ACCIDENT

Aircraft Type and Registration:	DJI Matrice M210 RTK, (UAS, registration n/a)	
No & Type of Engines:	DJI 3515 Electric motors	
Year of Manufacture:	2017 (Serial No: EK290958468403)	
Date & Time (UTC):	14 January 2019 at 1103 hrs	
Location:	Colwyn Bay, Conwy	
Type of Flight:	Aerial Work	
Persons on Board:	Crew - N/A	Passengers - N/A
Injuries:	Crew - N/A	Passengers - N/A
Nature of Damage:	Extensive damage to aircraft and payload	
Commander's Licence:	Other	
Commander's Age:	32 years	
Commander's Flying Experience:	21 hours (of which 4 were on type) Last 90 days - 4 hours Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the remote pilot	

Synopsis

The unmanned aircraft system (UAS) was fitted with a third-party lidar[1] pod for its planned survey mission which involved flights of around 8 minutes duration. As it commenced its pre-programmed route, it appeared to continue to climb above the 30 m height that had been set. The remote pilots observed that is was too high and attempted to land it immediately. The aircraft appeared unresponsive to the remote pilot's inputs and it then commenced an uncontrolled descent, rapidly increasing speed, until it struck the ground.

History of the flight

The same aircraft and lidar pod had been used to conduct two test flights three days previously. These flights were flown without incident.

On the day of the accident flight, the remote pilots established a suitable launch and recovery area and attached the third-party lidar pod to the aircraft, Figure 1. After completing pre-flight checks on the hardware, a flight was plotted and checked on the autonomous flight app being used to control the flight.

Footnote

[1] Lidar is a surveying device that uses laser light to measure distances.

Figure 1

UAS with third-party lidar pod attached prior to flight

The aircraft was launched using the app and it initially ascended as expected, but then continued to climb to an estimated altitude of 70 m, which was above the 30 m maximum altitude that had been set. The remote pilots discussed this and checked the available data whilst maintaining visual contact with the aircraft. Both the remote control and the app indicated that the aircraft was at an altitude of 28 m.

The remote pilots recalled that the app reported a "critical battery/current error" or similar and decided to land the aircraft immediately by selecting the RETURN TO HOME on the remote control. The app confirmed the request and LAND was selected.

The aircraft appeared unresponsive and the remote pilots attempted to verify it was descending. The remote control and app indicated that it was at 28 m and 27 m, respectively, and the battery levels were OK, indicating between 85 to 100 %.

The aircraft then began to descend, rapidly increasing in speed until it struck the ground, causing substantial damage to it and the payload. There were no injuries or other damage.

Recorded information

The flight data stored by the aircraft was not available. It is possible that it may have been lost had the aircraft had been powered up again after the accident flight. However, a limited data set was available from the autonomous flight app.

This data showed that 14 seconds into the flight the motors were under heavy load - high current draw, and the battery voltage dropped to around 3V in each cell. A notification 'BATTERY VOLTAGE (20.556V) IS TOO LOW AT 84% - FAILURE MAY BE IMMINENT' was displayed.

The flight mode then changed to AUTO LANDING and it descended to 30 m, the voltage stabilised once it had levelled at this altitude. It then commenced a descent at less than 5 m/s.

The flight mode then changed to P-GPS (positioning mode), possibly as a result of manual control being taken, and it then climbed slightly and reached a maximum speed of 13.9 mph before commencing a rapid descent.

During the majority of the flight, the sonar (ultrasonic) altitude indicated between 0.3 ft and 1 ft and only when the speed started to increase, during the last 3 seconds of the flight, did the sonar altitude increase to 11.5 ft before there was a loss of this data for the last 1.5 seconds of the flight.

Aircraft information

The Matrice M210 RTK UAS has a maximum takeoff weight of 6.14 kg specified.

The aircraft has a positioning mode, 'P-mode' or 'P-GPS'. In this mode it uses GPS signals and its forward and downward vision systems to locate itself, automatically stabilise, and navigate between obstacles.

The downward looking vision system consists of a stereo vision sensor and two ultrasonic sensors which it uses to help the UAS maintain its current position. The system is mounted on the underside of the main body and the fields of view are shown in Figure 2.

The lidar pod was supplied by a third-party company and was designed so that the downward view of the vision system was not obstructed by the pod or its mounting.

The pod was powered by a battery pack which, for this flight, had been attached to the end of the pod. There was a cable and connector connecting the battery to the pod. The installation can be seen in Figure 1.

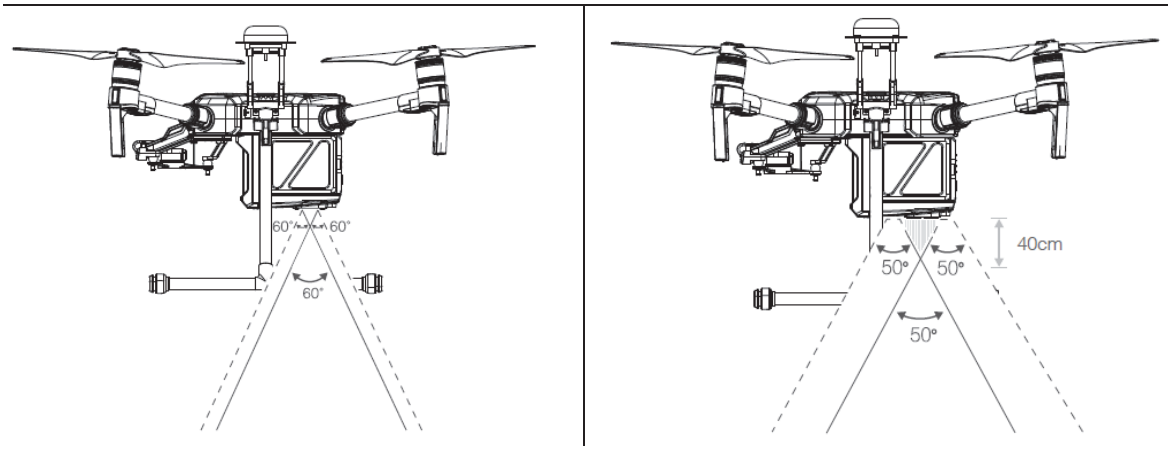

Figure 2

Field of view depiction, ultrasonic sensors (left) and stereo vision system (right)

Autonomous flight app

The app being used to control the flight was '*Litchi for DJI Drones*' and had been selected by the UK agent for use with the lidar. It was reported that this app offered the opportunity for a higher quality point cloud to be generated by the lidar, than by other apps, due to the way it managed corners on the planned route. The app developer's website listed a number of UAS' that were compatible with the app, but the accident type was not one of them.

The UK agent reported that they had been successfully using this app for some time with this type of UAS.

Weight and balance

The supplier of the lidar pod provided a weight calculation for the operating company as follows:

> *'M200/210 with single gimbal mount, lidar GPS, blades, TB50 battery = 4.15 kg*
>
> *M200 M8 lidar = 1.75 kg*
>
> *M8 lidar 2.7 amp power pack = 0.2 kg*
>
> ***AUW M200/210 with Lidar 6.1 kg'***

The UAS operator advised that they had specifically chosen the smaller capacity, and weight, TB50 batteries to maximise payload, as they were aware that with the lidar pod the UAS would be close to its maximum specified weight.

The AAIB asked the operator to weigh an equivalent aircraft fitted with the TB50 batteries. This was done using bathroom-type scales, which indicated a weight of 4.4 kg. The UAS manufacturer's website indicated the M210 RTK weight to be 4.42 kg with the TB50 battery.

If the total weight is calculated using the measured weight of the UAS, and the stated weight of the pod and battery pack, the ready to fly weight for the accident flight was 6.37 kg. This is above the maximum 6.14 kg specified by the manufacturer.

Meteorology

The wind was from 320° at 11 kt (5.8 m/s). The visibility was good, with some cloud cover and no precipitation. The temperature was 8.6 ºC and the QNH 1022 hPa.

Other information

There are no regulatory standards for compatibility testing of third-party equipment and software when used with a UAS.

Analysis

Due to the lack of detailed recorded data, it was not possible to determine the cause of this accident. There are, however, some points for discussion.

The aircraft was being operated at above its maximum specified operating weight. The autonomous flight software being used commanded a rate of ascent, this would lead to a high current draw as the electric motors work to achieve the programmed performance with the overweight aircraft. The high current draw seen during ascent may have led to the low battery voltage and its warning. The battery voltage recovered once the UAS had levelled and the electrical load reduced.

Although the lidar pod had been designed not to obscure the downward looking sensors, the data suggests that the ultrasonic sensors were picking up an obstruction between 0.3 ft to 1 ft range. This could have been the red and black cable and connector, seen below and to the side of the main body in Figure 1. This unsecured cable could have been blown in to the sensors field of view by the downdraft from the propellers. The obstruction appears to move when the speed increased, perhaps due to a change in airflow which may have moved the cable out of view.

The change to P-GPS mode approximately 3.2 seconds before the end of the flight and prior to the uncontrolled descent could suggest that manual control was unintentionally taken, and not realised, by the remote pilots.

The autonomous flight app being used did not list this type on its list of compatible UAS.

In the absence of any regulatory requirements, it is incumbent on UAS operators and remote pilots intending to add third-party equipment to a UAS to ensure that the equipment and any apps that are being used will not adversely affect the operation of the UAS in any way.

This accident appears to be in part due to the aircraft being operated above it's maximum specified takeoff weight. It would therefore be prudent if UAS operators and remote pilots, perhaps as part of the pre-use assessment of third-party equipment, check the actual weight of the intended combination to ensure operating limitations are not exceeded.

Conclusion

The aircraft was being flown with a payload which unintentionally meant it was being flown above its maximum specified weight. This could have caused the high load on the batteries which may have been the reason for the battery warning during its ascent. In response to this warning the remote pilots commanded a return to home which the UAS initially followed, but it then transitioned to a manual P-GPS mode and entered an uncontrolled descent to the ground. The autonomous flight app being used did not list this type on its list of compatible UAS'.

Safety actions

The UAS operator is updating its procedures to include the following checks:

1/ Before any new aircraft / payload combination is flown, its actual weight will be established and recorded, by weighing, to ensure it is within specified limits.

2/ Before any new app or software is flown, confirmation, in writing, of its compatibility with other equipment by either the airframe manufacturer or the app developer is required.