral descents. The following are selected extracts from some of the publications.

Safety Notice No. 31, '*Paragliders: 360 Degree Turns And Nose-Down Spiral Dives',* published by the BHPA includes the following:

Following some recently reported incidents prompting further investigation, it has become apparent that it is possible for pilots to unintentionally enter a nose-down spiral dive from a sustained 360 degree turn – and that recovery from this spiral can be difficult.

An article on the wing Manufacturer's website notes:

Several accidents have already happened [involving fatalities] … *Remember that a spiral can be very disorientating.*

An online Paramotoring and Paragliding magazine included the following caution:

Other Factors Affecting Spiral Stability; … there are many other important variables that effect spiral stability. Weight: Gliders are more spirally unstable when the wing is more highly loaded.

1.8.3 Wing Collapse

Should the airflow over and through the wing become sufficiently disrupted, for instance due to wing surge, wing stall, line entanglement, or turbulence, the aerodynamic shape of all, or part of the wing can be lost in what is known as 'wing collapse'.

A wing surge occurs when the wing '*surges*' forward and '*overtakes*' the pilot. One manoeuvre where this might occur is during a mistimed wing-over. In such circumstances, and especially if the suspension lines, and thus the wing become unloaded, the airflow over the wing and into the baffled cells will be disrupted. The following is an extract from a safety article in a paragliding magazine:

Collapses happen due to a sudden transitory negative angle of attack. The air hits the wing at an angle from up above on the leading edge, instead of from underneath like in normal flying. The internal air pressure is not enough to keep the airfoil's shape, and the punched part of the wing folds underneath. There are symmetric or frontal collapses as well as asymmetric ones. The latter are by far the most common ones.

Lift decreases and drag increases on whatever side of the wing the collapse happens. The harness (and pilot) will also fall down lower on the side where lift was lowered or disappeared. Simultaneously, the increased drag on that same side of the wing will induce a turning motion at the wing level. As soon as a certain bank angle is achieved, if the folded part of the wing does not unfold and there is no pilot input, a spiral dive could start. The bigger the collapse, the quicker and more violent the consequences will be. Higher wing loading also increases speed and the violence on a wing's behavior. A collapse … can also happen while doing wingovers if the timing at some point is not appropriate.

1.8.4 Spiral Dive

In a spiral dive the paraglider or paramotor will descent rapidly, whilst continuing in a series of 360 degree turns. A spiral dive may be performed intentionally, in order to rapidly lose altitude, or inadvertently due to pilot mishandling. During a spiral dive the rate of descent and rate of rotation can increase dramatically. Pilots are advised to commence recovery from a spiral dive ideally by 1,000 ft above the surface. Spiral dives may result in pilot disorientation and occasionally blackout. The following is an extract from a paragliding magazine:

A spiral [dive] *can be induced by the pilot applying progressive additional brake input on one side while simultaneously weight shifting to the same side. It can also happen as a consequence of a big collapse if the wing does not reopen immediately and there is no pilot input.*

Sink rate becomes really high; it can go up to 4000 feet per minute on certain paragliders. The pilot's speed along the "helix" or "corkscrew" shaped trajectory can exceed 50 miles per hour. Speeds are very high, and we can quickly run out of time and altitude. At least 500 feet or more of altitude is needed to successfully exit a spiral dive and regain normal flight, depending on the pilot's skills and type of paraglider used.

1.9 Video Recording of the Event

Witness No. 3 provided the Investigation with a copy of a video recording taken on the beach at the time of the accident. The video was approximately seven minutes in length, during which the paramotor appears for 1.04 seconds.

1.9.1 Audio Evidence

At the beginning of the recording, the sound of the paramotor engine was heard increasing in intensity as it climbed in the direction of the camera. The sound level from the engine then decreased as the paramotor flew in a southerly direction away from the camera. Later, the tone of the engine was heard increasing on the recording just prior to impact.

1.9.2 Video Evidence

The video recording of the paramotor in flight lasted 1.04 seconds from when the paramotor came into view of the camera, until the impact. The video was examined by the Investigation with the assistance of experienced paramotor and paraglider pilots.

The subject matter experts' review of the video indicated that:

- The paramotor wing was in a leading-edge-down orientation.
- The full underside of the wing was facing the camera and the Pilot's position relative to the wing suggests that the paramotor was steeply banked.
- The wing appeared to be fully inflated just prior to impact.

From this, the subject matter experts informed the Investigation that, in their opinion, the paramotor was in a right-hand steep spiral dive with a high forward speed and a high rate of descent estimated to be between 20 - 30 m/s (3,940 - 5,900 fpm).

The subject matter experts also expressed the opinion that, based on the speed and rate of descent of the subject paramotor, the spiral dive most likely commenced at an altitude greater than that estimated by the witnesses.

1.10 Visual Assessment of Aircraft Altitude over Water

The Investigation found no evidence that the Pilot was carrying an altitude measuring device, such as a portable altimeter. Subject matter experts also told the investigation that paramotor and paraglider pilots, when flying over water, may find it difficult to accurately assess their height over the surface. The following is an extract from a training document published by the US Navy.

> *Over water low altitude flying has always been deceptively dangerous. Not only is there a false sense of security with the absence of vertical obstacles, but certain sea conditions virtually eliminate the pilots ability to judge his height above the water.*

1.11 Regulatory Background

The BHPA informed the Investigation that currently the UK regards paramotors or powered paragliders in the same class as unpowered paragliders. As such, unless the pilot intends flying for hire or reward, instructing, or performing tandem flights, they are currently unregulated in the UK. These aircraft do not require registration in the UK.

The Investigation notes that, in Ireland, paramotors or powered paragliders, are categorised as powered aircraft, and as such, come under Statutory Instrument S.I. 107 of 2015, which requires powered aircraft to be registered for use in the State. In addition, the IAA issued Aeronautical Notice G.13 on 30 May 2016, to clarify the status of powered paragliders or paramotors, restating that the requirements of S.I. 107 of 2015 apply.

The subject paramotor was unregistered in Ireland.

2. ANALYSIS

The Investigation found no evidence of pre-existing defects with the wing, harness, '*Active System Arms*', or engine that may have contributed to the accident. The damage to the engine mounting bolts was consistent with them being subject to significant impact forces. The damage to the propeller indicated that the engine was under significant power at impact; this was supported by audio evidence and witness statements. The damage to the wing and suspension lines was likely due to attempts to free the Pilot and recover the wing to shore following the accident.

The Investigation found that the weather conditions at the time of the accident were benign. The local airflow was a light easterly breeze over the sea, and was unlikely to have been turbulent. Therefore, the Investigation is of the opinion that the prevailing weather conditions did not contribute to the accident.

The launch, climb-out and initial manoeuvres of the paramotor appeared normal to the witnesses. It was observed flying over the water and was seen to perform a number of steeply banked manoeuvres, descending to the surface, and climbing back to altitude. One witness stated that he saw the paramotor performing steep figure-of-eight turns, and the Investigation considers it likely that this was an attempt by the Pilot to fly wing-over manoeuvres.

Fifteen minutes prior to the accident the paramotor was observed "*spinning*" and descending "*as if out of control*", but recovering close to the surface and climbing back to altitude. Just prior to the accident the paramotor climbed to what one witness estimated was 150 ft (but which may have been higher), and commenced a series of steep right hand turns, which appears to have developed into a right hand spiral dive resulting in an impact into shallow water at a high forward speed and at a high rate of descent. The Investigation has considered factors that may have contributed to such a spiral dive.

2.1 Pilot Induced Spiral Dive

Paraglider and paramotor pilots may train for, and practice the use of spiral dives. This manoeuvre can be used as a means of rapidly losing height when required. However, there are hazards associated with spiral dives, which are well documented and are included in training syllabi and flight manuals. The Investigation is of the opinion that the Pilot, having completed an SIV course, would have been aware of the hazards associated with the spiral dive. Although the Pilot may have been attempting other descending manoeuvres it is considered unlikely that he would have deliberately performed a spiral dive from such a low height.

2.2 Partial Wing Collapse

A partial wing collapse can lead to a rapid descent, and spin towards the side on which the collapse has occurred. Thus, a partial collapse of the right hand portion of the wing could lead to a rapid right hand spiral dive. One witness stated that the right hand side of the paramotor wing appeared to collapse, following which the paramotor descended rapidly.

The steep right hand turns observed just prior to the spiral dive may have been an attempt by the Pilot to perform a wing-over. This manoeuvre, if unsuccessfully executed, could have resulted in a surge and partial wing collapse which would account for the rapid right hand spiral dive that led to the accident.

2.3 Total Flying Weight

The wing Manufacturer stated that spiral dives with sink rates in excess of 8 m/s are possible, but should be avoided. The test certificate for the wing states that at the maximum total flying weight, rates of descent in excess of 14 m/s may occur during steep turns. Immediately prior to impact the paramotor rate of descent may have been as high as 30 m/s.

The Pilot had recently undergone stability training, which involved practicing recovery from extreme manoeuvres. This was carried out without the addition of a power unit and its associated additional weight. The Pilot may therefore have been less familiar with the behaviour of the wing under these conditions.

The maximum total flying weight placarded on the wing involved in this accident was 125 kg. The Investigation determined that on the day of the accident, the total flying weight was approximately 140 kg. Given that wing flight characteristics and performance have only been demonstrated and tested up to the placard weight, flight at weights above this could potentially lead to unexpected flight characteristics such as higher rates of descent developing during steep turns and spiral dives, or a longer time required to recover from upset events.

The Pilot was a member of the BHPA, through which he trained and acquired his various certificates and endorsements. The Investigation accordingly issues a Safety Recommendation to the BHPA in regard to paramotor flying weights.

Safety Recommendation No. 1

The BHPA should consider circulating a notice and/or conducting an educational campaign to stress to its members the importance of ensuring that all equipment is operated within the limitations laid down by the manufacturer. (**IRLD2017001**)

The Investigation also issues a Safety Recommendation in this regard to the Irish Aviation Authority, the regulator of aviation activity in Ireland.

Safety Recommendation No. 2

The IAA should consider issuing a notice and/or conduct an educational programme for all involved in paramotoring, to stress the importance of operating all equipment within the limitations laid down by the manufacturer. (**IRLD2017002**)

The General Aviation Safety Council of Ireland (GASCI) promotes safety awareness among all those involved in the Irish GA community, including paramotoring and paragliding. The Investigation therefore issues a Safety Recommendation in this regard to GASCI.

Safety Recommendation No. 3

GASCI should consider circulating a notice and/or conducting an educational campaign to stress to its members the importance of ensuring that all paramotor/paraglider equipment is operated within the limitations laid down by the manufacturer. (**IRLD2017003**)

2.4 Paramotor Manoeuvring Height

The Investigation believes that that paramotor was manoeuvring at a height that was insufficient for recovery from certain upsets or loss of control.

The fact that the paramotor was being flown over water may have led the Pilot to believe that his height above the surface was sufficient to commence the steep manoeuvres safely. The Pilot was observed performing a large number of steep turns which may have led to disorientation. Furthermore, the wing Manufacturer's Flight Manual states that a series of steep turns may develop into a spiral dive which may cause disorientation. Disorientation would have led to the Pilot being unable to accurately assess the rate of descent that had developed, which could have delayed the corrective action required to recover from the spiral dive. The manual also cautions that '*Spiral dives cause disorientation and need time and height to recover. Do not perform this manoeuvre near the ground'.*

2.5 Registration of Paramotors

The Investigation notes that there is a requirement in Ireland to register a paramotor. However, the Investigation is mindful that, in this case, the Pilot acquired his equipment, and learned to fly the paramotor in the UK and in a BHPA-approved flight training facility, where there is no requirement to register a paramotor. Therefore, the Pilot may have been unaware of the registration requirements in Ireland.

3. CONCLUSIONS

(a) Findings

1. The Pilot had been flying paragliders since 1997 and was regarded by peers as an experienced paraglider pilot.

2. The Pilot had obtained the paramotor approximately one year before the accident and amassed approximately 25 flying hours.

3. The Pilot had undergone SIV/Stability Training using the accident wing, but without the additional weight of the motor and associated equipment.

4. There was no evidence of pre-impact damage that may have contributed to the accident.

5. The Pilot may not have been familiar with the altered flight characteristics of the wing when flying with the additional weight.

6. The data panel stitched to the wing stated that the maximum total flying weight was 125 kg.

7. The wing flight test data sheet indicates that, at the maximum total flying weight of 125 kg, steep turns will result in a rate of descent in excess of 14 m/s.

8. The total flying weight at the time of the accident was approximately 140 kg.

9. Flying at weights outside the limitations set by the wing Manufacturer could adversely affect the behaviour of the wing.

10. During the accident flight, the paramotor was observed performing a number of steeply banked manoeuvres including wing-overs.

11. The Pilot may have become disorientated during the steep turns and thus may not have been aware of his height above the surface or the rate of descent of the paramotor during the final sequence of turns.

12. Flight over water may have contributed to misjudgement of height above the surface by the Pilot.

13. One witness stated that just prior to the accident the right half of the paramotor wing appeared to deform, which may have been a precursor to entry into a spiral dive.

14. The paramotor descended rapidly, in a spiral dive with a high forward speed and a rate of descent that was estimated to be up to 30 m/s (5,900 fpm) immediately prior to impact.

15. It is considered unlikely that the Pilot intentionally commenced the spiral dive.

16. Once the spiral dive had developed, there was insufficient height for the Pilot to recover the paramotor to normal flight.

(b) Probable Cause

Inadvertent entry into a spiral dive at a low height.

(c) Contributory Cause(s)

1. Performance of steep manoeuvres at a low height.

2. Insufficient height to recover once high descent rate had developed.

3. Possible pilot disorientation.

4. Paramotor flying weight in excess of the placarded maximum flying weight.

4. SAFETY RECOMMENDATIONS

No.	**It is Recommended that:**	**Recommendation Ref.**
1.	The BHPA should consider circulating a notice and/or conducting an educational campaign to stress to its members the importance of ensuring that all equipment is operated within the limitations laid down by the manufacturer.	**IRLD2017001**
2.	The IAA should consider issuing a notice and/or conduct an educational programme for all involved in paramotoring and paragliding, to stress the importance of operating all equipment within the limitations laid down by the manufacturer.	**IRLD2017002**
3.	GASCI should consider circulating a notice and/or conducting an educational campaign to stress to its members the importance of ensuring that all paramotor/paraglider equipment is operated within the limitations laid down by the manufacturer.	**IRLD2017003**

View Safety Recommendations for Report 2017-001

Appendix A

The European Standards document, EN 926-2, Table 1.

#	Flight Characteristics	Pilot Skills Required
A	Paragliders with maximum passive safety and extremely forgiving flying characteristics. Gliders with good resistance to departures from normal flight.	Designed for all pilots including pilots under all levels of training.
B	Paragliders with good passive safety and forgiving flying characteristics. Gliders with some resistance to departures from normal flight.	Designed for all pilots including pilots under all levels of training.
C	Paragliders with moderate passive safety and with potentially dynamic reactions to turbulence and pilot errors. Recovery to normal flight may require precise pilot input.	Designed for pilots familiar with recovery techniques, who fly 'actively' and regularly, and understand the implications of flying a glider with reduced passive safety.
D	Paragliders with demanding flying characteristics and potentially violent reactions to turbulence and pilot errors. Recovery to normal flight requires precise pilot input.	Designed for pilots well practiced in recovery techniques, who fly very actively, have significant experience of flying in turbulent conditions, and who accept the implications of flying such a wing.

Appendix B

P.AP. Active System Arms

The following is an extract from the P.AP. Chassis and Harness use and maintenance manual:

The active system arms connect the harness to the chassis. Carabiners are located on the harness where the paraglider risers are attached. The active arm connections points on the active arms work on a scale from A-F. Before your first flight on the PAP machine it is necessary to find your ideal static balance when seated in the harness in the normal flight position, wearing your flight suit and equipment. This is be best achieved by suspending yourself & the machine from a static frame. Moving the attachment points on the active arms forwards and backwards equally (A, B, C, D, E or F), you can find the optimum tilting angle off the propeller to the ground. For lighter pilots move the shackles backwards and for heavier pilot's move forwards.

This section of the manual also gives weight guidelines for the attachment points A-F, as follows:

A = +/- 50 Kg.
B = +/- 60 Kg.
C = +/- 70 Kg.
D = +/- 80 Kg.
E = +/- 100 Kg.
F = + 140 kg.

Figure A1: Extract from P.AP. manual showing Active System Arm

Figure A1, which is taken from P.AP. Manual, illustrates the shackle attachment at position D. On the Active System Arms of the accident paramotor, the shackle was found in position E as shown by the red arrow.

- END -

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No. 996/2010, and Statutory Instrument No. 460 of 2009, Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulation, 2009, the sole purpose of this investigation is to prevent aviation accidents and serious incidents. It is not the purpose of any such investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

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