Australian Government
Australian Transport Safety Bureau

Collision with terrain involving Lockheed Martin Stalker XE UAS

Avoca Race Track, Victoria, 25 October 2016

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Aviation Occurrence Investigation
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Addendum

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Collision with terrain involving Lockheed Martin Stalker XE UAS

What happened

On 25 October 2016, an instructor was supervising students in the operation of a Lockheed Martin Stalker eXtended Endurance (XE) unmanned aerial system (UAS) (Figure 1) at the Avoca race track in Victoria.

Figure 1: Typical Stalker XE aircraft

Source: UAS manufacturer

At about 1700 Eastern Daylight-saving Time (EDT), the instructor reviewed the student's programmed mission and proceeded through the ground control station (GCS) launch wizard application. The launch wizard functions as a pre-flight checklist and ensures that all systems are ready for flight and that the mission is valid. The student then armed the aircraft for launch, pulled the aircraft back on the bungee cord and released the aircraft in accordance with the normal bungee launch procedures.

After release, the aircraft tracked straight ahead for 10 seconds according to standard operation, then climbed and commenced a right turn towards the first programmed waypoint. After passing the first waypoint, the aircraft made another right turn towards the second waypoint. About 20 seconds into the flight, the aircraft entered an uncontrolled descent from about 225 ft above ground level, and collided with the ground. The aircraft sustained substantial damage and no one was injured.

Manufacturer's investigation

Power failure

The aircraft was powered by a lithium polymer battery. A battery adapter cable was plugged into the aircraft's battery. The adapter cable was connected to the aircraft's main power cable via the main power (battery) connector. The main power cable was secured into a pocket at the back of the connector pin.

After the accident, the aircraft's negative main power cable was found to have separated from its pin in the connector.

The battery connector consisted of two mating pairs of contacts. In normal operation, all current flow passed through spring contacts on the male plug to the female contact. Spring tension increased the mating area and generated pressure upon the surfaces.

A different Stalker XE aircraft also experienced a battery connector failure about one month prior to this incident. In both incidents, the failed battery connector pins had the following problems:

- significant pitting and erosion of the outer quarter of the male contact
- heat damage to the spring contact surface
- loss of spring tension in most or all of the contact springs
- minor pitting of the outermost edge of the female contact.

It was determined that the capacitive load of the electrical system caused inrush current,[1] and the operator payload and communication links increased both the capacitive load and the power draw. The contact damage from the inrush current initiated the failure process. Sustained current, which produced contact heating, then removed the contact temper[2] and significantly degraded the connection. The manufacturer was able to duplicate the unsoldering failures via this mechanism.

The connector failure was likely the result of multiple factors:

1. Inrush current produced pitting, erosion and metal splatter on other contact surfaces.
2. The erosion and splatter then produced localised areas of very high current density.
3. The current density resulted in localised hotspots that removed the spring contact temper, which produced very high resistance on that spring contact.
4. The load was then distributed across the remaining spring contacts, compounding the failure rate.
5. Eventually the connector resistance was high enough that the normal operating current heated the solder joint until the solder melted and the circuit was interrupted.

The first steps probably took many flight cycles to develop, while the last probably required only seconds to a few minutes of normal operating current.

The separation of the negative main power cable from its pin in the main power connector interrupted electrical power to all of the aircraft systems. This included the autopilot, motor and control surface servos.

Uncontrolled flight

The flight data stopped suddenly at 225 ft – the subsequent lack of data logging indicated a power interruption to the autopilot.

Once battery power was lost, all systems in the aircraft were inoperative and any subsequent ‘flight’ was uncontrolled. Due to the loss of electrical power to the motor and the autopilot, the aircraft was unable to glide to a safe landing.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The main power connector pins had sustained degradation from arcing and high temperatures due to inrush current, resulting in increased resistance.

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1 Inrush current, input surge current or switch-on surge is the maximum, instantaneous input current drawn by an electrical device when first turned on (Wikipedia).

2 Tempering involves heating steel to a specific temperature to achieve certain properties such as hardness and elasticity and to remove brittleness.

- During the initial climb, high current across the increased resistance of the main power connector heated the negative pin to a temperature high enough to melt the solder on the negative main power cable.
- The separation of the negative main power cable from its pin in the main power connector interrupted electrical power to all aircraft systems, including the autopilot, motor and control surface servos.
- Due to the total loss of electrical power, the aircraft was unable to maintain normal flight or conduct a safe glide landing, therefore collided with the ground.

Safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following safety action in response to this occurrence.

Aircraft manufacturer

As a result of this occurrence, the aircraft manufacturer has advised the ATSB that they are taking the following safety actions with regard to Stalker XE aircraft:

- All battery connectors are being replaced and sacrificial pigtails are being added to the connectors, to be replaced after a number of connections.
- The aircraft battery circuitry is being modified to prevent arcing during connection and disconnection.

General details

Occurrence details

Date and time:	25 October 2016 – 1658 EDT	
Occurrence category:	Accident	
Primary occurrence type:	Collision with terrain	
Location:	Avoca race track, Victoria	
	Latitude: 37° 05.28' S	Longitude: 143° 26.18' E

Aircraft details

Manufacturer and model:	Lockheed Martin Stalker XE
Serial number:	241
Type of operation:	Aerial work – check & training
Aircraft damage:	Substantial

About the ATSB

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; and fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope, fact-gathering investigation was conducted in order to produce a short summary report, and allow for greater industry awareness of potential safety issues and possible safety actions.