ACCIDENT

Aircraft Type and Registration:	Evolve Dynamics Sky Mantis	
No & Type of Engines:	4 electric motors	
Year of Manufacture:	2020 (Serial no: ED-SKM-2020-08-030)	
Date & Time (UTC):	25 July 2022 at 1300 hrs	
Location:	St Albans, Hertfordshire	
Type of Flight:	Commercial Operations (UAS)	
Persons on Board:	Crew - N/A	Passengers - N/A
Injuries:	Crew - N/A	Passengers - N/A
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Other	
Commander's Age:	52 years	
Commander's Flying Experience:	20 hours (of which 8 were on type) Last 90 days - 3 hours Last 28 days - 0 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The unmanned aircraft fell to the ground from a height of 20 m due to a loss of electrical power. This was caused by separation of electrical connections due to thermal damage of the UA and battery connectors. Damage was also found to the batteries fitted during the three previous flights.

The manufacturer has updated the Sky Mantis Operating Manual to highlight the need to check the aircraft and battery connectors during pre-flight checks.

History of the flight

The Evolve Dynamics Sky Mantis UAS was being operated in support of emergency services that were tackling a building fire in St Albans. The UA had successfully completed two flights at the site and was about 13 minutes into its third flight when, from a height of about 20 m, it suddenly fell to the ground. The aircraft was destroyed (Figure 1). The operator had a 200 m cordon in place and was operating the aircraft overhead waste land. No persons were injured.

The UAS operator had purchased the aircraft in 2020, which was supplied with five batteries. The operator's procedures required that a weekly check flight was performed, which took place on the morning of the day of the accident. The aircraft's battery was replaced prior to each flight on the day. These are referred to as 'check flight', 'flight 1',

'flight 2' and 'accident flight' batteries in this report. The pilot stated that he did not notice anything unusual during his checks of the aircraft between flights.

Figure 1

Sky Mantis after the accident

Aircraft information

The Evolve Dynamics Sky Mantis is an electrically powered, 7.5 kg quadcopter UAS designed for use by the emergency services sector. Lift and propulsion are provided by four electric motors mounted at the end of fuselage arms which drive two-bladed propellers.

Aircraft electrical power is provided by a 34Ah Lithium-ion battery (Figure 2). This is fitted into the rear of the aircraft and secured in place using a locking mechanism, which provides a visual indication when it is correctly latched. The battery charge level is displayed using four LED's that are fitted adjacent to the latches on the rear of the battery (Figure 3).

At the front of the battery is an electrical connector that mates with contacts inside the aircraft. This provides multiple paths for electrical power to be provided so that the loads can be evenly distributed. The connections on the battery are provided by pads that are held in place by thermoplastic composite material, and the corresponding mating pins inside the aircraft are spring loaded.

The aircraft may be stored with a battery fitted or removed. When removed, the battery compartment is open.

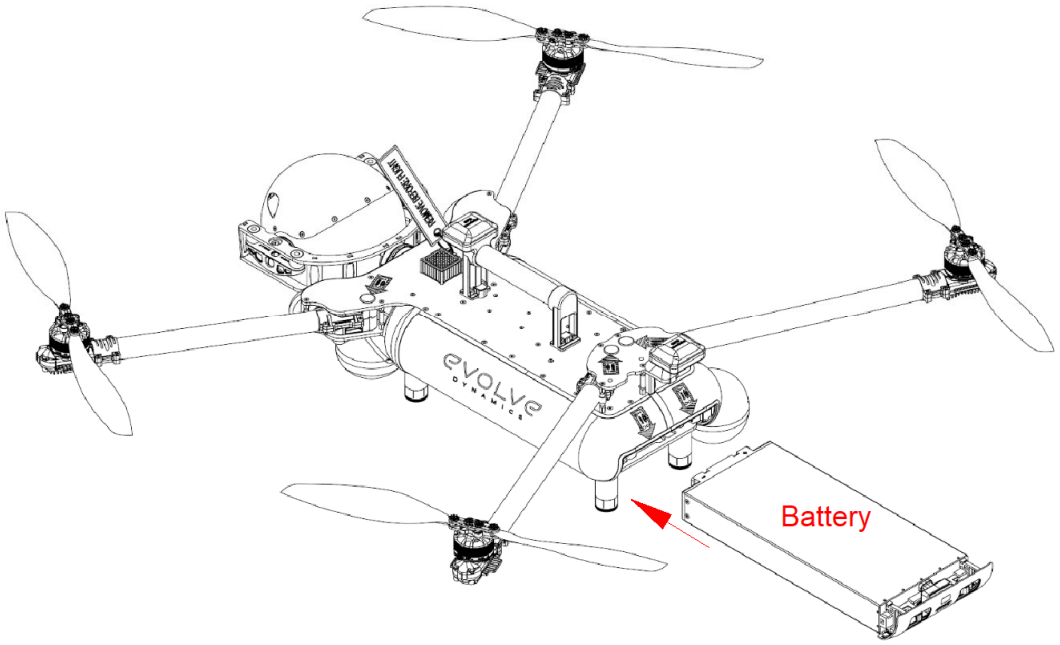

Figure 2
Sky Mantis battery insertion

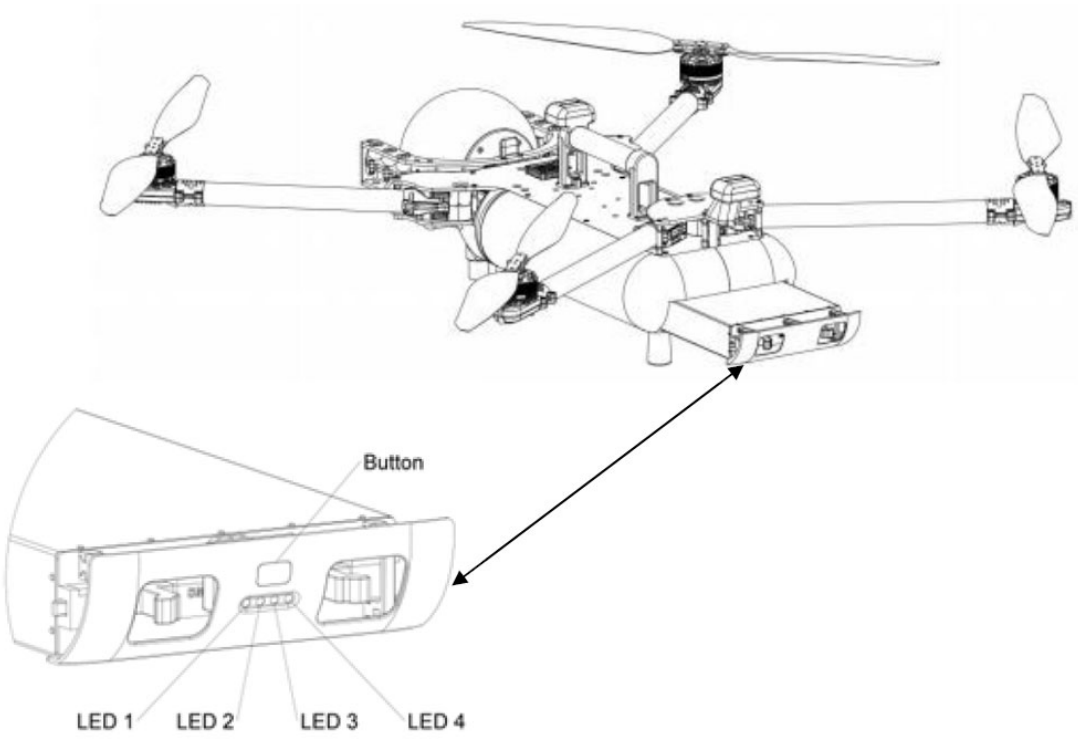

Figure 3
Sky Mantis battery charge indicator

Aircraft examination

The aircraft and its five batteries were examined by the manufacturer. This showed that the aircraft's battery connector had been extensively damaged by heat, which had caused 12 of its pins to collapse within the connector. The corresponding electrical connector pads on the flight 2 and accident flight batteries also showed varying levels of thermal damage (Figure 4). The flight 2 battery connector pads had receded slightly into the battery, and there were adjacent scorch marks. The accident flight battery was much more significantly damaged, with the pads having collapsed within the battery.

The contacts on the check flight and the unused fifth battery appeared undamaged, but the flight 1 battery showed evidence of scorching near one of its contacts.

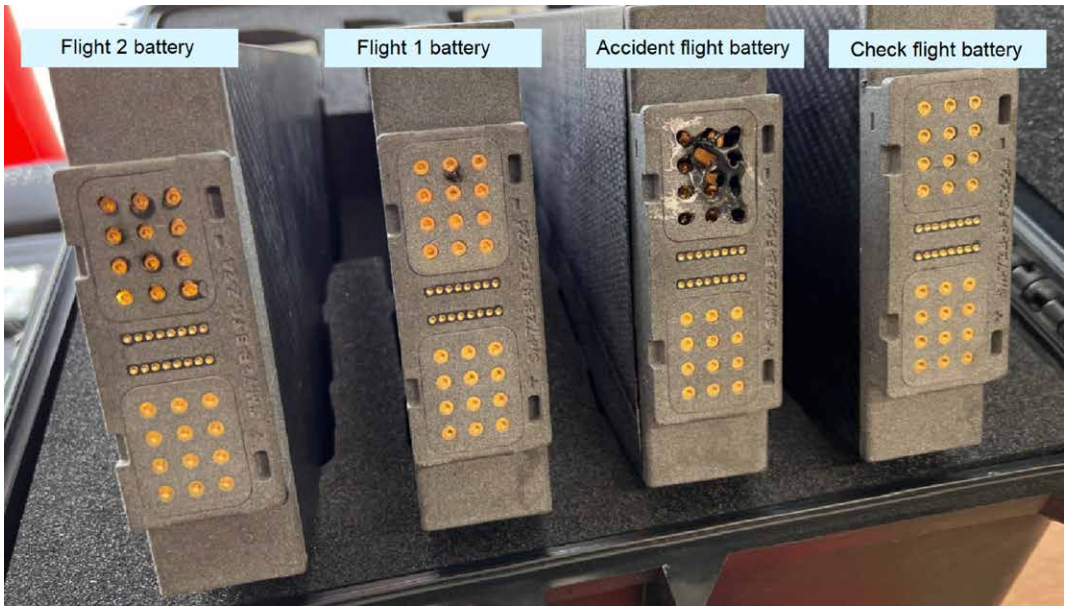

Figure 4

Damage to battery connectors

The manufacturer stated that that the damage to the connectors was a result of the number of pins in contact within the connector having been progressively reduced, which led to the electrical current through the remaining connections causing sufficient heat to distort the plastic of the connector. This led to the further loss of electrical load sharing between connections and additional heat, until the point where a complete loss of electrical power occurred. The recorded flight logs were also consistent with this, showing that at 13 minutes 27 seconds into the accident flight, there was a complete loss of electrical power. In the final minute of the flight preceding the loss of power, there were also several rapid fluctuations in the battery supply voltage and current flow to the aircraft. These were considered to be related to the connector starting to fail. A check of the battery charge indicator after the accident showed that it was at 75% charge remaining.

Due to the extent of the damage to the aircraft connector, it could not be established why its pin contacts had not been mating correctly with the battery connections. The manufacturer's

experience of the aircraft and battery connectors was that they had been reliable in-service, with only one other similar failure of the connector. However, this other occurrence had been due to a battery that had overheated whilst the aircraft was being operating at very high temperatures in a desert environment, and for a prolonged period at high loads. Possible wearing of the contacts was also considered but the manufacturer stated that they had a number of aircraft in service with much higher operating hours with no evidence of connector related issues. As part of its iterative development process, the manufacturer has now enhanced the design of the aircraft connector and the batteries to improve the electrical contacts, and so reduce the potential for heat damage.

Battery latching

In 2019 the AAIB investigated an accident[1] involving an Evolve Dynamics Sky Mantis UAS that had dropped to the ground from a height of 50 m when its electric motors stopped, despite the battery being fully charged. It was concluded that this was caused by the battery not being fully locked in place. The manufacturer subsequently changed the battery latch mechanism to provide visual confirmation that the battery was locked in place. This change had been applied to the batteries used by the operator of the accident aircraft.

Operational information

The manufacturer provides Operational Information to pilots/operators using an online system. At the time of the accident, this information included the requirement that pilots/operators were to '*Ensure before each flight that all parts are in good condition. DO NOT fly with damaged or worn parts'*. The manufacturer advised that this was intended to cover checks of the battery and aircraft connectors. Following the accident, the manufacturer amended the pre-flight checklist, by adding the following item: '*Aircraft and battery contacts clean and undamaged*'. The operator of the UAS has incorporated this into information and training it provides to its pilots.

Analysis

The aircraft lost electrical power in flight and fell to the ground because of separation of electrical contacts between the aircraft and battery connections. The separation was a result of a loss of structural integrity due to thermal damage to the connectors.

The small scorch mark on the flight 1 battery indicates that the battery connector on the aircraft had been damaged at some point prior to, or during, flight 1. It was not determined as to how this occurred, but it is possible that foreign object debris could have entered the open battery compartment prior to fitting the battery, or that the battery was not fully locked into place during this flight. Either possibility could have resulted in an increase in inter-contact resistances, causing temperature increases of the connector material that allowed pins to recede or be damaged. This damage eventually culminated in an electrical thermal run-away during the accident flight until pin separation occurred.

Footnote

[1] AAIB Bulletin 7/2019 https://www.gov.uk/aaib-reports/aaib-investigation-to-evolve-dynamics-sky-mantis-uas-registration-n-a [accessed November 2022].

The scorch mark on the flight 1 battery, and more extensive thermal damage evident on the flight 2 battery went unnoticed by the pilot during his checks between each flight.

Safety action taken

The manufacturer has updated the Sky Mantis Operations Manual to include an instruction during pre-flight to check that the aircraft and battery connections are clean and undamaged.