ACCIDENT

Aircraft Type and Registration:	Avy Aera 1.5
No & Type of Engines:	5 Electric motors
Year of Manufacture:	2021 (Serial no: 007)
Date & Time (UTC):	6 May 2022 at 1225 hrs
Location:	Lamlash, Isle of Arran
Type of Flight:	Private
Persons on Board:	Crew - N/A Passengers - N/A
Injuries:	Crew - N/A Passengers - N/A
Nature of Damage:	Damage to lift motor boom, fuselage and landing gear
Commander's Licence:	Other
Commander's Age:	34 years
Commander's Flying Experience:	1,784 hours (of which 75 were on type) Last 90 days - 12 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries made by the AAIB

Synopsis

The UA was hovering at between 50 m to 65 m agl during a demonstration flight, when a rhythmic, lower than normal sound was heard emanating from the UAS. It then dipped and spiralled downwards during which control could not be re-established. The UA hit the ground and was severely damaged. A fatigue failure of a blade attachment bolt caused one of the lift propeller blades to detach in flight.

History of the flight

The UA was hovering during a demonstration flight and was being flown in various manual modes. After about three minutes in the hover, at between 50 m to 65 m agl, a rhythmic lower than normal sound was heard emanating from the UA. A few seconds later it dipped to the left and slowly spiralled downwards. Despite attempts to regain control and fly the UA back to the launch site, the UA was unresponsive and eventually hit the ground. The UA was severely damaged by the impact.

UAS description

The Avy Aera 1.5 is a fixed-wing, payload-carrying UAS which launches and lands vertically. Four electric lift motors mounted on twin booms, drive propellors that enable the vertical takeoff, hover and landing capability. A single electrically driven pusher propeller creates the thrust for horizontal flight. When the correct airspeed during launch for wing-borne flight

is attained, the lift propellers cease to rotate and they remain stationary until the aircraft is commanded to slow and transition back to the hover. The UA is capable of beyond visual line of site operations. See Figure 1 for an image of the UA hovering.

Figure 1

Avy Aera 1.5 in flight
(image courtesy of manufacturer)

The lift propellers consist of two blades held between upper and bottom plates which form an articulated propellor hub. Each blade is held in place by a single M3 bolt and a stiff nut and are designed to pivot around the bolt in the horizontal plane. A small stop pin protrudes from the underside of the blade boss which engages with a groove in the bottom plate. This is designed to prevent the blade from 'overshooting' ie travelling too far and folding back on itself. Figure 2 shows the propeller hub assembly components.

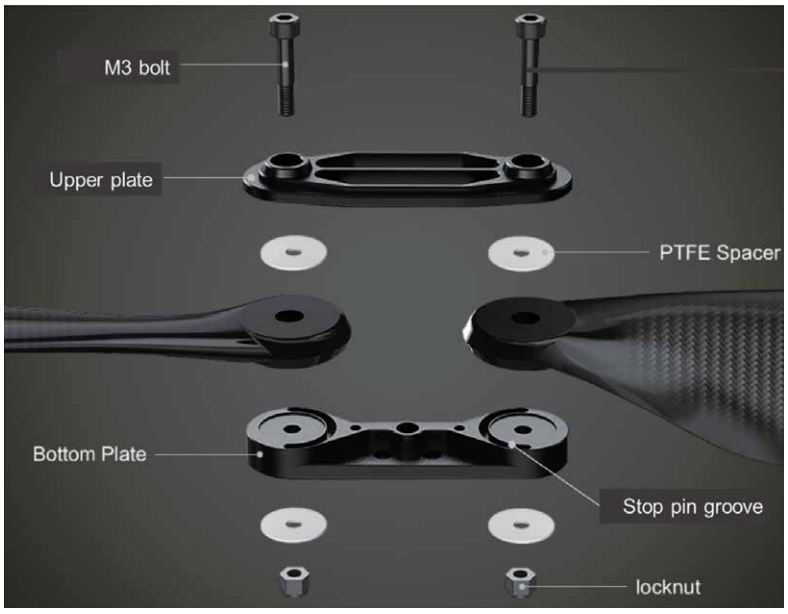

Figure 2

Propeller hub components
(image courtesy of the manufacturer)

The blades are fixed pitch, and the thrust is varied by increasing or decreasing the speed of the motor. Figure 3 shows a lift propeller (there is slight damage apparent on this example, but it is not the propeller that failed).

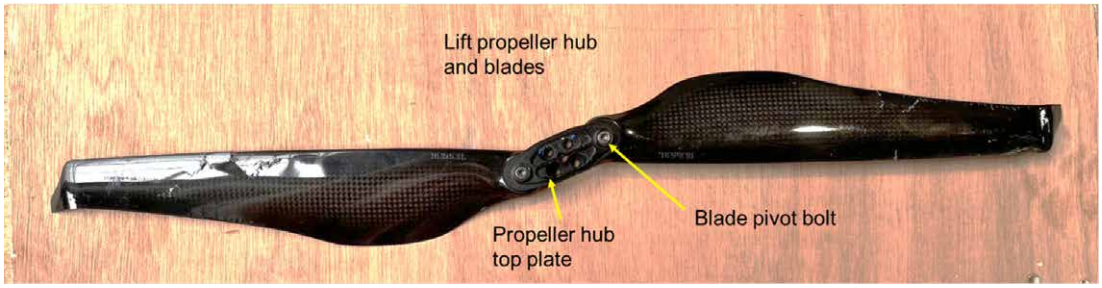

Figure 3

Example lift propeller
(image courtesy of the manufacturer)

Examination

Examination of the UA after the accident found that a blade of one of the lift propellers had detached from its hub in flight. The nut and bolt which held the blade in position had failed near the interface of the plain shank and threaded portion of the bolt. The threaded portion had remained within the stiff nut. The failure of the bolt had allowed the upper and bottom hub plates to separate and open out releasing the blade. Figure 4 shows the failed bolt with its nut and separated hub plates.

Figure 4

Separated hub plates and failed bolt. (The hub is shown inverted)
(image courtesy of the manufacturer)

Manufacturer's investigation

The manufacturer carried out a metallurgical examination of the M3 bolt and concluded that it had failed due to fatigue within the threaded portion under the nut. Further investigation, which included test running of example propellers, identified the probable causes of the fatigue failure of the bolt to lie with the design of the propeller and the loads they encounter in flight.

It was found that design features of the hub plates and blades could lead to a backlash between the blade boss and the bolt. This in turn can result in vibrations when the propeller is rotating. Results of the testing suggested that these vibrations lead to cyclical loads which manifest themselves as shear and bending loads in the bolt. In addition, it was also found that the failed propeller hub assembly stop pin groove was damaged and showed evidence of fretting on the underside of the blade boss (Figure 5).

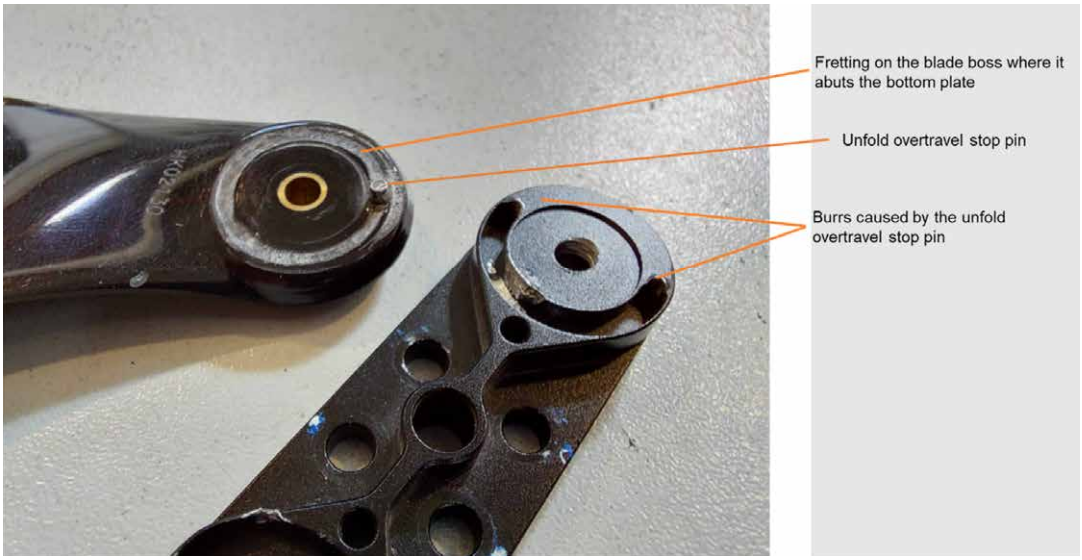

Figure 5

Fretting on the blade boss and damage to the ends of the stop pin groove (image courtesy of the manufacturer)

It is possible that the damage to the stop pin and groove increased the risk of backlash within the assembly, thereby exacerbating the cyclical loads on the bolt.

The manufacturer also considered the tightness of the bolt. The nature of the design means that any wear or backlash between the blades and the hub is taken up by tightening the nut during assembly and maintenance. There is no specified torque setting and hence any inconsistency of torque within the nut and bolt could also lead to a fatigue failure of the bolt.

Safety actions

As a result of this accident the following safety actions have been taken:

The manufacturer has introduced a 10-hour replacement schedule for the propellers and immediate propeller replacement if a Quadchute[1] event occurs.

The manufacturer is carrying out a review of propeller designs for UAs under its development.

Footnote

[1] Quadchute: if fixed-wing mode fails (eg loss of altitude), multicopter mode takes over and brings the aircraft to a steady hovering position.