

ACCIDENT

Aircraft Type and Registration:	DJI Mavic 2 Enterprise	
No & Type of Engines:	Four electric motors	
Year of Manufacture:	Unknown	
Date & Time (UTC):	7 August 2022 at 1648 hrs	
Location:	Bangor Train Station Car Park, Gwynedd	
Type of Flight:	Emergency Services Operations	
Persons on Board:	Crew - None	Passengers - None
Injuries:	Crew - N/A	Passengers - N/A
Nature of Damage:	Damaged beyond economic repair	
Commander's Licence:	Other	
Commander's Age:	37 years	
Commander's Flying Experience:	7 hours (of which 4 were on type) Last 90 days - 1 hour Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB	

Synopsis

The UAS was being used in a police operation over an abandoned building near a public car park and train station. During hover over the building the aircraft's motors stopped and the aircraft fell vertically with no prior warning to the remote pilot. The aircraft struck the roof of the building and the battery separated. Recorded data indicated that the battery probably disconnected in flight. This could have been caused by the battery not having been fully latched prior to takeoff, or the latching mechanism or battery being worn from repeated use resulting in an in-flight disconnection. The operator has taken safety action to remind their pilots of the importance of pre-flight checks and checking airframe and battery condition at their base.

History of the flight

The 1.1 kg Mavic 2 Enterprise UAS was being used to locate suspects during a police operation. The wind was light, the air temperature was 18°C and there was no precipitation. The Mavic needed to be deployed quickly but the remote pilot reported checking the battery and the aircraft prior to takeoff. He decided to take off from near the corner of a car park (Figure 1) next to an old industrial site to the south-east that had been fenced off. The pilot was contacted by another officer and asked to fly to and hover over the middle of an abandoned building on the industrial site.

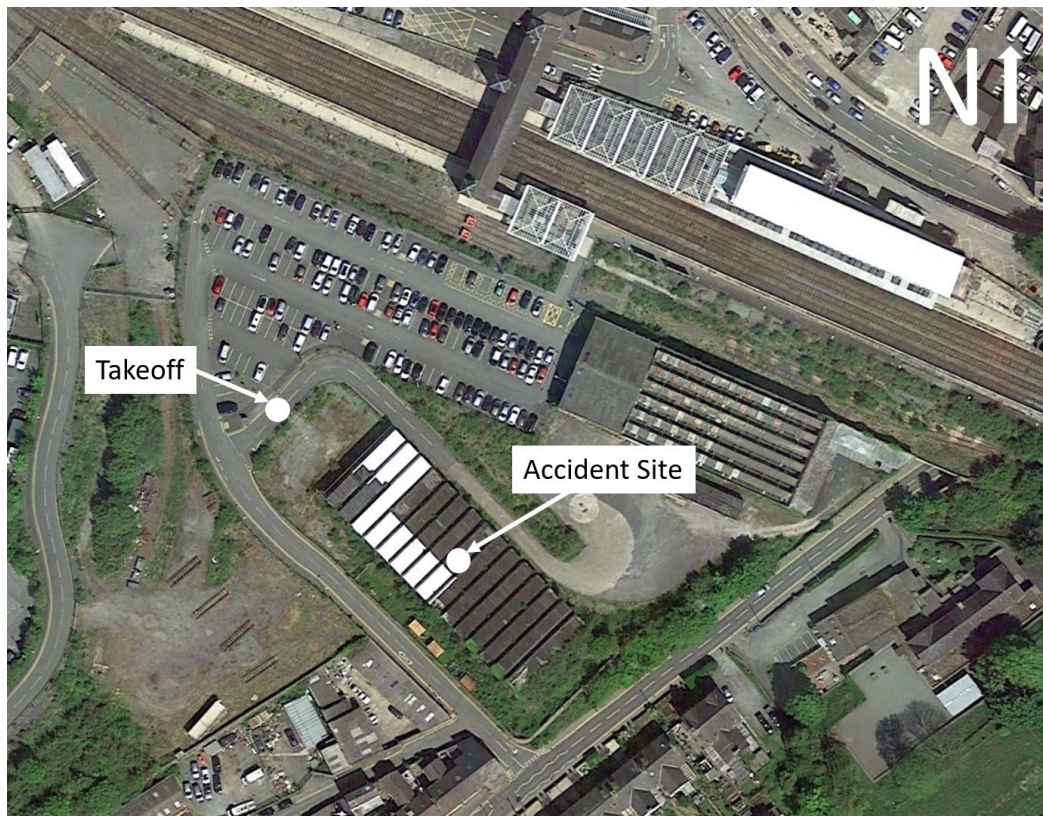


Figure 1

Takeoff and accident site location

(Imagery ©2023 Bluesky, Infoterra Ltd & COWI A/S, CNES / Airbus, Maxar Technologies, Map data ©2023)

About 4 minutes after takeoff another officer joined him who he asked to act as his observer. The aircraft was hovering over the centre of the building in Figure 1 when, about 6 minutes after takeoff, the pilot lost signal and video feed on his controller screen. The observer told him that they had seen the aircraft drop and the noise had stopped. The pilot looked up and could not see the aircraft.

It was located shortly afterwards on the roof of the building. The battery had separated from the airframe and they were about 1.3 metre apart from each other.

Recorded information

The recorded data file was downloaded from the controller. No faults were recorded and it showed the battery state of charge reducing linearly from 98% to 77% when the recording ended while the aircraft was in a hover at a height of 39 m above the takeoff point. Battery voltage fluctuations began 4 seconds before the end of recording. The last data point was recorded 5 minutes and 42 seconds after takeoff.

The data was sent to the aircraft manufacturer for analysis. They stated that there was an *'abrupt change in battery voltage before the flight record ended'* and that *'it could be possible that it was because of the battery disconnection (or loose connection) from the aircraft due to improper installation of the battery or the battery being swollen (*The battery has been*

used for about 3 years according to the log file and high temperature during Summer may have an impact on the battery)'.

They stated that another possible reason for a loose connection was the battery having been used for three years and '*probably reaching its end of lifecycle*'.

The remote pilot was wearing a video camera (bodycam) which showed him setting the aircraft on the ground prior to takeoff (Figure 2). The operator and remote pilot reported that this image shows that the gap between the battery and airframe is larger than it should be when the battery is correctly installed. This picture was sent to the aircraft manufacturer and they stated that it was not possible to judge from this image if the battery was partially attached or not, or whether it was swollen or not.



Figure 2

Image from the pilot's bodycam prior to takeoff

The video camera also showed the aircraft, as a very small dot, falling from the sky. Another small dot was sometimes apparent directly above it, which the operator thought was the separated battery, but it was likely an artefact of the video. When a bird flew across the camera's field of view a small dot also appeared behind it. There was no indication that the aircraft had struck a bird.

Aircraft examination

The aircraft had suffered damage to its underside, with damage to the motor arms and the camera/gimbal assembly. The battery had black scuff marks (Figure 3). The operator re-installed the battery into the aircraft which showed that the scuff marks did not form a line with any marks on the aircraft's upper surface (Figure 4). This showed that the marks were made on the battery after it had separated from the airframe. However, the damage to the battery was not consistent with it falling from a height of more than 20 m on to a solid roof; there were no dents. It was also only about 1.3 m away from the airframe, so it is probable that the battery separated when the airframe struck the roof.



Figure 3
Battery from the accident Mavic



Figure 4
Accident battery re-installed in accident Mavic

The operator tested the battery locking mechanism after the accident with the accident battery, and it functioned normally. The battery was powered on and it provided power to the aircraft.

The operator also carried out a test with a partially latched battery and were able to power up the aircraft with no warnings provided to the pilot.

The operator reported that the battery did not exhibit any signs of swelling, and they reported that the data from the battery showed that its highest recorded temperature was 42.3°C, which is below the temperature limit of 50°C. The battery had had 46 charge cycles.

Aircraft manufacturer information

The aircraft manufacturer has published safety guidelines¹ for the Mavic 2 Enterprise which contains a Pre-flight Checklist which states:

'Ensure the Intelligent Flight Battery is mounted firmly in place'

In the section 'Maintenance and Upkeep' it states:

'The battery is rated for 200 cycles. It is not recommended to continue use afterward.'

They have also published battery safety guidelines for the Mavic 2 Enterprise² which state:

'Never use or charge swollen, leaky, or damaged batteries.'

'The batteries should be used at temperatures between -20° and 40°C. Use of batteries in environments above 50°C can lead to fire or explosion.'

The aircraft manufacturer stated that *'if the battery was properly handled according to the guideline, the possibility of abnormal performance of the battery is very low'*.

Operator information

The operator concluded that the most likely cause of the accident was that the pilot had not properly installed the battery and fully engaged the locking mechanism. They considered that the pilot had likely rushed to set up the aircraft, due to the nature of the urgent deployment, and not realised the battery was not properly installed.

The operator also noted that the pilot had not placed the aircraft on a takeoff mat to prevent dirt ingress into the motors and did not wait until joined by an observer before taking off. He also did not brief the observer on what their role was.

Analysis

The aircraft's motors stopped and the aircraft fell vertically with no prior warning to the remote pilot. The recorded data indicates that the most likely cause was a loss of battery power to the aircraft which instantly cut off the motors and the link to the controller. The battery state of charge was 77% at the time and there had been no warnings related to the battery. Both the operator and the aircraft manufacturer concluded that the most likely cause was the battery becoming disconnected. The damage to the battery was consistent with it having separated when the aircraft struck the roof of the building, and this detachment was more likely if it was already loose.

Footnote

¹ https://dl.djicdn.com/downloads/Mavic_2_Enterprise_Advanced/Mavic_2_Enterprise_Series_Disclaimer_and_Safety_Guidelines.pdf. Accessed 17 January 2023.

² https://dl.djicdn.com/downloads/Mavic_2_Enterprise_Advanced/Mavic_2_Enterprise_Intelligent_Flight_Battery_Safety_Guidelines.pdf. Accessed 17 January 2023.

The operator believed that the pre-flight checks were probably rushed and that the body worn camera image showed the battery not fully engaged. The aircraft manufacturer could not confirm whether it was fully engaged, but it is possible that it was not. It is also possible that the battery was engaged at that time, but that the latching mechanism or battery were slightly worn from use which led to an in-flight disconnection. There was no indication that the battery was swollen or had exceeded the temperature limit.

There are no sensors on the battery locking mechanism to detect and warn the pilot that a battery is not fully latched. For this type of UAS it is important that it is flown in a manner to reduce the risk to uninvolved third parties if it were to fall vertically, and in this case the aircraft was being flown over a large abandoned building which reduced that risk.

Conclusion

The aircraft's motors stopped and the aircraft fell vertically with no prior warning to the remote pilot. Recorded data indicated that the battery probably disconnected in flight. This could have been caused by the battery not having been fully latched prior to takeoff, or the latching mechanism or battery being worn from repeated use leading to an in-flight disconnection. The operator has taken safety action to remind their UAS pilots of the importance of pre-flight checks and checking airframe and battery condition at their base.

Safety Action

The operator has shared the learning from this accident with all its UAS pilots and reminded them of their responsibility to turn on their body worn camera before they carry out the UAS pre-flight checks so that the checks are captured, and of their responsibility to take time on the UAS checks that are completed at a local air base to ensure the aircraft is fit for use.

They also planned to reinforce the briefing of observers, and to carry out routine checks of the batteries.