SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Section/division **Accident and Incident Investigations Division** Form Number: CA 12-57

LIMITED ACCIDENT INVESTIGATION REPORT

Reference Number	CA18/2/3/10036						
Classification	Accident	**Date**	2 September 2021		**Time**	0615Z	
Type of Operation	Remotely Piloted Aircraft Systems (Part 101)						
Location							
Place of Departure	Ghaamsberg, Northern Cape Province		Place of Intended Landing		Ghaamsberg, Northern Cape Province		
Place of accident	Ghaamsberg, Northern Cape Province						
GPS Co-ordinates	Latitude	S29º26'25"	Longitude	E18°59'44"		Elevation	4740ft
Aircraft Information							
Registration	ZT-WIV (Serial Number: M80DFK13030148)						
Model/Make	DJI M600 Pro						
Damage to Aircraft	Destroyed		Total Aircraft Hours		112.06		
Pilot-in-command							
Licence Valid	Yes	Gender		Male		Age	39
Licence Type	Remote Pilot Licence (Drone)						
Total Hours on Type	754		Total Flying Hours		754		
People On-board	0	Injuries	0	Fatalities	0	Other (On Ground)	0

What Happened

On Thursday, 2 September 2021, a pilot was flying a drone registered ZT-WIV, which took off from Ghaamsberg in the Northern Cape province on a survey flight. The pilot stated that during the return flight, the drone transmitted error messages indicating that the motors were reaching maximum speed allowed; this was followed by compass and inertial measurement unit (IMU) errors. The drone then disconnected, and the pilot lost display of all telemetry. The pilot lost visual of the drone as it impacted rocks at the base of the terrain it was surveying. The drone and the under slung payload were destroyed.

Figure 1: The drone at the base of the mountain. (Source: DC Geometrics)

Figure 2: MagArrow which was the payload. (Source: DC Geometrics)

Figure 3: This is how the payload was suspended on the drone. (Source: geometrics.com)

Description and operation of the drone (Source: DC Geometrics)

The drone bases its terrain following on an accurate digital terrain model being available. The navigation software relies on this entirely for safe flight over terrain. In flat or undulating terrain no real problem exists and the height of flight safety margin is more than sufficient, even if the shuttle radar topography mission (SRTM) or advanced land observation satellite (ALOS) satellite data is used. However, in mountainous terrain these datasets from satellites are not accurate enough and the required flying heights no longer provide them with the safety margin required.

The operator reported that their client supplied them with a Lidar terrain model with an inaccuracy of 2.5m in x, y, and z. Generally, this high-quality dataset should be fine to fly safely. Within the survey area, there are a few areas of gorges and cliff faces which, in close analysis, seemed to fall within the shadow of the Lidar and were averaged out, therefore, supplying incorrect information in small critical spots within the survey block. The operator used this information to follow the terrain accurately using their drone navigation planning software. In this case, the terrain model was out by 10m in some areas, according to their calculations. These areas were of enough height and vertical angle to conflict with the flying height, which probably resulted in the impact with the ground. The operator's navigation is based on placing waypoints at appropriate places for the drone to follow, point-to-point. The waypoints only 'look down' directly and give the drone the

height information based on this. In Figure 4, it can be seen that the terrain starts to vary more; and more waypoints are placed to ensure that the terrain is followed accurately. *The key point to notice is that the waypoints only look down*.

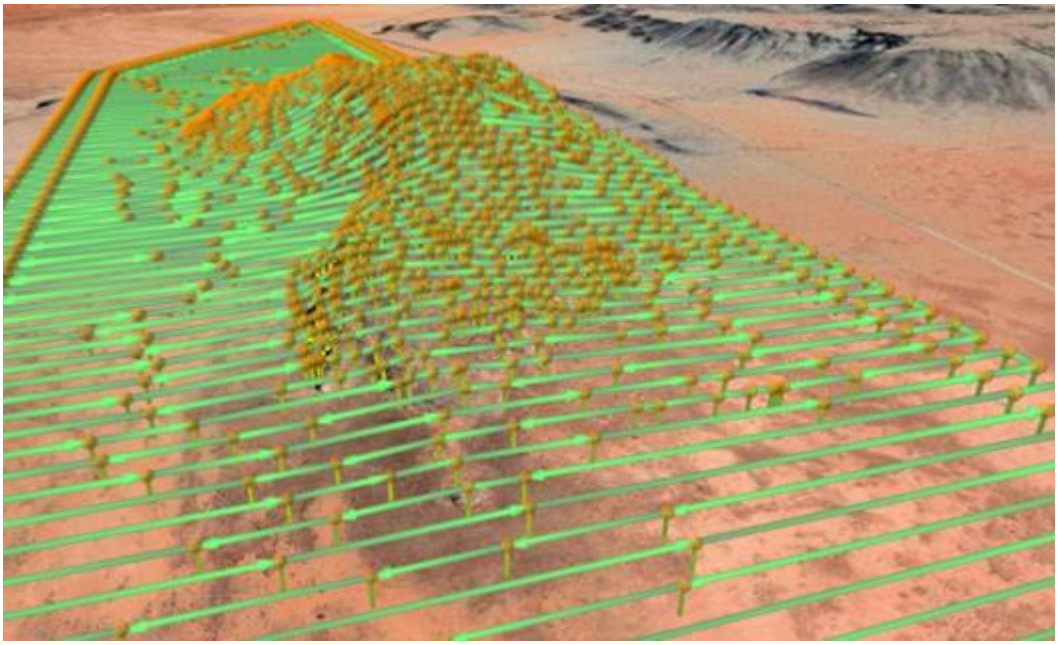

Figure 4: The terrain showing waypoints. (Source: DC Geometrics)

The pilot was in possession of a Remote Pilot Licence (RPL) issued on 3 January 2018. The pilot did his proficiency on 6 March 2020 with an expiry date of 31 March 2022. The pilot was in possession of a Class 4 aviation medical certificate which was issued on 3 November 2017 with an expiry date of 30 November 2022.

The pilot had flown remotely piloted aircraft system for 754 hours and had flown 32 hours in the 90 days prior to the accident.

Probable Cause:

Pilot lost sight of the drone, resulting in the drone colliding with the base of the mountain while returning to base (launch position).

Contributary Factor:

The client provided the operator with inaccurate data which the operator did not verify, resulting in inability of the drone's navigational software to deal with the vertical cliff faces or drop offs.

Safety Actions

New software has been developed that allows the operator to put tight parameters on the terrain and generate new surface of the earth within these parameters and, by so doing, avoid severe terrain where the Lidar might have incorrect data. The software will allow the drone to fly smoothly

over such areas while still allowing precise height control over flatter terrain. Here are some examples (Figure 5 images) the operator had generated from rough terrain and the outcome after they applied corrections.

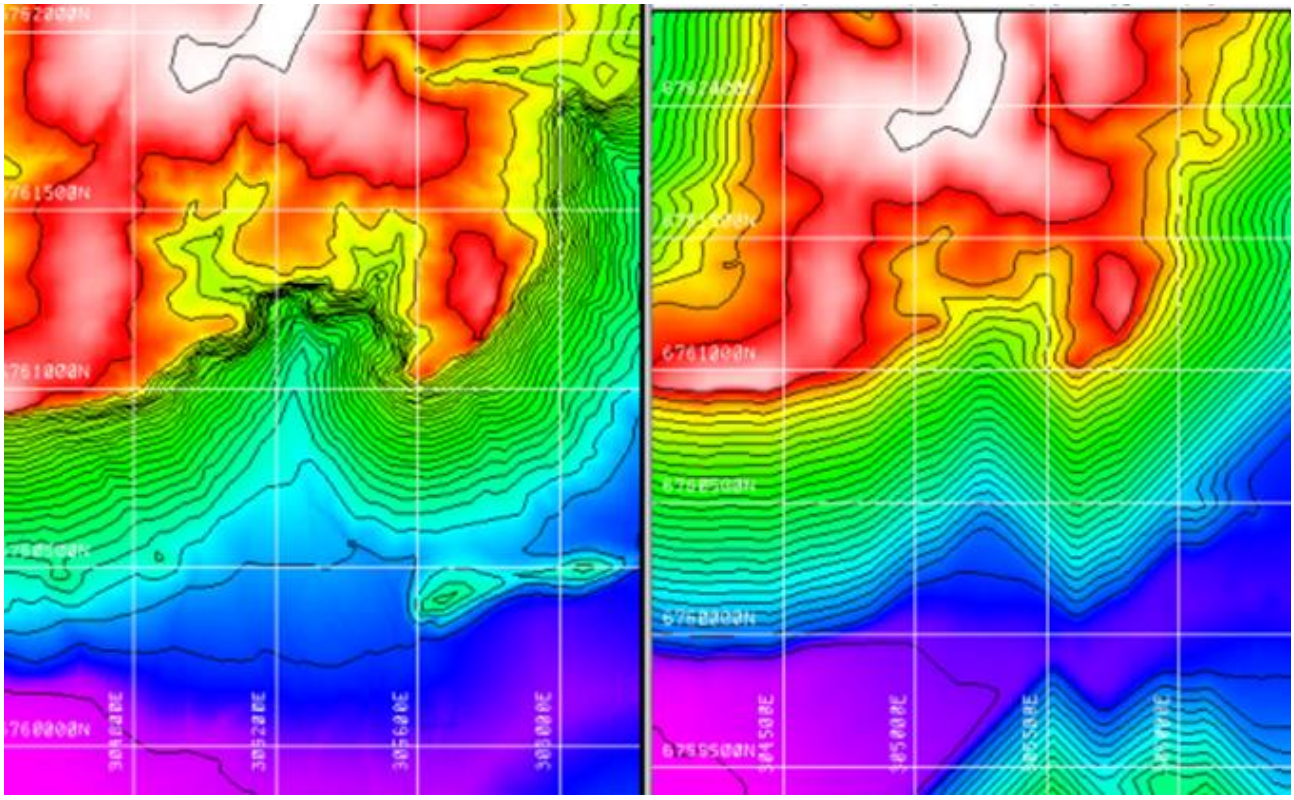

Figure 5: Contour map showing area layout. (Source: DC Geometrics)

Note the deep in the gorge in Figure 5 (left image); the terrain has very sudden vertical edges (contour interval 10m). In Figure 5 (right image), after correction of a predetermined maximum climb, speed and height control, the terrain model is smoothed out to allow the drone to fly very easily over this area. The client will need to accept that in these instances, the drone will be significantly higher above ground than the proposed flying height; safety will overrule the proposed height. The new waypoints will be generated based on this corrected surface. No attempt will be made to navigate the very steep terrain at all except when using the operator's version that has been generated.

The ground surface was adjusted to allow easy flying for the drone with no possibilities of obstacles. The climb and descent rates never exceed 40 degrees at any time. The drone will be programmed to start its climb or descent some distance before or after a steep edge to allow for this to occur. The operator believes that this software is a world first in the marketplace and will offer a real sense of satisfaction, not only to them (operator), but to their clients and insurers.

Safety Recommendation
It is encouraged that the operators must verify data and waypoints provided by their clients to have accurate Digital Terrain Model (DTM) to minimise risks and accidents.
Purpose of the Investigation
In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011, 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****.*
About this Report
Decisions regarding whether to investigate, 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, no 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 brief report. The report has been compiled using information supplied in the initial notification, as well as follow-up information 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 accident. *This report provides an opportunity to share safety message/s in the absence of an investigation.* *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.*
Disclaimer
This report is produced without prejudice to the rights of the AIID, which are reserved.

This report is issued by:

Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa