ACCIDENT

Aircraft Type and Registration:	DJI Matrice M210 Version 1 (UAS, registration n/a)
No & Type of Engines:	4 electric motors
Year of Manufacture:	2017 (Serial no: 0G0DECG0230007)
Date & Time (UTC):	19 November 2020 at 1150 hrs
Location:	Poole, Dorset
Type of Flight:	Emergency services operations
Persons on Board:	Crew - None Passengers - None
Injuries:	Crew - N/A Passengers - N/A
Nature of Damage:	Damage to right leg and propeller blades
Commander's Licence:	Other
Commander's Age:	38 years
Commander's Flying Experience:	14 hours (of which 5 were on type) Last 90 days - 2 hours Last 28 days - 1 hours
Information Source:	AAIB Field Investigation

Synopsis

The quadcopter unmanned aircraft (UA) was being flown over the city of Poole during a police operation when the wind at 400 ft exceeded the forecast wind, the manufacturer's wind limit and the maximum restricted speed of the UA. The UA drifted beyond visual line of sight and then communication with it was lost. When the battery level was low it entered an auto-land mode but collided with the wall of a house, damaging its propeller blades before coming to rest on a balcony.

The investigation revealed that shortly after takeoff one of the UA's two batteries had disconnected which resulted in its maximum speed being restricted, but this restriction is not referenced in the user manual and neither the remote pilot nor operator were aware of it. When the UA detected that the manufacturer's wind limit had been exceeded, the message triggered on the pilot's controller display was '*Fly with caution, strong wind'* instead of advising the pilot that the limit had been exceeded and that the UA should be landed as soon as possible.

Three Safety Recommendations are made to the UAS manufacturer and one to the CAA on Visual Line of Sight guidance.

History of the flight

The DJI Matrice M210 Version 1 is a quadcopter UAS with a maximum takeoff mass of 6.14 kg. It was being used for a police operation over the city of Poole. The remote pilot was working with an observer who had a slave controller. At 1108 hrs the remote pilot obtained a wind forecast at 400 ft of 24 mph from the north-west using a UAS weather forecast app. At 1117 hrs, a flight towards the south-west was carried out with no issues. The two batteries were replaced and then at 1145 hrs the UA took off again. Standard control checks were carried out at a height of 10 m before climbing to 120 m (400 ft) and flying south-east towards a target location that was 500 m away.

The remote pilot reported that he maintained a good visual sight of the UA and referred to his controller for flight and aircraft information. He then noticed two messages on the controller screen: one stating '*Battery communication error'* and then another stating '*Fly with caution, strong wind'*. He noted that one of the batteries was showing 97% state of charge (SOC) while the other battery SOC was decreasing faster than normal. The pilot tried to fly the aircraft back towards him, but it did not appear to be moving any closer. He then noted that one battery was showing 58% SOC while the other was still showing 97%. The pilot used the map function to check the aircraft's orientation and confirmed it was correct, but it was still not returning. The aircraft's distance from the pilot began to increase beyond 500 m which is not normally possible because the maximum flight distance from the remote pilot had been set to 500 m using the DJI Pilot app.

The pilot was now very concerned and activated the *'Return to home (RTH)*' feature on the controller, but it did not appear to engage despite being operated multiple times. RTH then appeared to activate but the aircraft did not move any closer. The pilot then switched to *'Sport Mode'* as per their emergency procedure which he expected would give him a top speed of 51 mph, allowing a greater ability to overcome the headwind. This cancelled the RTH feature so he pressed RTH again, but it would not re-engage. The remote pilot asked the observer to try engaging it using his slave controller, but this did not work either. At this stage neither the pilot nor the observer could see the aircraft, but they could see it on the moving map heading slowly towards Poole Park boating lake in a south-easterly direction (Figure 1). Both controllers then lost communication with the aircraft.

The pilot and observer packed their kit and drove to the last location of the aircraft shown on the map display. When they arrived in the area of the last position, the controllers regained communication with the aircraft and displayed its GPS coordinates. They found the aircraft on a first-floor balcony of a house (Figure 2). There was no one at the front of the property but there was light foot traffic along the path by the lake, about 30 m from the aircraft's location. The aircraft's right leg had snapped at the mounting bracket, three propeller blades had shattered, and one propeller had detached but was located next to the aircraft.

Figure 1

Accident flight ground track

Underlying image © Google Earth ™

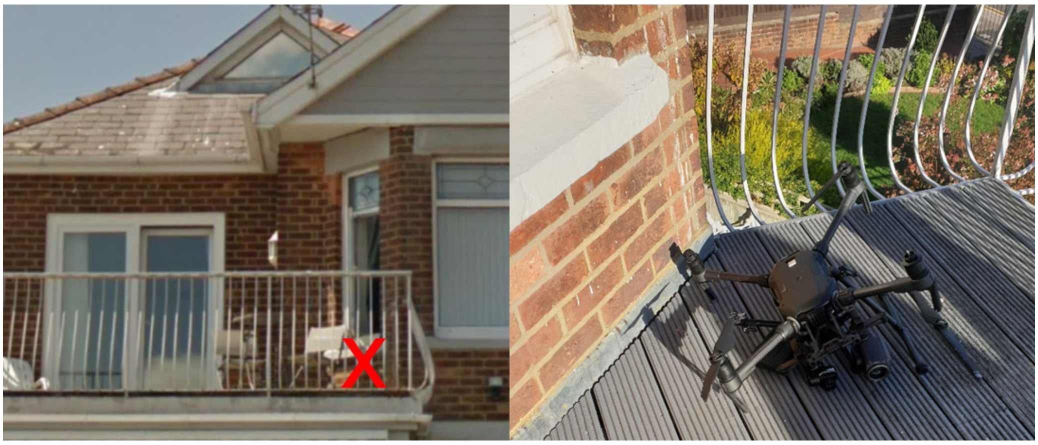

Figure 2

Accident site location and damage to UA

Remote pilot comments

The pilot reported that he could not recall the exact wording of the warning that flashed up regarding the battery and that he had not seen it before or since. He said that the messages flash up on the screen of the controller for a few seconds, then go into a temporary alarm stack that can be reopened but they also disappear from this stack in a matter of “seconds rather than minutes”. He stated that there is no audio alarm for any messages which is an issue because the pilot needs to spend more time looking at the UA than looking at the controller screen.

The pilot reported that his pre-flight check involved a full check of both batteries for damage, operational use and full charge, but a future consideration would be an additional safety check where both pilot and observer independently check both batteries are secured.

He also said he would recommend that every operator perform a battery/power check at the beginning of a flight by monitoring the screen, to ensure both batteries are reducing charge at the same rate prior to climbing away.

Recorded information

The operator sent the data log files from the master controller and the aircraft to the AAIB and the aircraft manufacturer for analysis. The data revealed the following sequence of events:

> 24 seconds after takeoff, at a height of 266 ft[1], Battery 1 lost communication with the UA. The manufacturer stated that this was probably caused by a physical loss of connection between the battery and battery terminal. This resulted in the battery no longer supplying power to the aircraft and the display of its SOC remained frozen at 97% for the rest of the flight. Battery 2 was now supplying sole power and its SOC started reducing faster than normal from 96% down to 16% by the end of the flight about 11 minutes later.
>
> According to the manufacturer the message displayed on the controller 24 seconds after takeoff was: '*The communication to the battery is abnormal. Please land as soon as possible and check if the battery is installed properly.*' However, the pilot did not recall seeing that level of detail.
>
> When Battery 1 became disconnected the total battery percentage figure dropped from 97% to 48% but this recorded parameter was not displayed on the pilot's controller. This drop in total battery capacity triggered a limitation on the aircraft's pitch attitude. The aircraft manufacturer stated that this was to ensure flight safety. The restricted aircraft pitch attitude resulted in the maximum airspeed also being restricted. The data shows that the pitch and roll attitude was always below 15° during the flight apart from momentary spikes up to 18° (the normal limit is 25°).
>
> 48 seconds after takeoff, at a height of 325 ft, and 181 m south-east of the pilot, the following message was displayed on the controller: '*High Wind Velocity. Fly with caution.*' This message is triggered when the aircraft has calculated[2] that the wind speed has reached 10 m/s (22.4 mph). This is referred to by the manufacturer as a 'Level 1 warning'.

Footnote

1 The height shown in this report is the recorded parameter 'GPS:heightMSL'. The takeoff figure was -1 ft and the end of flight figure was 5 feet. The ground level at takeoff was 6 ft above sea level and the ground level at the end of flight was 0 ft above sea level, so the altitude (amsl) and height (agl) were considered equal in this report.

2 The UA cannot measure windspeed directly, but it knows its groundspeed and direction from GPS, and it can estimate its airspeed and direction based on the aircraft's pitch attitude and motor speeds. When both groundspeed, airspeed, and their directions are known, the windspeed and direction can be calculated.

1 minute and 11 seconds after takeoff, a wind ‘Level 2 warning’ was triggered when the windspeed reached 12 m/s (26.8 mph), but the message displayed to the pilot was the same as a ‘Level 1 warning’: ‘*High Wind Velocity. Fly with caution*.’

None of the above three alerts were accompanied with an aural alarm, and the manufacturer was unable to say how long the alert messages would remain visible for on the controller screen.

The UA calculated wind profile for the flight is shown at Figure 3.

6 minutes and 37 seconds after takeoff, at a height of 393 ft and 552 m south-east of the pilot, with the recorded windspeed at 33 mph and increasing, the aircraft was drifting in the direction of the wind at a groundspeed of 7 mph with no pilot input, while pitched 13° into wind. With no pilot input the groundspeed would normally be zero.

7 minutes and 0 seconds after takeoff, at a height of 393 ft and 633 m away, the UA entered RTH mode, but the UA did not start to move towards the takeoff location because it could not overcome the wind with its limited pitch attitude.

8 minutes 28 seconds after takeoff, at a height of 232 ft and 806 m away, communication between the controller and UA was lost. At this time the UA was drifting south-east at 3 mph. When communications are lost the UA would normally enter a ‘Failsafe RTH’ mode, but it could not return home due to the wind and limited pitch attitude.

10 minutes 5 seconds after takeoff, at a height of 297 ft, the UA entered an ‘Auto Land’ mode and started a descent. Battery 1 SOC was still 97% and battery 2 SOC was at 23%.

11 minutes 17 seconds after takeoff, the descent ends at a height of 3 ft, and the motors stop. The final 30 ft of descent was at an average descent rate of 1.7 ft/second.

Aircraft information

The DJI Matrice M210 Version 1 is operated using a tablet device running either the DJI GO4 app or the DJI Pilot app. The pilot in this accident was using the DJI Pilot app. The aircraft user manual[3] contains some information and screenshots for the DJI GO4 app but none for the DJI Pilot app and there is no separate user manual for the DJI Pilot app. The aircraft user manual does not provide any information on the caution or warning messages that can appear in either app.

Footnote

3 Matrice 200 Series M210/M210 RTK User Manual V1.4 (2018.11) – latest version at the time of the accident.

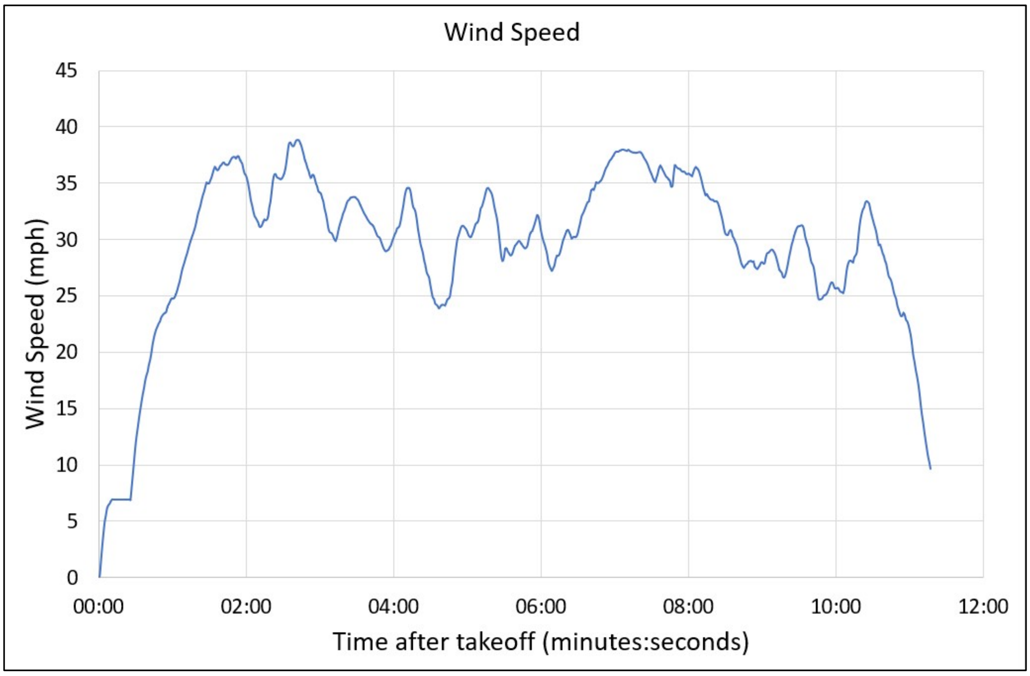

Figure 3

Calculated Wind Speed recorded by UAS (mph)
Peak wind is 39 mph at time 02:41

The aircraft has three operating modes: (1) P-mode is the normal control mode; (2) A-mode is a manual mode without position holding; and (3) S-mode is the 'sport mode' which provides for a higher top speed. The user manual states the following speed and pitch angle limits:

	Max Speed	Max Pitch Angle
P-mode	35.8 mph	25°
A-mode	35.8 mph	25°
S-mode	40.3 mph	30°

Table 1

Matrice M210 speed and pitch angle limits (from aircraft user manual)

The accident aircraft was fitted with dual camera gimbals with a Z30 Zenmuse camera and a XT2 Zenmuse thermal camera. The manufacturer's website provides different speed limits depending on whether one or two camera gimbals are fitted, whereas the user manual only provides one set of figures. In P or A mode, with dual gimbals, the website states a maximum speed of 38 mph, which is 2.2 mph higher than that in the user manual. With a single gimbal the website states a maximum speed of 51.4 mph in both A-mode and S-mode, and 38 mph in P-mode.

The user manual does not state that the aircraft's pitch attitude or top speed are restricted below a certain battery level. The aircraft manufacturer was unable to provide further information on the battery capacity trigger figure, the pitch limit in degrees or the resulting airspeed limit. According to the accident recorded data the aircraft appears to limit its pitch and roll attitudes to 15°, which is 10° less than the limit specified in the user manual for A and P modes.

The user manual and website state a *'Max Wind Resistance'* figure of 12 m/s which is equal to 26.8 mph. The *'Matrice 200 Series Disclaimer and Safety Guidelines v1.6'* states: *'Do not fly when the wind speed exceeds 12 m/s or 27 mph'*. Whereas a section of the user manual entitled *'Flight Environment Requirements'* states *'Do not use the aircraft in severe weather conditions. These include wind speeds exceeding 10 m/s, rain, and fog'*. 10 m/s is equal to 22.4 mph.

The Matrice 200 series of UAS are no longer produced. They have been replaced by the Matrice 300 series UAS.

Operator information

After the accident the operator removed the batteries, re-charged them, and installed them in a Matrice M210 Version 2 which has some differences to the Version 1 but the motors are the same. The aircraft was flown in a hover until the batteries had reduced from 100% to 20%. They repeated the test three times and the flight times varied between 23 minutes 44 seconds and 25 minutes 33 seconds. The air temperature during the tests was between 9° to 11° C.

The operator had an Emergency Procedure for *'Loss of GPS or Fly Away'*. The symptom was described as '*Drone not holding position and/or drone drifting with the wind'*. The first four pilot actions were:

> '1. *If using M210 or Inspire, ensure the switch in controller is set to P-GPS and not ATTI (top left side of the controller).*
>
> 2. *Consider putting drone in to Sport Mode if wind is strong to give extra motor power to drone.*
>
> 3. *Activate RTH if able.*
>
> 4. *Attempt to regain control of drone using stick inputs. If control is regained, land immediately. Verbalise input commands so observer can note any actions.*[4]'
>
> The subsequent actions involve activating the pilot's body-worn video camera, considering stopping the motors, using the moving map to determine its location and orientation, and notifying other airspace users.

Footnote

[4] The following is a note which was not part of the text: 'Sport Mode' or 'S-mode' does not 'give extra motor power'. It increases the pitch limit to 30° which increases its capable speed.

The operator stated that they operate to the 12 m/s (27 mph) manufacturer wind limit. They routinely operated the Matrice out to a distance of 500 m, in part they stated because 500 m was a distance that the CAA had established as being the accepted range for VLOS operations. They stated that the Matrice is "easily visible" in the sky at 500 m but that it is much more difficult to identify forward and backwards movement purely by line of sight. They stated that the orientation can be obtained by trial and error. If you move the stick left and the UA moves right then you know it is facing towards you. If there is no apparent movement then you know it is side-on and moving the stick forwards can then establish its orientation. The operator also stated that, if necessary to avoid collision, the pilot can also increase or decrease the height of the UA as required. But if the video and telemetry feed is available then this would be used to confirm orientation.

After this accident the operator started training their pilots to be able to recover the Matrice from a distance of 500 m without reference to the video or telemetry, and also in manual A-mode to simulate a loss of position holding capability that could result from a loss of GPS or compass interference.

In October 2021 the operator notified the AAIB that they had retired their Matrice M210 UAS and were using the newer Matrice M300. They also stated that they have implemented the following measures:

- *'All our pilots have recently had their annual CPD where they received a specific classroom input and practical familiarisation on the M300, its capabilities and limitations. This is approximately 90 minutes in the classroom and then a practical flight with an instructor. As part of this all pilots are reminded about reading notifications on the screen and the fact there is a bell in the top left corner so any new notifications are highlighted with a red number, so if a pilot missed one they can click the bell to see any warnings that have been shown.*
- *We have now introduced a buddy check system so both crew members have to confirm the integrity of the battery and that it is secured in to the drone correctly – on the M300 there is now a safety clip that secures the batteries in place and the drone will not allow a pilot to start the motors or take-off unless this clip is in place.*
- *The M300 also displays wind speed and wind direction in the pilot app (in metres/second) whilst flying so all our pilots are aware of the maximum operating limits and are trained to keep an eye on this during flight.'*

Visual Line of Sight (VLOS) rules

The UAS Implementing Regulation (EU) 2019/947[5] states that:

> *'Visual line of sight operation' ('VLOS') means a type of UAS operation in which, the remote pilot is able to maintain continuous unaided visual contact with the unmanned aircraft, allowing the remote pilot to control the flight path of the unmanned aircraft in relation to other aircraft, people and obstacles for the purpose of avoiding collisions.'*

The CAA's document on *'Unmanned Aircraft System Operations in UK Airspace – Guidance'* (CAP 722)[6] provides the following additional guidance on VLOS in section 2.1.1:

> *'Operating within Visual Line of Sight (VLOS) means that the remote pilot must be able to clearly see the unmanned aircraft and the surrounding airspace at all times while it is airborne. The key requirement of any flight is to avoid collisions and a VLOS operation ensures that the remote pilot is able to monitor the aircraft's flight path and so manoeuvre it clear of anything that it might collide with. While corrective lenses may be used, the use of binoculars, telescopes, or any other forms of image enhancing devices are not permitted. Putting things in very simple terms, when operating VLOS, the aircraft must not be flown out of sight of the remote pilot's eyes.*
>
> *The CAA will normally accept that the VLOS requirement is met when the UA is flown out to a distance of 500 metres horizontally from the remote pilot, but only if the aircraft can still be seen at this distance.*
>
> *The 'operating height' is limited to a maximum distance of 400 feet (120 metres) from the closest point of the earth's surface (see para 2.1.1.1 below). Operations at a greater distance from the remote pilot may be permitted if an acceptable safety case is submitted. For example, if the aircraft is large it may be justifiable that its flight path can be monitored visually at a greater distance than 500 metres. Conversely, for some small aircraft, operations out to a distance of 500 metres may mean it is not possible to assure or maintain adequate visual contact, and so the aircraft must obviously be kept closer to the remote pilot.'*

The CAA were asked why a figure of 500 m was chosen as the normally acceptable distance for VLOS. The CAA stated that it was not based on any calculations of size of a typical UAS at that distance, but rather it was a '*pragmatic anchor point'* in guidance from one of their UAS policy experts.

The CAA were of the view that if you needed to rely on the controller screen to determine the UA's orientation then that would not satisfy VLOS rules.

Footnote

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0947 [Accessed 18 February 2022]
[6] CAP 722, Eighth Edition, 5 November 2020

The Matrice M210 has dimensions of 0.51 x 0.51 x 0.38 m without the propellers. Its height is 0.38 m so when it is flying level and viewed from a distance, it presents a profile of 0.51 m by 0.38 m. At a horizontal distance of 500 m this dimension would present an angular size of 0.06° by 0.04°[7]. On a piece of paper held at a normal reading distance[8] of 35 cm, the size of the Matrice can be represented by a small square of dimensions 0.4 by 0.3 mm.

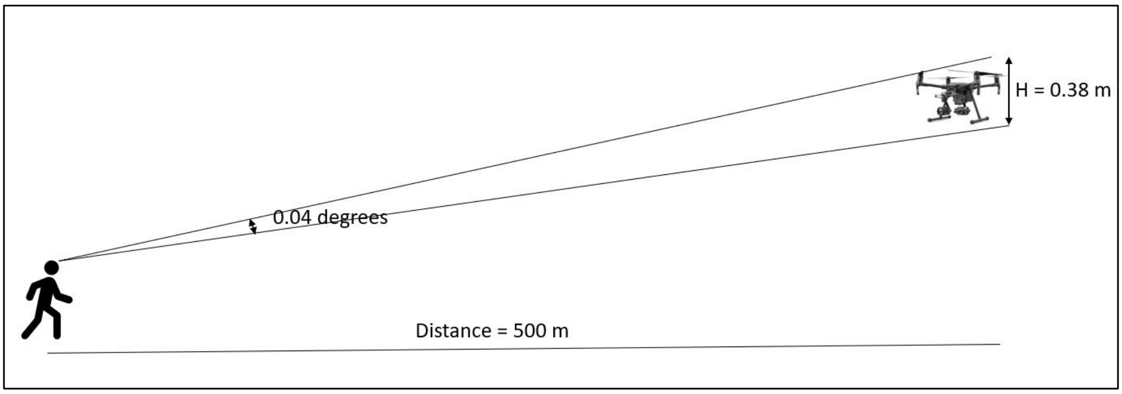

Figure 4

Angular height of Matrice M210 at a distance of 500 m

UAS manufacturer support

The UAS manufacturer has provided support to this investigation and has assisted in analysing some of the data. However, a number of follow-up questions were posed to the UAS manufacturer in July 2021 which had still not all been answered by December 2021 despite multiple chases. In a report on a DJI Matrice 200 accident[9], published on 18 February 2021 the AAIB issued the following safety recommendation to the manufacturer:

> **Safety Recommendation 2021-016**
>
> It is recommended that DJI introduce an effective system for providing timely technical support to State safety investigations.

The manufacturer's response on 30 June 2021 included the following:

> *'DJI has over the past 15 years developed and refined drone technology that has been widely adopted by professional and recreational users alike. Based on our user experience data, we estimate there are tens of millions of drone flights every year. Since no one in the world has ever died as a result of a drone flight,*

Footnote

[7] How to calculate angular size is explained in https://www.open.edu/openlearn/science-maths-technology/the-sun/content-section-3.2 [Accessed 18 February 2022]

[8] Normal reading distance from https://www.ncbi.nlm.nih.gov/books/NBK423833/ [Accessed 18 February 2022]

[9] Link to report: https://www.gov.uk/aaib-reports/aaib-investigation-to-dji-matrice-200-v1-uas-registration-n-slash-a-210919 [Accessed 18 February 2022]

this means the accidental fatality rate for drones is zero – making it the safest form of aviation the world has ever known.

While this and other data reaffirms our conviction that our products are safe and reliable, we have long believed that incidents and accidents involving drone safety must be investigated to understand their causal factors. DJI routinely participates in regulatory efforts around the world to gather safety data on drone performance, study drone safety factors in academic experimentation, and investigate drone incidents.

As previously discussed, DJI has introduced a process for how to coordinate our different teams, gather information systematically under firm timelines, and ensure we can respond appropriately. DJI's main contact point for AAIB will remain our European Policy team, which will coordinate internal investigations and occasionally organize direct meetings or exchanges between AAIB and the expert engineering teams.'

On 3 December 2021 the AAIB had a meeting with the DJI's European point of contact. They said they had developed additional new processes to improve the timeliness of responses to AAIB questions for future investigations.

Analysis

Cause of the fly away accident

The fly-away event was caused by a number of factors. Battery 1 became disconnected shortly after takeoff which resulted in the UA being powered by Battery 2 alone. The cause of the battery disconnection could not be determined, but the battery functioned normally when fitted to another UA so it is probable that it was not fully pushed into place before takeoff.

The battery disconnection meant that the UA sensed a large drop in total battery capacity which triggered a restriction in its pitch limit and therefore its top speed. From the data the pitch limit appeared to be about 15°.

The wind at 400 ft increased beyond the 24 mph speed forecast by the pilot's UAS weather forecast app. The wind reached a calculated peak of 39 mph, but varied mainly between 25 mph and 35 mph. The UA's top speed in P-mode was either 35.8 or 38 mph. If it had been able to achieve 38 mph then it would not have drifted away in the wind. Even at a top speed of 35.8 mph there were periods when it would have made progress back towards the home point. However, with the restricted pitch attitude that was about 10° less than normal, this was not possible. The pilot's attempt to use S-mode as per the operator's emergency procedure did not allow an increase in speed as the restricted pitch limit also applied in S-mode.

The UA drifted beyond visual line of sight and communication was lost which meant that a recovery was no longer possible. The UA could not auto-return-home due to the wind.

When the battery 2 level dropped to 23% the UA entered an auto-land mode but was unable to avoid the wall of a house resulting in damage to the propeller blades and a subsequent impact with the balcony. If the balcony had been occupied, people could have been seriously injured by the propeller blades.

The following were contributory factors to the accident:

Awareness of the wind speed

The wind at 400 feet cannot be directly measured so the pilot was reliant on a wind forecast. The forecast was for a wind 3 mph below their operational limit and the manufacturer's limit. The pilot believed that S-mode would give him a top speed of 51 mph, so he may have considered that he had a significant safety margin if the wind increased beyond the forecast. But with both camera gimbals fitted the speed limit was 40.3 mph. However, this was still higher than the peak wind of 39 mph so recovery would still have been possible.

The pilot also believed that he would receive a wind warning that would tell him to land if the wind increased excessively. He reasonably interpreted the '*High Wind Velocity. Fly with caution'* message to mean that he could continue the flight. The user manual does not provide any information on the alert messages that can appear, or the appropriate actions to take.

The manufacturer appears to have used the same message for both a Level 1 and a Level 2 wind warning, causing confusion to the remote pilot on the action to take. The manufacturer had set a wind limit of 27 mph, and therefore the Level 2 wind warning should have advised the pilot to land as soon as possible. Therefore, the AAIB makes the following Safety Recommendation:

Safety Recommendation 2022-001

It is recommended that DJI amend the DJI Pilot and DJI GO4 apps to warn the remote pilot when the wind limit has been exceeded and that the UA should be landed as soon as possible.

The pilot is required to maintain visual line of sight with the UA and therefore could miss an alert message on the controller screen if they are concentrating on manoeuvring the UA visually. If messages related to safety of flight had an associated aural warning the pilot's attention could be drawn to them. Therefore, the AAIB makes the following Safety Recommendation:

Safety Recommendation 2022-002

It is recommended that DJI amend the DJI Pilot and DJI GO4 apps so that an aural alert is triggered when alert messages relating to safety of flight appear.

The pilot's awareness of the wind would also be improved if the controlling apps displayed the wind speed that is calculated by the UA. This is a feature on the newer Matrice 300 series UAS.

Awareness of the pitch attitude restriction

Neither the operator nor the pilot was aware that below a certain total battery SOC, the aircraft's pitch attitude is restricted to about 15°, 10° less than normal, and 15° less than in S-mode; and that this results in a lower top speed. These facts are not mentioned in the UAS user manual or on the manufacturer's website. The limit is also triggered at a total battery capacity level which is not displayed to the pilot. The total battery capacity figure had logic to ignore the capacity of battery 1 which was not connected, whereas the DJI Pilot app only displayed two separate battery levels, and battery 1 was still showing 97%.

Operators and pilots need to be made aware of the pitch attitude limit, the reduced speed limit, and at what battery levels this is triggered. Otherwise, more operators will be caught out by stronger than forecast winds. Therefore, the AAIB makes the following Safety Recommendation:

Safety Recommendation 2022-003

It is recommended that DJI amend the Matrice 200 series user manual to provide information on the pitch attitude limiting system, including the new maximum speed which results from the limit, and the battery level at which it triggers; and communicate this change widely to pilots and operators.

Visual line of sight rules

The VLOS regulation requires the pilot to maintain '*continuous unaided visual contact'* with the UA which allows them to control the flight path in order to avoid collisions. To be able to take avoiding action to avoid a collision a pilot needs to know the orientation of the UA. At a certain distance the UA will appear as just a dot in the sky with no orientation information apparent. The pilot might recall which orientation it is in so can take rapid avoiding action, but if they lose track of its orientation then accurate and rapid flight path control becomes impossible. The regulation requires interpretation to establish the acceptable distance for VLOS. CAP 722 is designed to provide guidance to help pilots interpret the regulation and provide guidance on safe practices. CAP 722 states that:

> *'The CAA will normally accept that the VLOS requirement is met when the UA is flown out to a distance of 500 metres horizontally from the remote pilot, but only if the aircraft can still be seen at this distance.'*

It is not clear why the CAA considers 500 m as a normally acceptable distance. A distance cannot be considered normally acceptable without specifying what a normal size is, which CAP 722 does not do. CAP 722 emphasises the importance of being able to avoid collisions but does not state anything about the importance of being able to recover the UA from that distance following a loss of position holding or telemetry. The smaller the apparent size of the UA in the sky the more difficult it will be to recover it manually, particularly in strong winds.

The operator had adopted a distance of 500 m for their VLOS operations in part because of the CAA's guidance in CAP 722. The Matrice M210 was the largest UA they operated at the time, and they accepted that its orientation could not be seen at that distance - at 500 m it has an apparent size of just 0.4 by 0.3 mm on a piece of paper held at normal reading distance. It is not entirely clear from the regulation or CAP 722 whether this is acceptable. The operator now trains its pilots to manually recover their UA from 500 m under manual mode without use of telemetry which helps to mitigate the risk, but this guidance on training is not in CAP 722.

Therefore, the AAIB makes the following Safety Recommendation:

Safety Recommendation 2022-004

It is recommended that the Civil Aviation Authority review the Visual Line of Sight distance figures in CAP 722 and amend the guidance to make it clear that just being able to see an unmanned aircraft is not sufficient for Visual Line of Sight operations and that pilots need to be able to demonstrate that at the distance they are flying, they can manoeuvre it rapidly to avoid a collision and can also land the unmanned aircraft safely following a loss of position-holding without reference to video or telemetry.

Conclusions

The fly away accident was the result of the following main causal factors:

1. Battery 1 became disconnected shortly after takeoff which reduced the UA's maximum pitch attitude and maximum speed.
2. The pilot did not notice that the 'battery communication' message included the words '*land as soon as possible'*.
3. When the wind measured by the UA exceeded the manufacturer's wind limit the alert message to the pilot advised him to '*fly with caution'* instead of to '*land as soon as possible*'.
4. The wind at 400 ft was stronger than forecast and at times above the UA's restricted maximum speed so the pilot could not fly it back towards him.
5. The wind speed calculated by the UA was not displayed to the pilot on his controller app so he did not know that the wind limit had been exceeded.
6. After communication was lost, the UA entered an auto-land mode but it was unable to avoid colliding with a wall.

The following factors contributed to the accident:

1. The pilot and operator were not aware that the UA's maximum pitch attitude and maximum speed were restricted at low battery levels as this information is not in the UAS user manual.
2. The pilot may have missed the '*land as soon as possible'* part of the battery message because it did not stay visible for long enough. An aural alert may have helped draw the pilot's attention to the seriousness of the message.
3. The disconnected battery was still showing a high SOC instead of showing zero or blank which would have been a clearer indication of a battery issue.
4. The pilot probably did not fully push battery 1 into place and the UA was not fitted with a battery safety clip which is a new part on the updated version of the UA.
5. The pilot's decided to launch from a position that would require flying downwind in a wind that was close to limits.

The operator has taken steps to mitigate the risks for future flights and has retired its Matrice M210 UA and replaced them with updated Matrice 300 series UA which have a battery safety clip and display wind speed on the controller app. Three Safety Recommendations have been made to the manufacturer.

The issues identified with the guidance on VLOS in CAP 722 were not a direct factor in this accident as the UA may not have been recoverable at a closer distance; however, the guidance should be improved to help reduce the chance of other types of VLOS fly away accidents which could result in injuries to people.

Published: 7 April 2022.