Mainair Sports Ltd Mainair Blade, G-BYLK

AAIB Bulletin No: 10/2002	**Ref: EW/C2002/01/01**	**Category: 1.4**
Aircraft Type and Registration:	Mainair Sports Ltd Mainair Blade, G-BYLK	
No & Type of Engines:	1 ROTAX 582-2V piston engine	
Year of Manufacture:	1999	
Date & Time (UTC):	2 January 2002 at 1058 hrs	
Location:	Abbey Farm, Alby, Norwich	
Type of Flight:	Training	
Persons on Board:	Crew - 2	
Injuries:	Crew - 1 Fatal; 1 - Serious	
Nature of Damage:	Substantial damage to trike	
Commander's Licence:	Private Pilots Licence (Microlights) with Instructor Rating	
Commander's Age:	43 years	
Commander's Flying Experience:	910 hours (all on type)	
	Last 90 days - 13 hours	
	Last 28 days - 2 hours	
Information Source:	AAIB Field Investigation	

History of the flight

The flight was a training detail for a student with a qualified instructor. It was to be conducted from Abbey Farm, Norfolk, which has a grass landing strip approximately 400 metres long oriented in a north south direction. The southern half of the runway is relatively level but the northern half slopes markedly down towards the northern end. There are trees and power lines located at the northern boundary of the field just beyond the end of the runway. The intention was to fly to another nearby farm strip that was more suitable for practice circuits. If the student performed satisfactorily the instructor was to send him solo.

Weather conditions recorded at Norwich Airport (24 km to the south) at 1050 hrs were temperature minus 1°C, dewpoint minus 3°C, surface wind 240/05 kt with scattered cloud at 25,000 feet. The weather stations at Buxton, seven miles south of the accident site, and Calthorpe, two miles to the south-east, however, recorded a wind speed of 0 kts. The surface of the landing strip at Abby Farm was frozen with a light covering of snow.

The instructor had flown the aircraft with a passenger the day before the accident and recalled that the aircraft had performed very well. After that flight, the wings were removed from the trike and placed, still rigged, in a barn adjacent to the airstrip. The trike was parked in a nearby garage. It was late when the aircraft was derigged and when placing the wing in the barn the instructor noticed that frost had formed on its upper surface. The weather conditions that day were similar to those on the day of the accident.

On the day of the accident, prior to the flight, the instructor briefed the student on the expected flying conditions. The instructor then went to fetch the trike from the garage whilst the student retrieved the wing from the barn. While the aircraft was being rigged, the student's father, who was there to watch and video the flight, pointed out to his son that there was a layer of frost on the upper surface of the wing. The instructor stated that he had been aware of a light dusting of frost on the upper surface of the wing, but had felt that it was insignificant, as the frost was 'thin enough that he could still see the stitching in the wing fabric underneath'.

A diagram of the upper surface of the wing, drawn shortly after the accident by the student's father, indicated that frost existed across the whole span of the wing approximately 12 inches back from the leading edge.

After rigging and during the pre-flight checks it was discovered that the hand throttle had frozen. The instructor used a hair dryer, connected to the electricity supply in the barn, to thaw it out. The student then seated himself in the front seat with the instructor in the rear and the pre-takeoff checks were resumed. After the engine had been started and allowed to warm for approximately three minutes power checks were carried out. The power check was satisfactory.

During the takeoff the student, who was in control of the aircraft during the initial part of the takeoff roll, kept the control bar in the neutral position as the aircraft accelerated. The instructor, who did not have his hands on the control bar, recalled that the aircraft accelerated well when power was applied. When 'the speed felt right' he indicated to the student to push the bar forward for rotation, which he did. The student then, correctly, brought the bar back towards neutral as the aircraft rotated and climbed to approximately 10 feet above the ground. The airspeed continued to increase but the aircraft did not climb. The instructor had the impression that the student was holding the bar too far back, preventing the aircraft from climbing. He assumed control and moved the bar forward to establish a climbing attitude. The aircraft, however, failed to climb. At this point, the instructor, now becoming concerned that they might collide with the trees and power lines at the far end of the field, initiated a turn to the left. He estimated that the aircraft was by now only 10 to 15 feet above the ground. During the turn the left wing tip contacted the ground. The trike subsequently collided heavily with the ground and rolled over, seriously injuring the instructor and causing the student to receive fatal head injuries.

Video evidence

The video recording of the flight, made by the student's father, was made available to the AAIB for examination. The pre-flight preparations are seen to be carried out satisfactorily prior to the takeoff and there are no indications of any problems with the aircraft. The lighting conditions and limitations of the video however precluded any assessment of the condition of the wing upper surface.

The aircraft was seen taking off on the northerly runway. It accelerated smartly down the runway when power was applied and appeared to perform satisfactorily, up to the point of lift-off. After lift-off the aircraft veered slightly towards the right and failed to gain height. The pitch angle of the wing was then seen to increase noticeably as the control bar was pushed forward. The aircraft however did not appear to climb. Moments later the aircraft is seen to commence a left turn before disappearing from sight below the brow of the strip.

Aircraft information

The Mainair Blade is a two-seat, flex-wing, weight-shift microlight aircraft. The pilots are seated in a 'trike' which comprises a triangulated aluminium frame, containing a fibreglass pod which forms the cockpit. The engine is rear-mounted in a pusher configuration. G-BYLK was fitted with an electric-start two-stroke Rotax 582 engine driving a four-bladed composite propeller. The wing is attached to the top of the vertical member of the aluminium frame (the monopole) which is located behind the rear seat. The wing can be pivoted by the pilots via a control bar that provides pitch and roll control. The polyester fabric wing obtains its structural stiffness from aluminium leading edge tubes which are attached to a central longitudinal keel tube. The leading edge tubes are braced with cross tubes which are also attached to the keel tube. The profile of the wing is achieved by shaped battens which slide into pockets in the fabric of the upper and lower wing surfaces. An in-flight trimmer system allows the trim speed of the aircraft to be varied by moving a trim wheel which adjusts the reflex of the wing by a series of cables connected to the wing trailing edge. The front seat is equipped with a lap strap-type seat belt. The rear seat is fitted with lap straps and non-inertia reel shoulder straps.

The aircraft has a cruising speed of 50 to 70 mph and a stall speed of 30 mph in level flight and 34 mph in a 30° banked turn.

Impact and wreckage information

The closure cap had been knocked off the tip of the left wing leading edge tube and impacted soil was found inside the tube, providing evidence that the left wing tip had struck the ground during the left turn initiated to avoid the hedge and power lines. From ground impact marks, produced by the nosewheel and right mainwheel, it was deduced that the aircraft had spun approximately 100° to the left and contacted the ground forcefully, travelling sideways, in a slightly nose-down attitude. Scrape marks on the upper part of the nose of the trike and the debris trail, which included instruments from the cockpit and fibreglass fragments from the trike fairing, indicated that the trike had rolled over. The trike then skidded upside down for approximately 30 metres before coming to rest inverted against the hedge at the northern end of the field. The aircraft was structurally intact, except for the monopole, which had buckled and folded sideways at a point 32 cm above where it exits the crossmember, approximately level with the top of the rear seat. The wing surfaces were inspected but no evidence of frost was found at the time.

Three of the four propeller blades had broken off and propeller strike marks in the ground and slashes in the wing fabric provided evidence of engine power at impact. The ignition switches and fuel cock were found in the 'ON' position and the rear seat hand throttle was in the full throttle position. The fuel tank contained 12 litres of fuel. No evidence of water or foreign object contamination was found in the fuel system. The engine oil and coolant levels were satisfactory.

The wreckage was taken to the aircraft manufacturer for a more detailed examination in the presence of the AAIB. The engine, fitted with a new propeller, started without hesitation and produced adequate power. The wing was inspected but no significant defects were found. The wing battens were checked against the manufacturers batten profile drawings. Those which were not damaged in the impact were found to be in conformance with the drawings.

Survivability

There is no requirement to wear a helmet when flying a microlight aircraft. Both pilots, however, were wearing open-face helmets and lap strap seat belts. The instructor's seat was fitted with 'non inertia-reel' shoulder straps, but he was not wearing them, as is common when instructing, since the shoulder straps prevent the instructor from being able to operate the control bar over its full range of movement. The fact that he was not wearing shoulder straps however did not significantly contribute to his injuries and did not contribute to the injuries sustained by the student. Both pilots' lap straps were still intact and were cut by rescuers when freeing the pilots.

Some degree of protection is usually afforded to the occupants by the monopole in the event of a roll-over, however in this accident the force of the impact was sufficiently high that the monopole had folded sideways by 90°, allowing the trike to contact the ground inverted.

The helmet, worn by the student, was a Communica 'Beta 3' helmet, which belonged to the instructor. It was purchased by the instructor in July 2000 and was still being advertised for sale in the microlight press in May / June 2001.

The helmet was sent to the RAF Centre of Aviation Medicine for detailed examination. The shell of the helmet was severely damaged at the front of its exterior surface, with two large cracks visible either side of the centreline. A third crack was visible on the extreme right hand edge of the forehead brim. Superficially, the underside of the helmet appeared undamaged, but when the comfort foam liner was lifted, the expanded polyurethane liner was found to be shattered in the area underlying the damage on the exterior. The polyurethane foam liner was brittle and appeared to possess limited energy absorption capabilities.

The 'Beta 3' helmet was not designed to meet an impact standard, as no such standard existed at the time the helmet was designed. The helmet was therefore offered purely as a communications helmet and advertisements and literature provided with the helmet clearly stated that the helmet was not designed to provide impact protection. This helmet has been sold in large numbers, but is now no longer manufactured.

A new helmet however is available, the 'Beta +', which has been designed and tested for impact protection and meets the impact standard of BS EN 966:1996, '*Specification for Helmets for Airborne Sports*' and is similar in size and appearance to the 'Beta 3'.

Although it cannot be accurately quantified, from the depth of the ground impact marks at the main impact point and the distance that the aircraft subsequently travelled, it was apparent that the aircraft struck the ground at a relatively high speed and rolled over violently.

Aircraft manual

The manufacturers aircraft manual contains 14 sections detailing all aspects of the aircraft and its operation. Section 3, titled '*Warning about the safe operation of your Blade*' contains various warnings and limitations. It includes details of manoeuvre limitations (ie limits on angles of bank and pitch); loading (positive 'g' must be maintained at all times); engine failures and warnings about unauthorised modifications and the fitting of non-approved replacement parts. This section however does not include a warning regarding ice or frost contamination.

A different section (section 7.16) of the manual (issue 4, dated 10 December 1997), deals with 'Flight in Rain and Ice'. It cautions against flying with frost or ice on the wings and states:

> *'..... In addition if the wing has been left out all night, and a frost has formed never fly until the wing is completely dry and all the frost on the wing has gone.'*

Section 7.9 deals with 'Take off':

> *'Take offs are straight forward and the wing will lift the weight and hence fly when the correct airspeed is reached. Make sure the trim control is set for take off, as indicated on the placard. The correct technique is to hold the wing parallel to the ground during the initial stages of the take off run so as to reduce the drag and increase the acceleration. At around 30 mph push the bar gently forwards slightly until the aircraft un-sticks, this should be approximately 35 to 40 mph. The trike unit will swing forward under the wing, and a wise pilot will hold the aircraft's climb rate down until a safe climb out speed is reached, 50 - 55 mph.....'*

Effect of frost contamination on wings

Previous accidents

Reports on previous accidents, provided by the BMAA, show that pilots attempting to fly flex-wing microlight aircraft with wings contaminated by frost or rain have typically been unable to climb or have stalled after takeoff, resulting in an accident or a heavy landing. None of these accidents have however resulted in fatalities.

CAA publication

CAA General Aviation Safety Sense Leaflet No. 3B entitled 'Winter Flying' cautions against flying with contaminated wings. Section 4 Paragraph (d) states that:

> *'Tests have shown that frost, ice or snow with the thickness and surface roughness of medium or coarse sandpaper reduces lift by as much as 30% and increases drag by 40%. Even a small area can significantly affect the airflow, particularly on a laminar flow wing.....'*
>
> *'Ensure that the entire aircraft is properly de-iced and check visually that all snow, ice and even frost, which can produce a severe loss of lift, is cleared.....'*

Follow-up action by the manufacturer

As a result of the accident the manufacturer is to amend the aircraft manual to further highlight the dangers of flying with ice and frost on a wing. The amendment is to be incorporate into the Aircraft Manuals for all the models currently under production. The amended entry will be as follows:

'.....Microlighting is, generally, a fair weather sport but light rain has little effect on flying control. You will notice a slight increase in stall speed but the effects are minimal.

Ice, however, is more serious and can occur through icing meteorological conditions, or by flying a wing which is wet from the bag, without giving it time to dry out. Icing will affect handling and speeds markedly and at the first sign you should cease flying or fly below icing conditions.

In addition if the wing has been left out all night, and frost has formed never fly until the wing is completely dry and all the frost on the wing has gone.'

Conclusion

Wreckage examination and testing failed to highlight any condition that could have affected the climb performance of the aircraft.

In the course of rigging the aircraft, the instructor was aware of a very thin layer of frost on the upper surface of the wing. Witness evidence indicates that the frost extended across the entire span of the wing reaching back approximately 12 inches from the leading edge. The instructor however considered, as probably many pilots would have done, it to be so thin that, in his judgement, it would have negligible effect on performance of the wing so did not feel the need to take any action.

Video evidence showed that the aircraft acceleration during the takeoff run was normal and the aircraft lifted at the usual point on the runway. After lift-off however, the aircraft failed to climb, due to the combined effects of the reduced lift and increased drag caused by the frost contamination on the wing upper surface. The recommended take-off procedure for the Mainair Blade Aircraft is to push the bar gently forward at an airspeed of between 35 and 40 mph. Even a modest increase in the stall speed of 30 mph, due to the presence of frost on the wings, would have resulted in the aircraft lifting off in a semi-stalled condition. This would have prevented it from climbing and accelerating. The situation would be compounded in a turn, where the stall speed increases with increasing angle of bank.

The evidence from this and previous accidents suggests that even seemingly insignificant amounts of frost, or even rain on the wings of flex-wing microlights can degrade the performance of the wing to the extent that the aircraft cannot be safely flown.

The dynamics of the impact resulted in the instructor receiving serious injuries and the student being fatally injured receiving a severe blow to the head. The helmet worn by the student was designed, when impact standards were not in force, as a communications helmet. It was designed for comfort and practicality and not impact protection. Helmets are now available, however, which have been demonstrated to meet specified impact testing criteria. It is probable that the force with which the student's head contacted the frozen ground would have been outside the limits of impact resistance, even for a helmet meeting the EN966 specification and the fatal head injuries incurred may therefore have been inevitable. Nevertheless, a helmet designed to EN966 standards may have affected the outcome of this accident.

Recommendations

In light of the above the following safety recommendations are made:

Safety Recommendation 2002-20

The BMAA should seek the best means available to bring to the attention of pilots of microlight aircraft the circumstances of this accident and seasonally consider reminding them of the dangers of attempting to fly with wings contaminated by frost or rain, however insignificant the contamination may appear to be.

Safety Recommendation 2002-21

The BMAA should recommend to its members the wearing of helmets which comply with the EN 966 standard for impact resistance.

Safety Recommendation 2002-22

The BMAA should encourage manufacturers of microlight aircraft, who have limitations and operational requirements relating to the safe operation of their aircraft interspersed throughout their manual, to include, in a suitably prominent position and with suitable highlighting where necessary, a dedicated section re-iterating all the aircraft limitations and operational requirements.