UAS LIMITED OCCURRENCE INVESTIGATION REPORT – FINAL

Reference Number	CA18/2/3/10306								
Classification	Accident		**Date**	10 May 2023			**Time**	1940Z	
Type of Operation	Unmanned Aircraft System – Surveillance (Part 101)								
Location									
Place of Departure	Vrede, Free State Province		Place of Intended Landing		Vrede, Free State Province				
Place of Occurrence	Vrede, Free State Province								
GPS Co-ordinates	Latitude	27° 27' 16.6" S	Longitude	29° 08' 27.6" E			Elevation	5 561 ft	
Aircraft Information									
Registration	ZT-XVM		Class	3A					
Make; Model; S/N	Arace, Sirin (Serial Number: SIR0053)								
Damage to Aircraft	Substantial		Total UAS Hours	679.22					
Pilot-in-command									
Licence Type	Remote Pilot Licence (RPL)		Gender	Male		Age	29		
Licence Valid	Yes	Total Hours	352.98	Total Hours on Type		352.98			
Total Hours 30 Days	38.55		Total Flying on Type Past 90 Days	170.45					
People Controlling	1	**Injuries (On ground)**	0	**Fatalities**	0	**Fatalities (on ground)**	0		

What Happened

On 10 May 2023 at approximately 1914Z, an unmanned aircraft system (UAS) Arace Sirin with registration ZT-XVM was launched for security surveillance from a landing pad in Vrede, Free State province. The flight was operated under beyond visual line of sight (BVLOS) rules by night and under the provisions of Part 101 of the Civil Aviation Regulations (CAR) 2011 as amended.

The pilot reported that he conducted the pre-flight checks with no anomalies noted. He then armed and launched the UAS for the mission with 94% battery power at approximately 1914Z. The pilot took off in "alt hold" mode *(an assisted flight mode with altitude hold only. Use this mode carefully, especially in windy environment!)* and thereafter, switched to "auto" mode *(performing automatic mission)* at 69.9 feet (ft) above ground level (AGL). Twelve minutes into the flight, the UAS switched to return-to-launch (RTL) mode uncommanded, and the pilot switched it back to "auto" mode. For about 8 minutes, the pilot kept reverting to "auto" mode each time the UAS switched to RTL mode whilst on the mission. Twenty minutes after launch, the UAS switched to "critical battery" failsafe mode (land mode) and the pilot immediately cancelled the mode and switched back to "loiter" mode *(assisted flight mode with position and altitude hold)*. The UAS completed the mission after 26 minutes from the start of the flight, with approximately 39% battery power remaining. Whilst returning to the launch pad for landing, the pilot noted the "potential thrust lost" warning indication on the remote pilot station. The UAS experienced potential motor thrust loss on motor 2. The UAS disconnected from the remote pilot station before it crashed to the ground approximately 900 metres (m) from the launch pad. The pilot recovered the UAS,

which had sustained substantial damage to the landing gear and gimbal. There were no reported injuries to persons on the ground.

Figure 1: The aerial view of the accident site. (Source: Google Earth)

Figures 2 and 3: The UAS at the accident site (left), and after its recovery (right). (Source: Operator)

Source: Operating Manual for Arace Sirin

Stage1 – Low battery failsafe

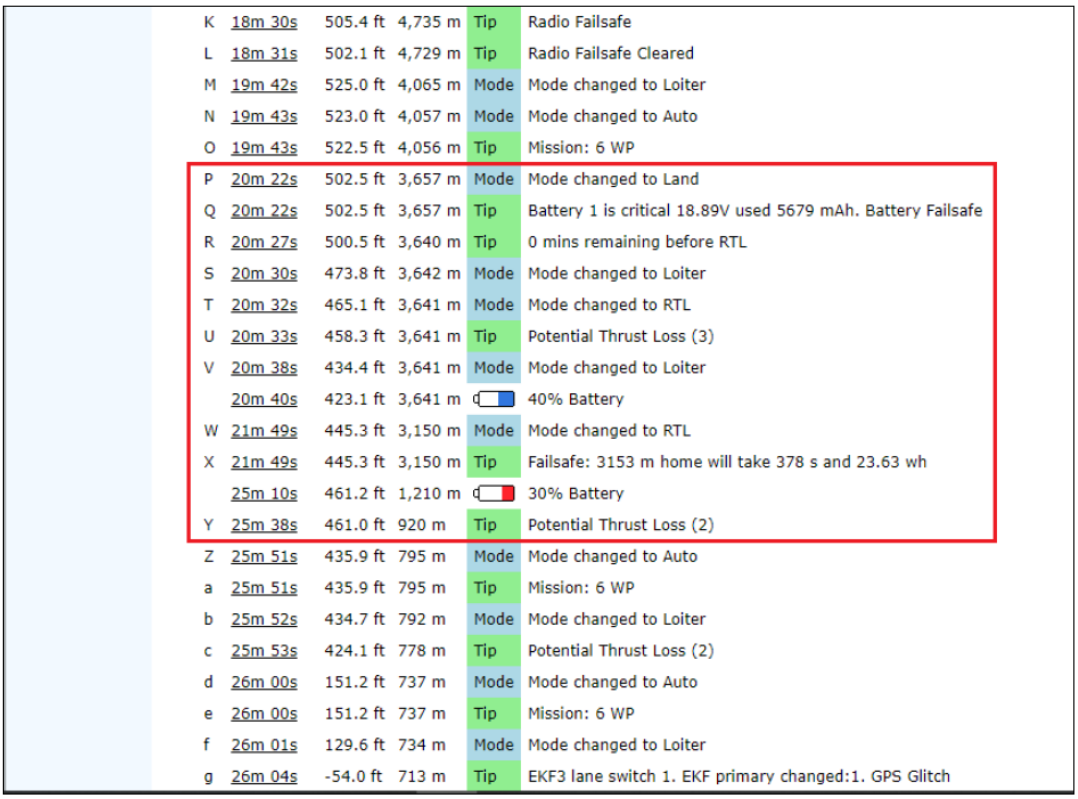
Low battery failsafe is triggered when flight battery voltage drops below 20V for at least 10 seconds. When low battery failsafe is triggered, Sirin will switch to Return To Launch (RTL) mode and starts to fly back to home location. (If current altitude is less than 65m than first it climbs to 65m then starts flying back). After reaching home location, Sirin will wait 5 more seconds above ground then performs auto landing and disarm.

Stage2 – Critical battery failsafe

Critical battery failsafe is triggered when flight battery voltage drops below 18,5V. When critical battery failsafe is triggered, Sirin will start landing immediately at its current location to reduce risk of uncontrolled falling and crash.

IMPORTANT NOTE! *After low battery or critical battery failsafe is triggered, it is always possible to switch mode back to (assisted flight mode with position and altitude hold) Loiter or (assisted flight mode with altitude hold only) Alt Hold mode by using the buttons below the (Liquid Crystal Display) LCD screen on the ground station. However, it is recommended to leave battery failsafe modes on because they are triggered to reduce risk of total power loss on flight battery!* ***Only switch mode in emergency cases (like there is an obstacle in the RTL path or there are people at the landing area)!***

Post-accident log analysis report was reviewed by the operator; it revealed the following:



K	18m 30s	505.4 ft	4,735 m	Tip	Radio Failsafe
L	18m 31s	502.1 ft	4,729 m	Tip	Radio Failsafe Cleared
M	19m 42s	525.0 ft	4,065 m	Mode	Mode changed to Loiter
N	19m 43s	523.0 ft	4,057 m	Mode	Mode changed to Auto
O	19m 43s	522.5 ft	4,056 m	Tip	Mission: 6 WP
P	20m 22s	502.5 ft	3,657 m	Mode	Mode changed to Land
Q	20m 22s	502.5 ft	3,657 m	Tip	Battery 1 is critical 18.89V used 5679 mAh. Battery Failsafe
R	20m 27s	500.5 ft	3,640 m	Tip	0 mins remaining before RTL
S	20m 30s	473.8 ft	3,642 m	Mode	Mode changed to Loiter
T	20m 32s	465.1 ft	3,641 m	Mode	Mode changed to RTL
U	20m 33s	458.3 ft	3,641 m	Tip	Potential Thrust Loss (3)
V	20m 38s	434.4 ft	3,641 m	Mode	Mode changed to Loiter
	20m 40s	423.1 ft	3,641 m		40% Battery
W	21m 49s	445.3 ft	3,150 m	Mode	Mode changed to RTL
X	21m 49s	445.3 ft	3,150 m	Tip	Failsafe: 3153 m home will take 378 s and 23.63 wh
	25m 10s	461.2 ft	1,210 m		30% Battery
Y	25m 38s	461.0 ft	920 m	Tip	Potential Thrust Loss (2)
Z	25m 51s	435.9 ft	795 m	Mode	Mode changed to Auto
a	25m 51s	435.9 ft	795 m	Tip	Mission: 6 WP
b	25m 52s	434.7 ft	792 m	Mode	Mode changed to Loiter
c	25m 53s	424.1 ft	778 m	Tip	Potential Thrust Loss (2)
d	26m 00s	151.2 ft	737 m	Mode	Mode changed to Auto
e	26m 00s	151.2 ft	737 m	Tip	Mission: 6 WP
f	26m 01s	129.6 ft	734 m	Mode	Mode changed to Loiter
g	26m 04s	-54.0 ft	713 m	Tip	EKF3 lane switch 1. EKF primary changed:1. GPS Glitch

Figure 4: The aircraft switched to “land” mode and the pilot cancelled it and switched to “loiter” mode. (Source: Operator)

Sequence of events:

At 19:14 UTC: The pilot armed the aircraft in "Alt Hold" mode and ascended to 69.9 ft AGL.
At 19:14 UTC: The pilot switched over to "Auto" mode and ascended further to 463 ft. AGL.
At 19:26 UTC: 12 minutes into the operation the aircraft switched to "RTL" due to a Radio Failsafe and the pilot immediately switched back to "Auto" mode.
At 19:34 UTC: 20 minutes into the operation the aircraft switched to critical battery failsafe (land mode) and the pilot immediately cancelled it and switched to "loiter" mode.
At 19:34 UTC: As the pilot was flying the aircraft to the home location, it had a potential thrust loss warning and started to descend rapidly.
At 19:40 UTC: The aircraft crashed into the ground.

The images below show individual battery cells of the UAS. It can be noted that cell 3 is damaged; and all four cells have a different cell percentage.

Figure 5: Cell 3 is at 0%. (Source: Operator)

Figure 6: Cell 5 is at 8%. (Source: Operator)

Figure 7: Cell 1 is at 17%. (Source: Operator)

Figure 8: Cell is at 24%. (Source: Operator)

1. The aircraft battery had a cell failure.
2. The pilot was flying waypoint missions (Auto mode).
3. The pilot cancelled the critical battery failsafe (Land mode).
4. The aircraft experienced a potential thrust loss.

Findings

1. The pilot was issued a Remote Pilot Licence (RPL) with visual line of sight (VLOS) and beyond visual line of sight (BVLOS) ratings on 19 June 2022 with an expiry date of 30 June 2024.

2. His Class 3 medical certificate was issued on 14 May 2022 with an expiry date of 31 May 2026 with no medical restrictions.

3. The remotely piloted aircraft systems maintenance technician was initially issued a licence on 21 June 2021 with an expiry date of 20 June 2023.

4. The operator was issued a Remote Pilot Aircraft Systems Operating Certificate (ROC) No. CAA/G1219D on 31 October 2022 with an expiry date of 31 October 2023.

5. The UAS was initially issued a Remotely Piloted Aircraft Systems Letter of Approval (RLA) on 7 April 2022 which was renewed on 27 February 2023 with an expiry date of 6 April 2024.

6. The UAS's last inspection was conducted at 674.00 total hours. It accumulated a further 5.22 hours since the last mandatory periodic inspection (MPI).

7. The downloaded logs showed that the pilot made inputs to the UAS which caused it to crash.

8. The UAS battery had a cell failure which likely caused an unstable power output, which resulted in multiple failure indications and a signal disconnection from the remote pilot station before it crashed.

9. The manufacturer rating for the battery is 500 cycles, however, the operator stated that they cannot measure the battery cycles. Therefore, they introduced a rule to the pilots at the beginning of this year that all batteries that are a year old or over should be tested.

Probable Cause

The UAS battery had a cell failure which likely caused an unstable power output that resulted in multiple failure indications and a signal disconnection from the remote pilot station before it crashed.

Contributing Factor

The pilot cancelled the "critical battery failsafe" mode.

Safety Actions

The operator issued the following recommendations and possible mitigations:
1. The pilot must follow Sirin Critical Battery Failsafe Procedure.
2. The pilot must check the batteries' cell-specific integrity before and after each flight.
3. The pilot must maintain situational awareness regarding on-screen vitals and flight modes.

Safety Messages

A substantial number of accidents and serious incidents were reported by the operator since the beginning of the year.
(1) The operator/manufacturer should consider reviewing the battery endurance of the UAS.
(2) The SACAA and the operator are to find common ground for a joint corrective action plan to reduce the high accident/serious incident rate at this operation.

About this Report

The decision to conduct a limited investigation is based on factors including whether the cause is known and the evidence supporting the cause is clear, the level of safety benefit likely to be obtained from an investigation and that will determine the scope of an investigation. For this occurrence, a limited

investigation has been conducted, and the Accident and Incident Investigations Division (AIID) has relied on the information submitted by the affected person/s and organisation/s to compile this limited report. The report has been compiled using information supplied in the initial notification, as well as from follow-up desk top enquiries to bring awareness of potential safety issues to the industry in respect of this occurrence, as well as possible safety action/s that the industry might want to consider in preventing a recurrence of a similar occurrence.

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011 and ICAO Annex 13, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and not to apportion blame or liability.

Disclaimer

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This report is issued by:
Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa