



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety

Central Region

August 22, 2021

INVESTIGATION SUMMARY

CEN21LA224

A. INVESTIGATION PARTICIPANTS:

Joshua Lindberg
Air Safety Investigator
National Transportation Safety Board

Shane Olson
Inspector
Federal Aviation Administration

Javier Caina
Director of Technical Standards
DJI

Jack Shen
General Manager - DJI Repair Center
DJI

B. ACCIDENT SUMMARY

On May 6, 2021, about 1045 eastern daylight time, a Dà-Jiang Innovations (DJI) Matrice 300 RTK small unmanned aircraft system (sUAS, commonly known as a drone), registration FA3HW43WTF, was involved in an accident near Young Harris, Georgia. The remote pilot in command (RPIC) sustained serious injuries. The flight was operated as a Title 14 *Code of Federal Regulations* Part 107 demonstration flight.

The purpose of the flight was to demonstrate for a potential customer the drone capabilities with a payload that consisted of a Zenmuse H20T camera and a Wingsland Z15 spotlight. The flight location was very close to a DJI GEO Zone designated as a “Restricted Zone.” According to DJI, in Restricted Zones, which appear red the DJI GO application, users will be prompted with a warning and flight is prevented. GEO Zones that prohibit flight are implemented around locations such as airports, power plants, and prisons.

After the accident, the RPIC stated that he was initially unaware of the Restricted Zone and never saw a notification on the remote controller during the flight. He added that he only discovered the Restricted Zone after a discussion with the NTSB. The RPIC stated that he performed a normal takeoff and flew the drone to the west over a wooded area about 393 ft above ground level (AGL). He stated that during the spotlight demonstration the drone was unresponsive to control inputs, so he utilized the return-to-home (RTH) function. During the RTH descent toward the home point the drone hovered about 7 ft AGL over a vehicle in the parking lot and was still unresponsive to any control inputs. When the drone would not land, the RPIC grabbed onto the landing gear and attempted to physically move the drone away from the vehicle. The drone resisted the physical displacement and maintained its position over the vehicle. The RPIC requested assistance from a demonstration attendee and handed him the remote controller. With guidance from the RPIC, he attempted several times to shut down the motors while RPIC held onto the landing gear with both hands. Finally, the RPIC attempted to remove the drone batteries when a propeller blade struck his right hand several times, which caused tendon and nerve damage. After the serious injury was sustained, the RPIC continued to hold onto the drone for several minutes until the batteries were exhausted and the motors stopped.

C. DETAILS OF THE INVESTIGATION

1.0 sUAS Information

Aircraft Model: Matrice 300 RTK / s/n: 1ZNDH3L0010562 / Registration: FA3HW43WTF
Aircraft Firmware version: v02.02.02.01 Release date: 2021/02/22

Note: The RPIC and operator stated that they believed the firmware was updated to v02.02.0301; however the data downloaded from the drone confirmed that it had not been updated and the most current version installed was v02.02.02.01.

Most current version? ☐ Yes ☒ No: v02.02.03.01 released on 2021.03.19

Note: This most recent firmware version did not include any updates that would have prevented this accident.

Batteries: Two TB60 Batteries

Weight: ~3.6 kg without batteries / ~6.3 kg with two TB60 batteries

Controller Model: DJI Smart Controller Enterprise / s/n: 1ZMLH3P00101DB

Controller Firmware version: Unknown / Release date: Unknown

Most current version? ☐ Yes ☐ No: Unknown / App: DJI Pilot

1.1 Airframe Damage

Two propeller blades chipped. No other damaged noted and all sUAS functions were normal.



Figure 1. Damaged propeller blades circled in red.

1.2 Accident Location



Figure 2. Restricted Zone highlighted in red and approximate accident location circled in yellow.



Figure 3. Accident location was just outside of DJI GEO Restricted Zone (prison)

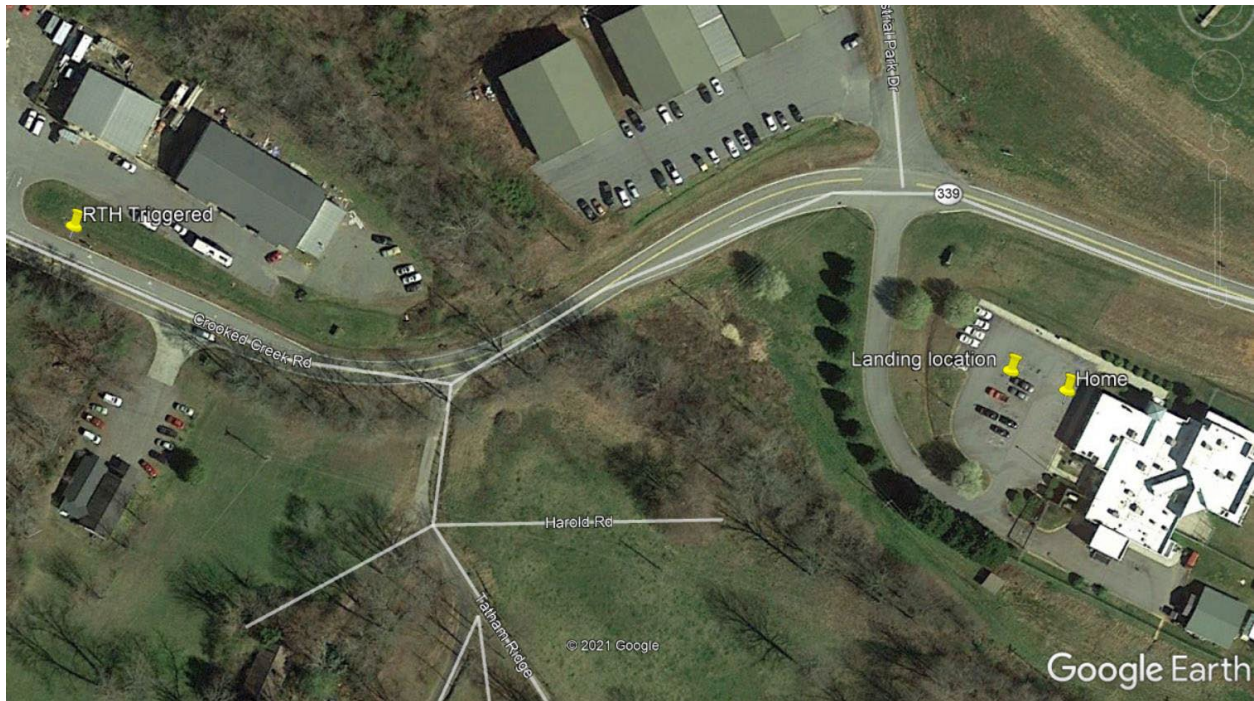


Figure 4. Flight event locations pinned in yellow.

1.3 Examination

On 5/14/2021, the following items were received by at DJI Repair Center in Cerritos, CA under case CAS-6387108-B0T6H8.

Product	SN	Quantity
24W USB Charger (NA)	143CGCB13100J9	1
Aircraft Body (Including Aircraft Body & Propellers & Package; Excluding Damping Module) (NA)	1ZNDH3L0010562	1
Matrice 300 RTK DJI Smart Controller Enterprise (US,EU,JP,TW)	1ZMLH3P00101DB	1
Matrice 300 RTK DJI Smart Controller Enterprise (US,EU,JP,TW)	1 MISSING S/N	1



Figure 5. Condition of the parts received from the operator.

1.4 Flight Log and App Flight Log Information

The following is a series of events based on the analysis done from both the aircraft flight log and the app flight log. Heights are presented relative to take off point and are not necessarily AGL at all times depending on terrain. Times are presented with respect to aircraft power-on; some screenshots from the app show time with respect to take-off as “Flight time.”

Stage 0: 0s~556s

- T=0s, Power-on at 10:22:54 EDT local time on 05/06/2021 (Flight Controller time recorded as 09:22:54 EST).
- GEO database is on the aircraft. The database was released in December 2019.
- T=11s, Home point set at 34.9843050 x -83.8291285, 18.7 ft outside from the western border of the GEO Restricted Zone (prison).



Figure 6. Home point (blue) and GEO Restricted Zone (prison).

- T=120s, Take-off. The aircraft worked under GPS mode and responded well to the pilot's command.
- T=363s, Aircraft reached its farthest point at 34.9847287 x -83.8320778, 393.7 ft height, 892.3 ft distance from home point.
- T=556s, H=393.7 ft the pilot triggered RTH at coordinate 34.9847275 x -83.8320819. The preset RTH altitude was 125 ft and the aircraft started to return home at current height. Battery level was 75%. Unit estimated 26.02 minutes of flight time remained.

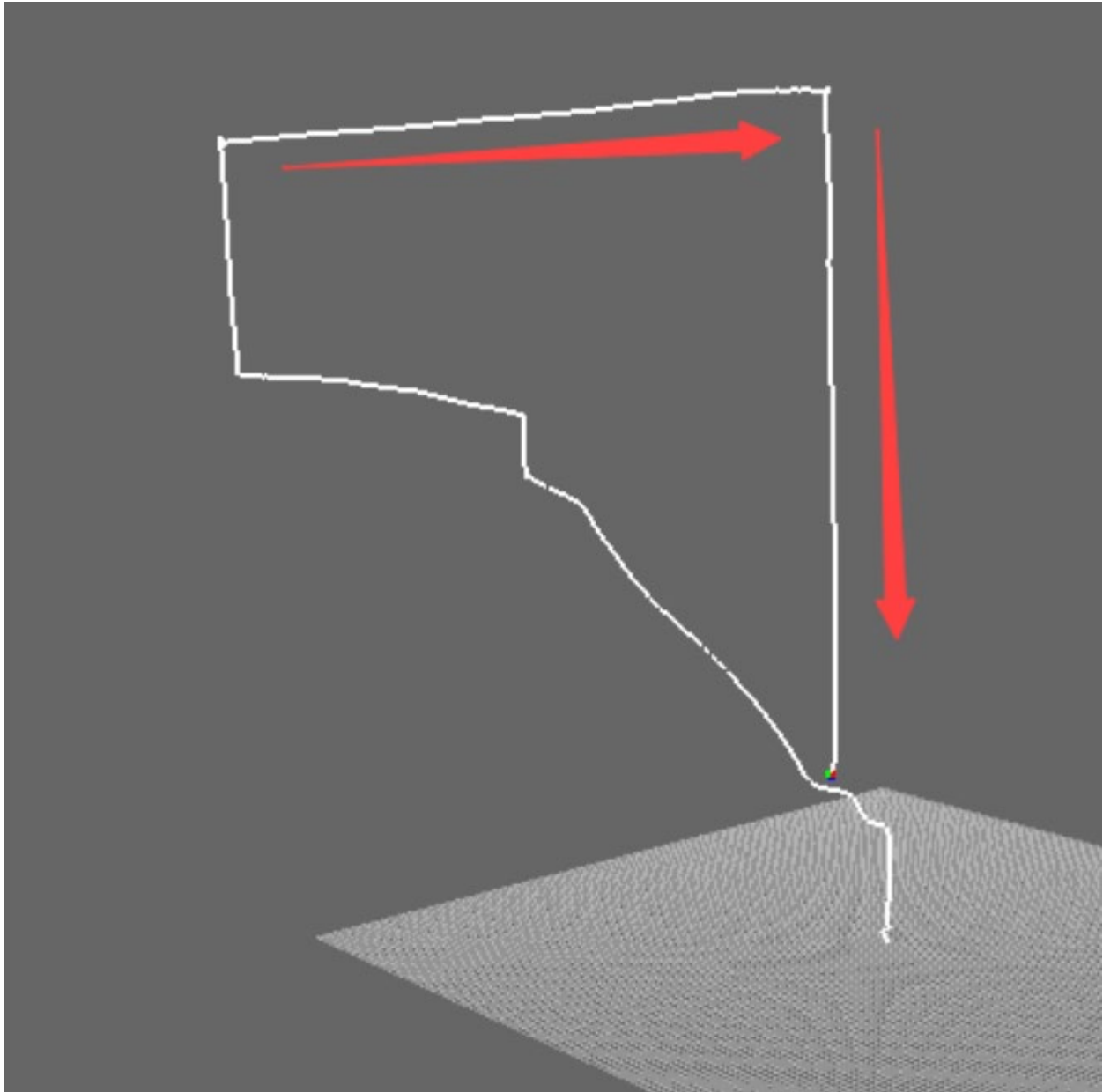


Figure 7. 3D flight path after the pilot triggered RTH.

Stage 1: 556s~653s

- T=584s, the aircraft returned to 56 ft from home point then stopped at the boundary of the restricted buffer zone. The app prompted a warning, the aircraft remained in RTH mode.
 - Note: A buffer zone is defined as an area with approximately 20 m (66 ft) width outside a No Fly Zone (NFZ). The purpose of a NFZ buffer zone is to account for estimation and control errors in order to avoid breaching the NFZ when the aircraft has forward speed. When approaching the buffer zone, the aircraft will reduce speed and stop at the buffer zone border.
- There was no pilot stick command input.

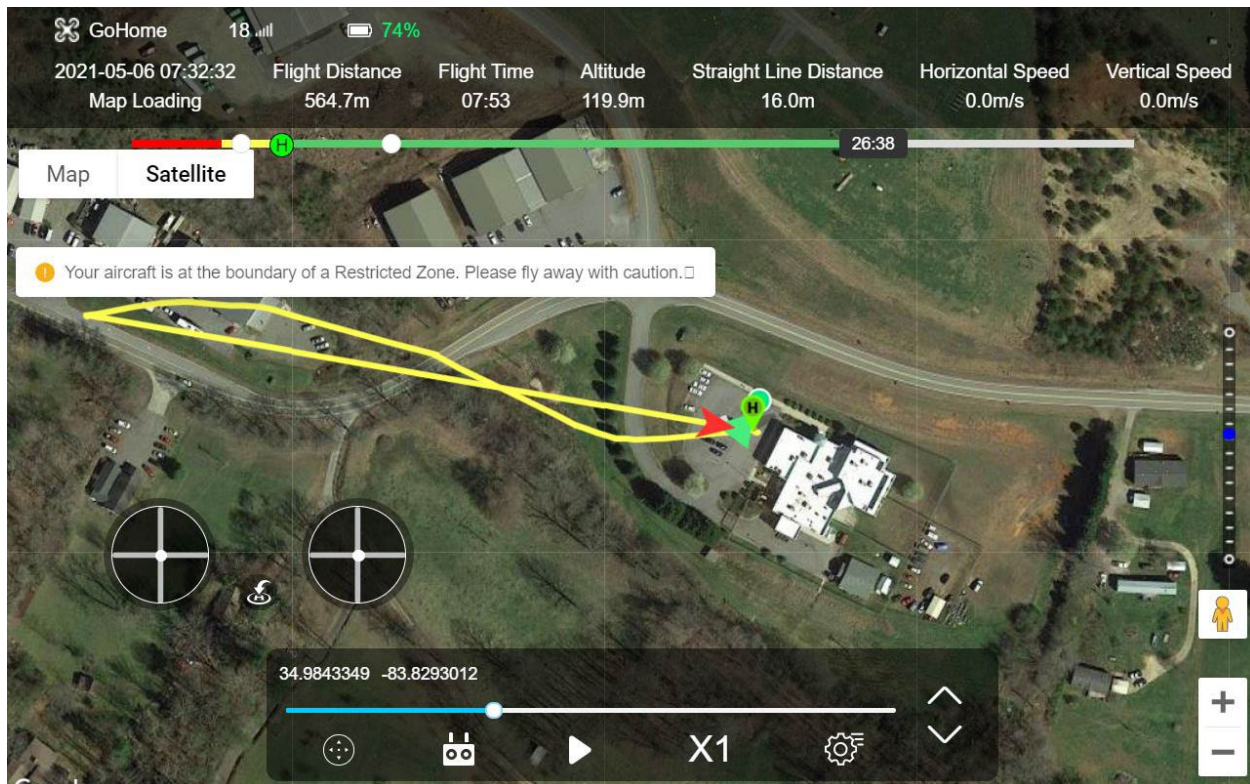


Figure 8. No pilot stick command input noted during RTH.

Stage 2: 653s~686s

- T=662s, the pilot lowered the aircraft with stick command from about H=393.7ft to H=6.6ft. The unit was responsive to the pilot's stick command.
- The aircraft would not descend to minimum RTH height H=2m (6.6ft) during RTH mode as designed. This function was to ensure aircraft safety upon RTH descending.
- Pilot stick command input:
 - Throttle down to lower the aircraft from 120m to about 2m.
 - Yaw stick command was recorded during this stage: the aircraft was not responsive as designed. As a safety measure, the unit was not responsive to yaw command to prevent the unit from flying sideways during RTH and colliding with a structure or person, as the obstacle avoidance sensor is forward facing.
 - Pitch forward stick command was recorded during this stage: The aircraft was not responsive as designed since it reached the boundary of geofencing restricted area buffer zone.

Stage 3: 686s~1347s

- T=686s, the aircraft hovered at approximately H=6.6ft. It recognized obstacles from this altitude and maintained current position.
- Multiple warnings were prompted on the app when the aircraft approached the Restricted Zone. Unit stopped approaching the Restricted Zone approximate 16 m away from the home point at around 34.9843413 x -83.8292948 as it reaches the buffer zone of the restricted area.

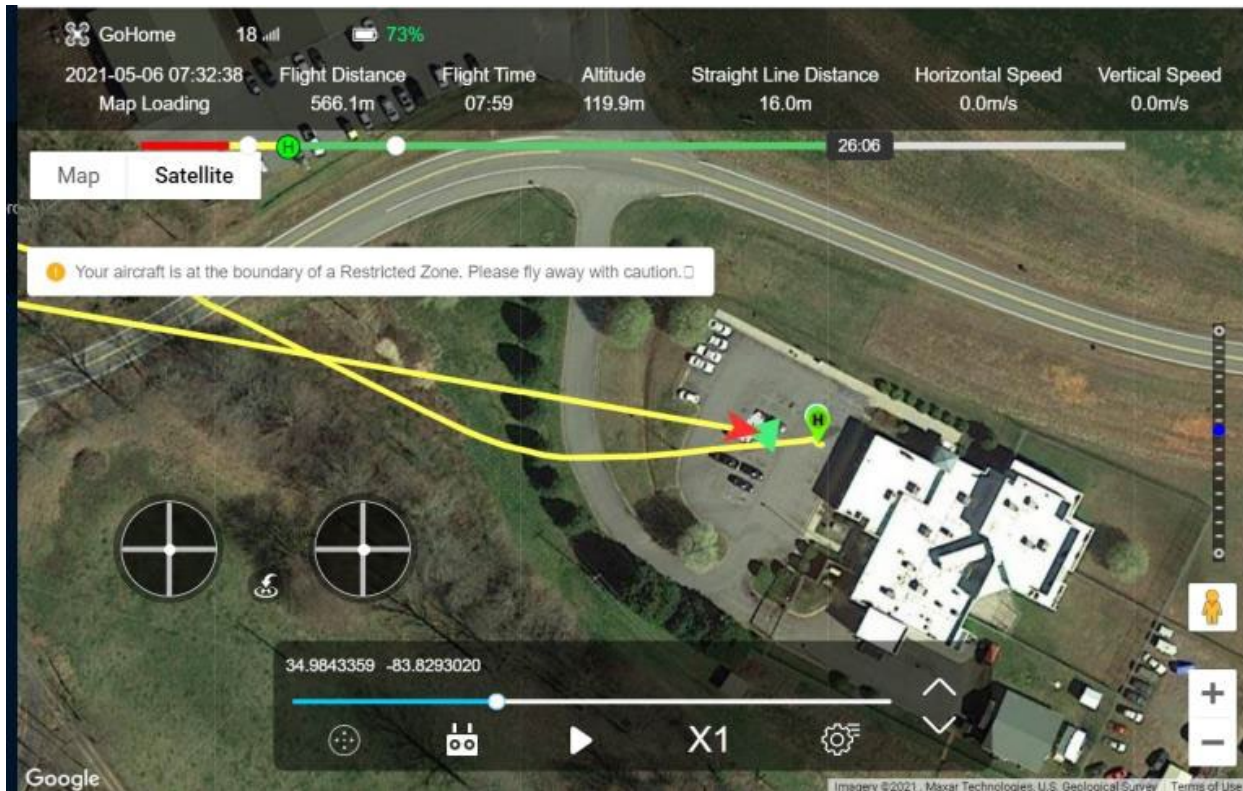


Figure 9. Warning at the boundary of the Restricted Zone.

- The aircraft would not ascend to preset RTH height since it was less than 50m (164ft) to the home point, as expected in the designed RTH function. It would not pitch forward either as it detected obstacles and reached the boundary of the geofencing restricted area buffer zone.
- T=892s-900s, yaw stick commands from the pilot were observed. The unit remained unresponsive as expected. The pilot input multiple stick commands during this period, but the aircraft remained unresponsive as it is still within RTH mode (in order to regain full control of the unit, the pilot should exit RTH mode first).
- During T=1164s-1503s, multiple events of height fluctuations were recorded without corresponding stick input, despite the unit increasing motor thrust output to maintain the balance, indicating external force was exerted to the unit that prevented the unit from maintaining the height.
- User stick command input:
 - Throttle stick command:
 - Throttle down was recorded. The unit would not descend to minimum RTH height H=2m (6.6ft) during RTH mode as designed. This function was to ensure aircraft safety upon RTH descending. Since the aircraft detected obstacles in close range, RTH locked the aircraft at current position. The aircraft was not responsive to user stick command.
 - Very brief throttle up commands were recorded. Aircraft height was not significantly affected by these commands.
 - Pitch stick command was recorded since the aircraft detected obstacles in close range, RTH locked the aircraft at current position. The unit was not responsive to pilot stick command.

- Roll and yaw command: The aircraft would not respond to yaw and roll command during RTH mode as designed.

Stage 4: 1348s~1369s

- T=1348s, the aircraft maintained height $H=1\text{m}\sim 2\text{m}$ (3.6ft~6.6ft). The user exited RTH mode manually by pressing the RTH button, then entered RTH again 3 seconds later. This action initiated a new RTH starting location.
- 18 seconds later the pilot exited RTH mode manually by pressing the RTH button, then entered RTH again 3 seconds later.

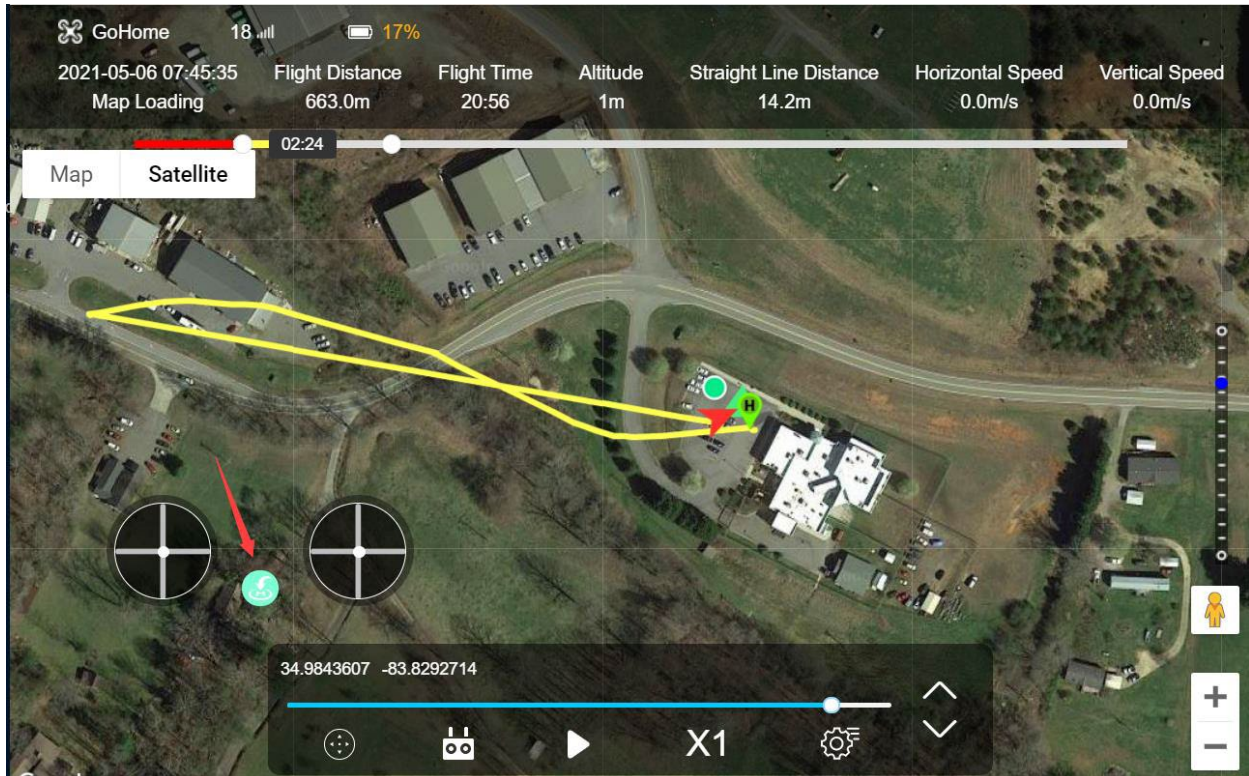


Figure 10a. Sequence of RTH command.

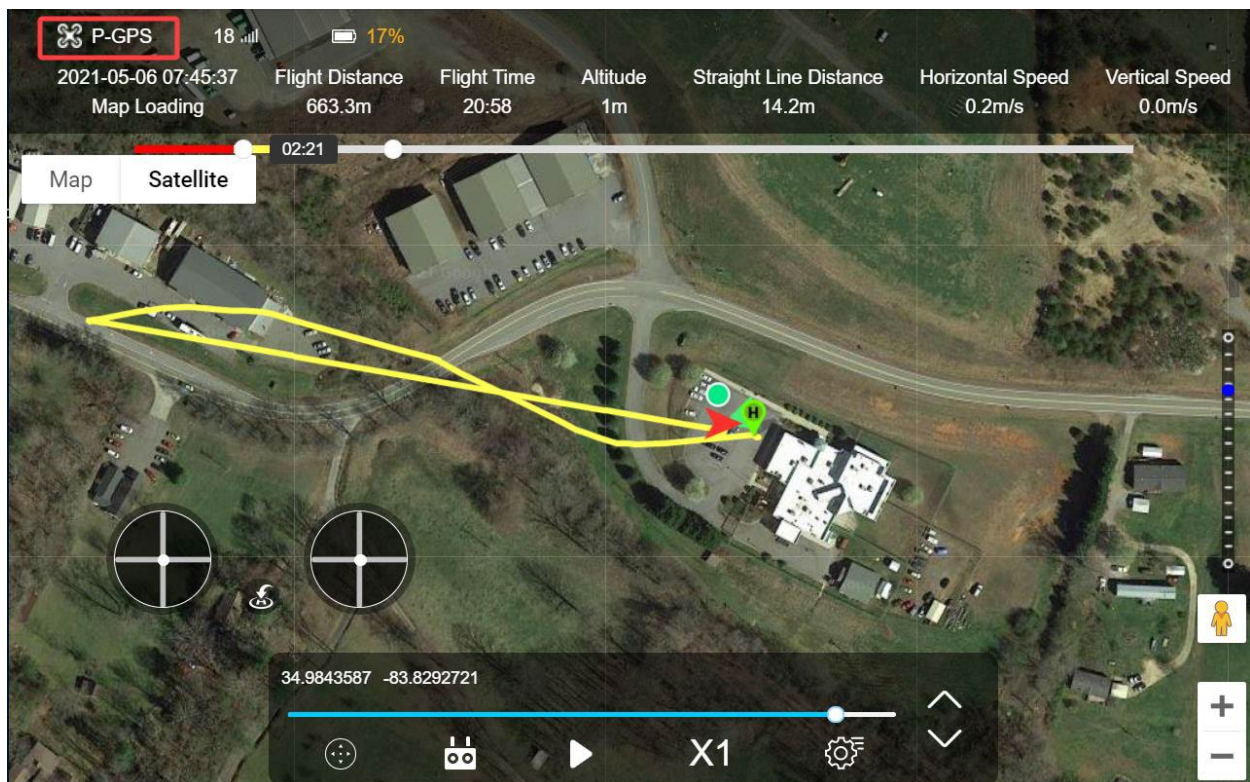


Figure 10b. Sequence of RTH command.

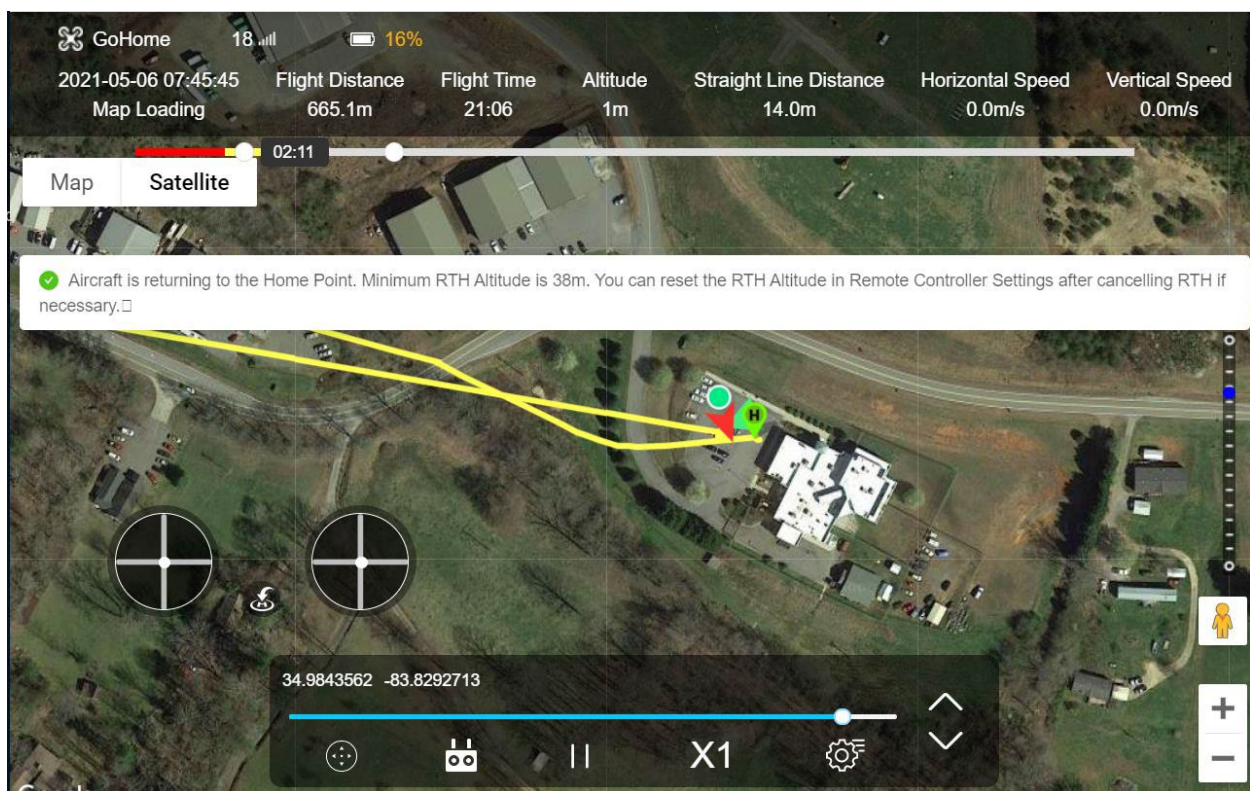


Figure 10c. Sequence of RTH command.

- The aircraft detected low altitude at approximately $H=1\text{m}$ (3.3ft) during newly initiated RTH and started to ascend to the minimum RTH height of $H=2\text{m}$ (6.6ft). The aircraft failed to ascend to the target height, despite increasing motor thrust output, indicating external force was exerted to the aircraft that prevented the aircraft from reaching the target height. The system prompted a high wind velocity warning as external force held the aircraft down.

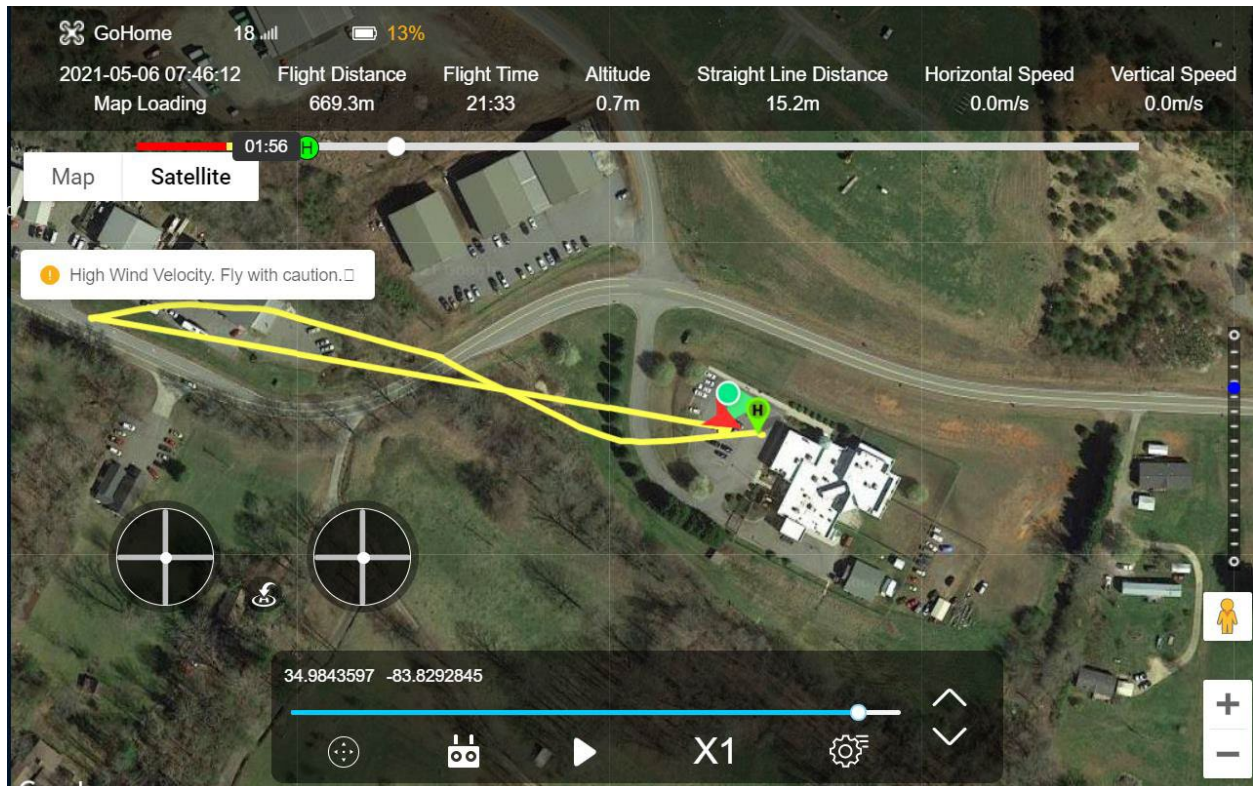


Figure 11. High wind velocity warning due to external forces on the aircraft.

- User stick command input:
 - Pitch backward stick command was recorded: The aircraft was not responsive as it was in RTH mode and at RTH starting location. Pilot canceled RTH and entered RTH again, which updated the RTH starting location. During RTH, the aircraft cannot fly backwards but only towards the home point as expected.
 - Throttle down was recorded: The aircraft would not descend to minimum RTH height $H=2\text{m}$ (6.6ft) during RTH mode as designed. This function was to ensure aircraft safety upon RTH descending.
 - Roll and yaw command: The aircraft would not response to yaw and roll command during RTH mode as designed.

Stage 5: 1372s~1447s

- $T=1372\text{s}\sim 1447\text{s}$, the aircraft maintained height between $H=1\text{m}$ to 2m (3.6ft to 6.6ft).
- The pilot exited RTH mode manually, then entered RTH again immediately. This action also initiated a new RTH starting location.

- Since the aircraft detected obstacles in close range, RTH locked the aircraft at current position. The aircraft was not responsive to pilot stick command as designed. The GPS coordinate on Google Map indicates a parking lot.

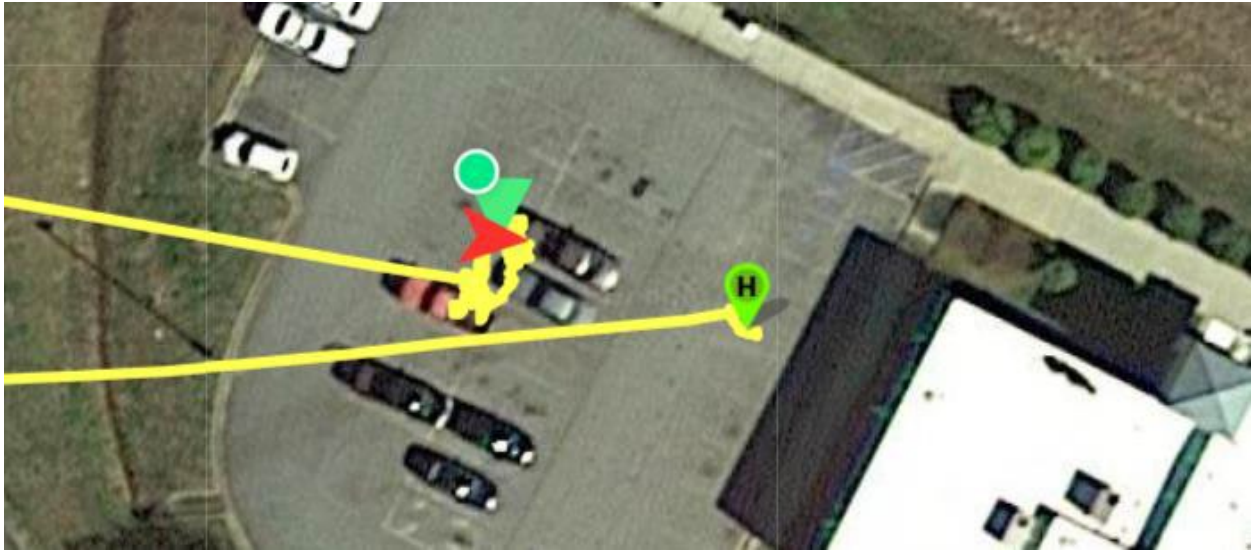


Figure 12. Aircraft flight path above the parking lot at the accident location.

The obstacles seem to be cars parked at the location, as seen from the following photo taken from the aircraft:

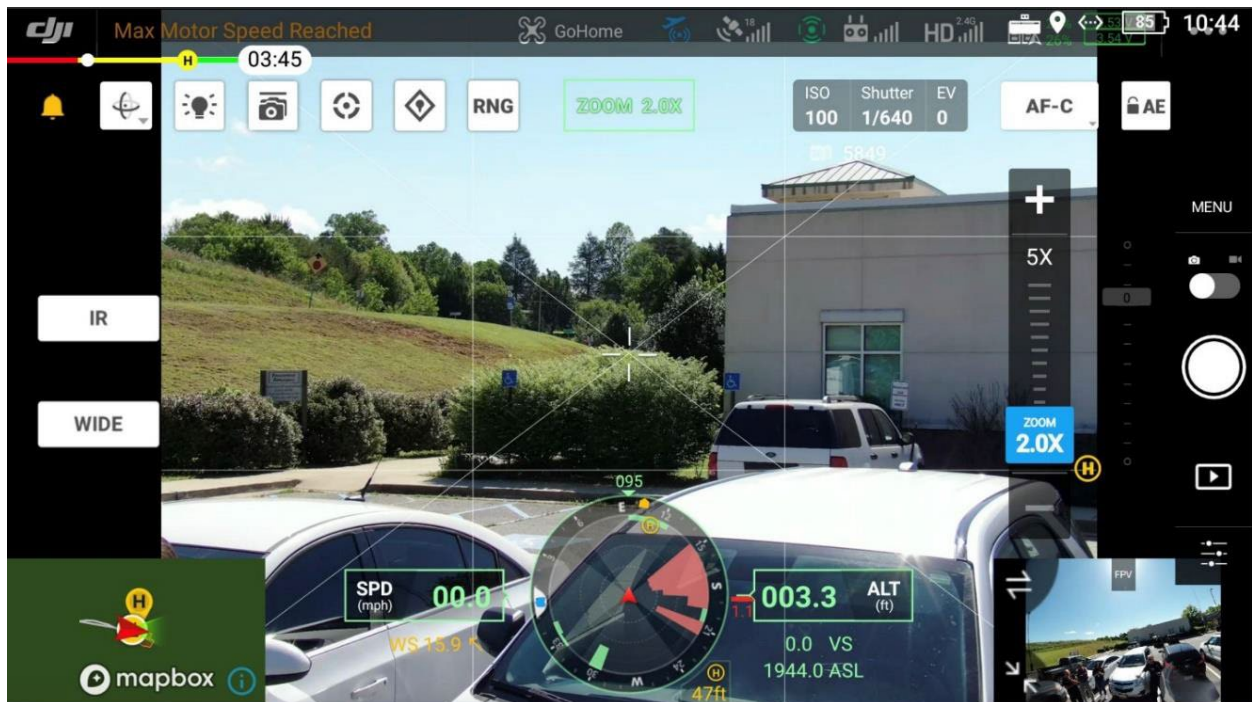


Figure 13. Screenshot from app showing cars as obstacles during the accident sequence.

- User stick command input:
 - The aircraft detected obstacles in close range, RTH locked the aircraft at current position. The aircraft was not responsive to pilot stick command until RTH is cancelled. The location where the unit detected obstacles matches the location the parking lot.

Stage 6: 1454s

- T=1454s, the aircraft entered low power landing mode.
- A warning was prompted at 10% battery level.

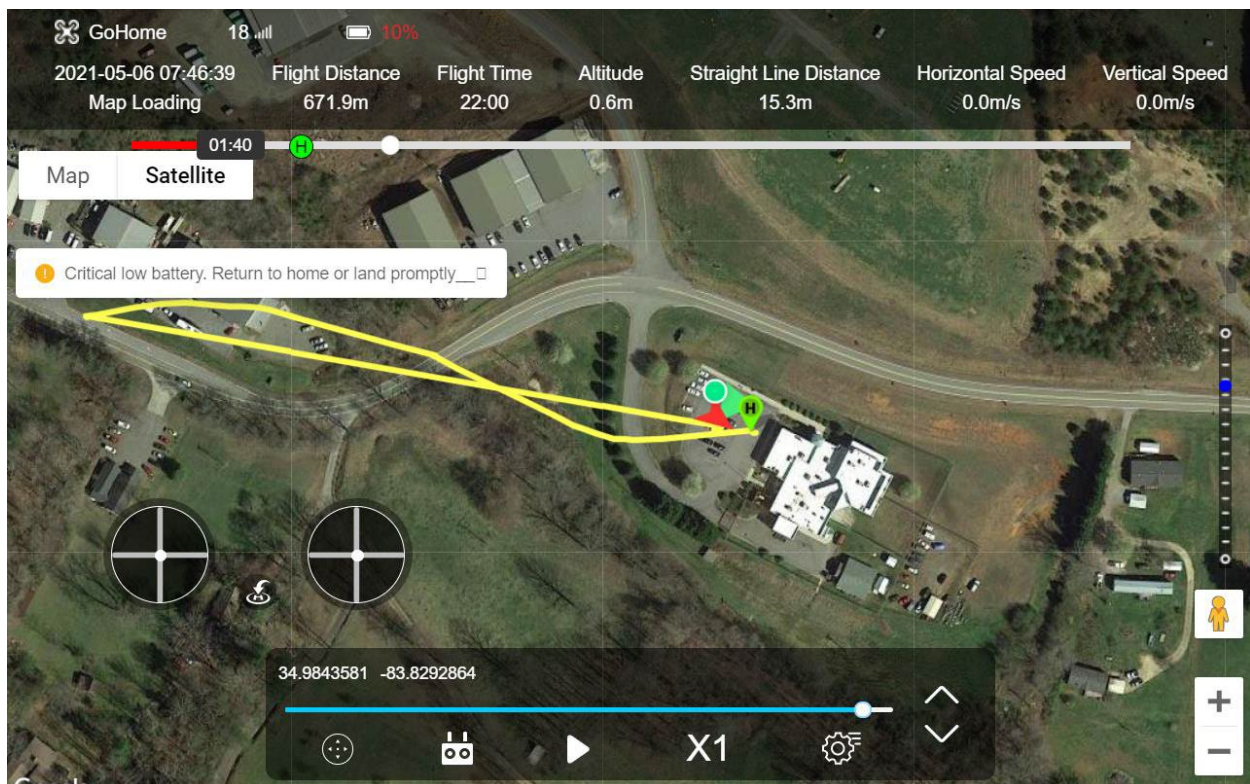


Figure 14. Critical low battery warning.

- As the battery level reaches 9%, battery installation error was prompted, indicating the battery was loosened by external force.

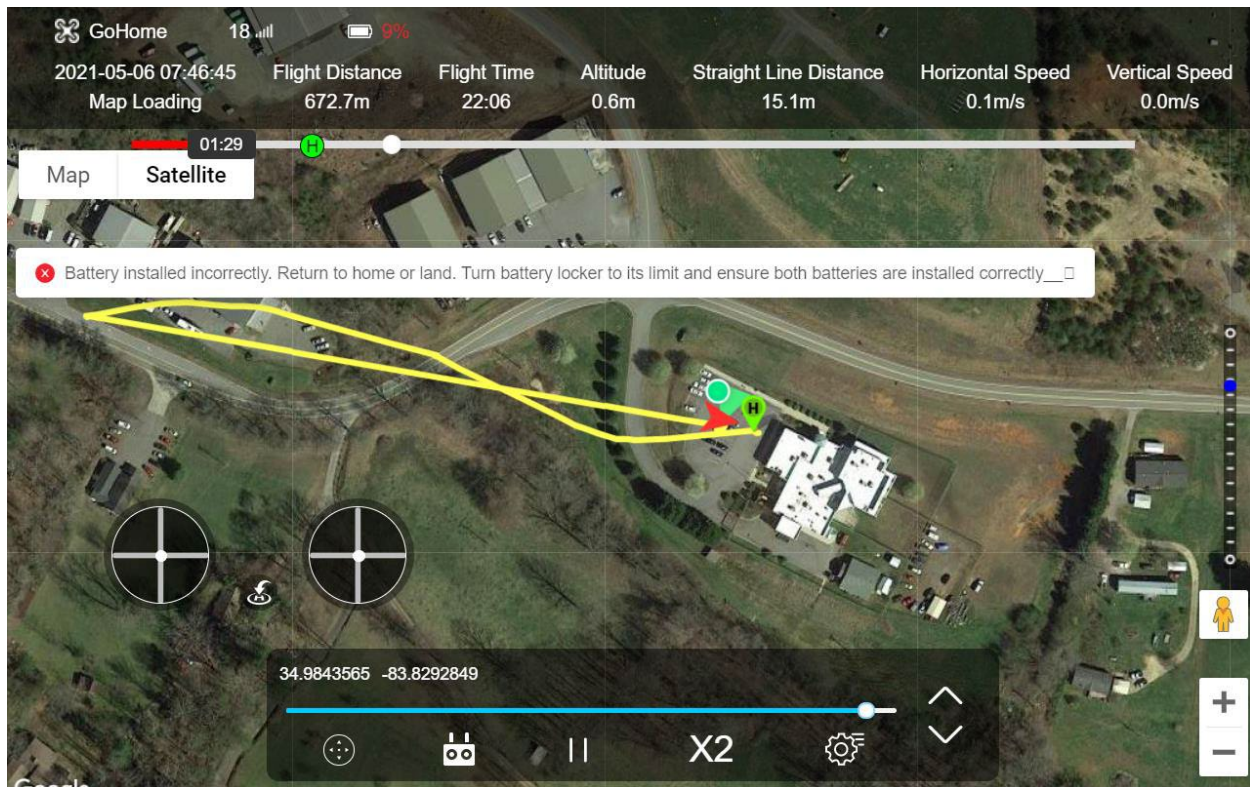


Figure 15. Battery installation error.

- As soon as the battery level reaches 7%, critically low battery auto landing was initiated.
- The aircraft failed to maintain altitude, despite increasing motor thrust output, indicating external force was exerted to the aircraft that prevented it from maintaining height. The aircraft eventually lost balance.

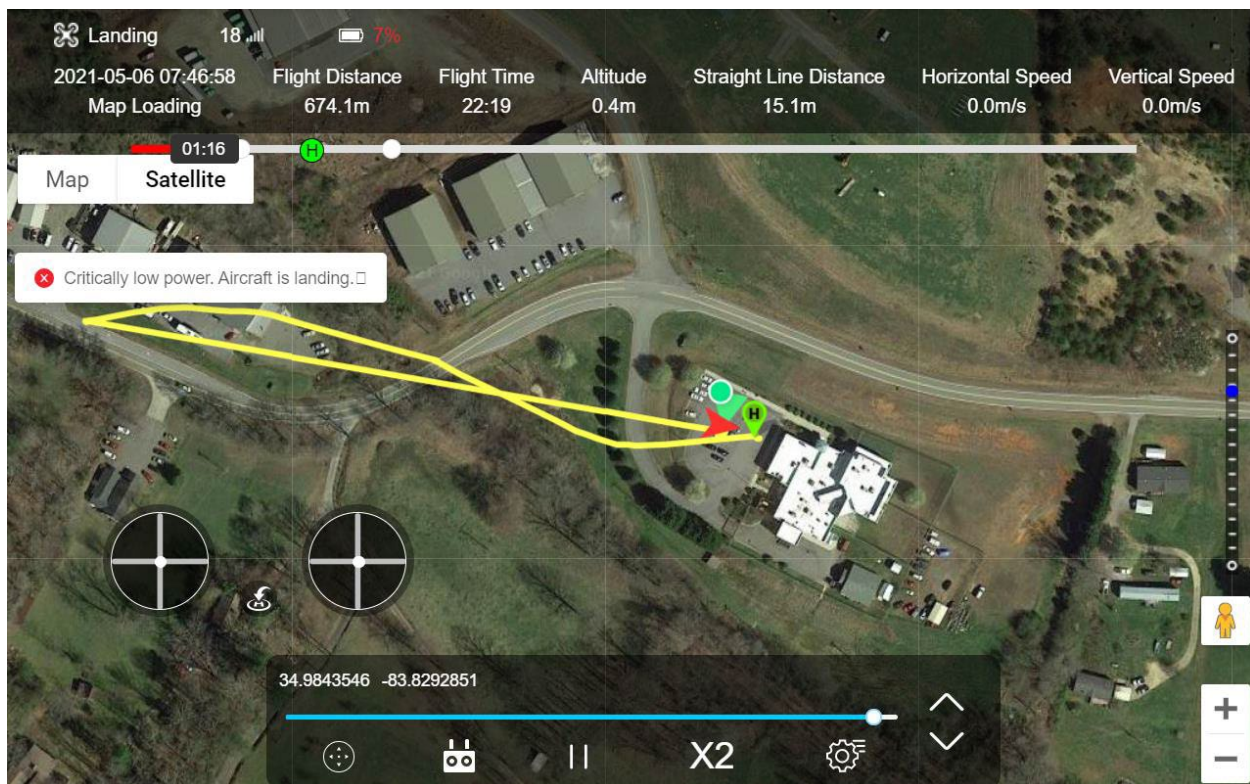


Figure 16. Critically low power warning.

- Approximate landing coordinates: 34.9843511, -83.8292909.

1.5 Corrective Actions and Related Information

- Pilots should be fully aware of the expected aircraft RTH behavior as described in the user manual. Actions that would have likely prevented this accident:
 - Quit RTH by pressing the Pause button or RTH button on RC or by pressing Smart RTH button in the app in order to fully control the aircraft by RC and find a place to land clear of obstacles (different to the home point).
- Pilots should take restricted zones into consideration the in the operation area as part of pre-flight planning and avoid setting home points within their corresponding buffer zones. Operations in close proximity to GEO zones should be conducted after initiating an unlock of the geofencing zone, to avoid undesirable flight control restrictions. For a Restricted Zone, the unlock process involves completing an online form, which is processed by DJI. Public Safety agencies such as the Sheriff's Department can participate in the Qualified Entities Program which removes geofencing features entirely.
- DJI stated that description of buffer zones will be added into the GEO section of DJI User Manuals for increased pilot awareness.