

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division

Washington, DC 20594

July 13, 2023

Onboard Image Recorder

Specialist's Factual Report By Sean Payne

1. EVENT

Location: Crosby, TN
Date: December 29, 2021
Helicopter: Robinson R-44 II, N544SC
Operator: Private
NTSB Number: ERA22FA096

2. GROUP

A group was convened on April 13, 2022. The group consisted of the following members:

Chairman:	Sean Payne Sr. Mechanical Engineer / Investigator National Transportation Safety Board (NTSB)
Member:	Pete Wentz Investigator-In-Charge (IIC) NTSB
Member:	Thom Webster Air Safety Investigator Robinson Helicopter Company
Member:	Patrick Hempen Director, Accident Investigation Federal Aviation Administration

3. DETAILS OF INVESTIGATION

On January 11, 2022, the National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following video file:

Recorder Manufacturer/Model: **GoPro Hero 9 Black**
Serial Number: **N/A**
Filename: **Multiple .MP4 files**

3.1. Recorder Description

The GoPro HERO is a compact, lightweight, POV digital camera enclosed in a ruggedized housing that allows the camera to be mounted in a variety of positions using an array of supported accessories.¹ Depending on the model, the camera supports 4K HD at 60 frames per second (fps) as well as other lower quality recording resolutions at higher frame rates.^{2, 3} The camera can be set to record still images simultaneously or independently of a video stream at a resolution of up to 12 megapixels.⁴ The camera supports recording to micro SD cards.⁵ A built in Wi-Fi module allows users to connect to the camera either via an accessory remote control or via a smart phone app that permits camera control and image transfer.⁶

3.2. Recorder Damage

Only the removable media card was sent to the laboratory. The functionality of the GoPro that recorded the files was not evaluated. The removable media card was read in a PC via a USB write blocker. Media capturing the accident flight was downloaded and is discussed later in this report.

3.3. Video Files

The video was provided at a resolution of 1920 x 1080 pixels and at a frame rate of 48 frames per second (fps). The accident flight recording consisted of video multiple files that were a continuation of each proceeding file. This sequencing of files is normal behavior for a GoPro camera recording a long duration video. The files recovered were continuous.

3.4. Timing and Correlation

The timestamps used in this report are expressed as eastern standard time (EST). Timing information was extracted from the GoPro metadata and was used to create a time correlation. Timing in this report is presented in the format HH:MM:SS, where HH stands for the number of hours, MM, the number of minutes and SS, the number of seconds in EST.

¹ POV – Point of View Shot – A photography technique that records the character's viewpoint from a singular camera location mounted in a manner that represents the character's field of view.

² 4K – A resolution format of 3840 x 2160 pixels.

³ HD – High Definition – A resolution generally consisting of greater than 480 lines of horizontal resolution.

⁴ Megapixel – (MP) – A count of a million pixels in an image or used to express the number of individual image sensor elements on a digital camera image sensor.

⁵ SD – Secure Digital – a standard for nonvolatile memory card used in portable devices.

⁶ Wi-Fi – A local area wireless technology that allows electronic devices to exchange data over a network.

3.5. Summary of Recording Contents

In agreement with the Investigator-In-Charge, a video group was convened, and a summary report was prepared.

Summary

The video started at 2:14:54 EST. The helicopter was already in flight. Figure 1 is a screenshot at the start of the recording. Recorded audio revealed sounds of the helicopter, engine and rotor system consistent with normal operation. The helicopter was on a magnetic heading of roughly 030 degrees. GoPro GPS Metadata showed the helicopter's groundspeed was 92 knots and GPS altitude was 1470 feet.

The helicopter was at position 1 marked in the KML (figure 21 presented at the last page of this report). Ahead of the helicopter was rising terrain, portions of which contained mountain top obscuration. The cloud layer appeared broken at the helicopter's current position, and thickening ahead of the helicopter and up along the horizon.



Figure 1. A screenshot of the GoPro recording at 02:14:54.

By 2:15:54, the helicopter had changed heading to the east. The helicopter appeared to be following State Road 339 in Sevier County, TN. The magnetic compass was showing roughly 120 degrees. The metadata showed the helicopter was at 90 knots and 1470 feet. Figure 2 is a screenshot of this time.

In figure 2, the helicopter was flying in a shallow valley. Ahead of the helicopter was rising terrain, portions of which contained mountain top obscuration. The area in the immediate vicinity of the helicopter appeared overcast and no longer broken.



Figure 2. A screenshot of the GoPro recording at 2:16:02.

By 2:17:13, the helicopter had changed heading to the southwest. The helicopter appeared to be following Dixon Branch Road in Sevier County, TN. The magnetic compass was showing roughly 240 degrees. The metadata show the helicopter was at 91 knots and 1620 feet. Figure 3 is a screenshot of this time.

The helicopter continued to follow Dixon Branch Road in a shallow valley. The clouds ahead of the helicopter appeared thicker and solid overcast. There was obvious mountain top obscuration to the left of the helicopter's track. As noted by the metadata discussed above, the helicopter had descended slightly from the last noted position (from 1620 feet MSL).



Figure 3. A screenshot of the GoPro recording at 2:17:13.

At 2:18:20, the helicopter had taken a track consistent with following State Road 416 in Sevier County, TN. Metadata show the helicopter was at 90 knots and 1688 feet. Figure 4 is a screenshot of this time.

Figure 4 showed the terrain ahead appeared to be rising. There was a solid overcast layer ahead. There appeared to be a horizon available, however, it was difficult to determine if there was mountain top obscuration ahead.



Figure 4. A screenshot of the GoPro recording at 2:18:20.

At 2:19:35, the helicopter had entered visible moisture. The helicopter flew in and out of the base of the overcast layer. Visibility ahead of the helicopter appeared significantly reduced. The metadata show the helicopter was at 85 knots and 1865 feet. The helicopter had descended slightly from the altitude noted previously. Figure 5 is a screenshot at this time.



Figure 5. A screenshot of the GoPro recording at 2:19:35.

Around 2:20:26, the helicopter had entered an area of increased visibility. The helicopter was over State Road 416. Figure 6 is a screenshot at this time. The metadata show the altitude was 1847 feet and 93 knots.

At this time (figure 6, 2:20:26), the left seat passenger had changed the view of the GoPro to more of a downward angle and the upper instrument panel was captured. The change in camera view was not related to the increase in visibility that was present ahead of the helicopter. An addition subfigure for each figure that captured the helicopter's instrument panel depicts a zoomed and cropped screenshot of the instrument panel at the same moment.



Figure 6. A screenshot of the GoPro recording at 2:20:26.

The helicopter continued to fly in an area of increased visibility. By 2:21:34, the helicopter had appeared to change heading to the left and was no longer flying over a road and flew over a series of hilltops.

By 2:22:02, the helicopter had emerged from flying over the hilltop and picked up a track line that followed State Road 321. Figure 7 is a screenshot at this time. Metadata showed the helicopter was at 94 knots and 1986 feet.



Figure 7. A screenshot of the GoPro recording at 2:22:02

The helicopter continued to track east on State Road 321. At times, the helicopter entered visible moisture at the base of the overcast cloud layer. By 02:23:00, the helicopter was directly over State Road 321 near an RV Park (*Outdoor Resorts at Gatlinburg*). The metadata show the helicopter's altitude was 86 knots and 2020 feet. There was rising terrain and mountain top obscuration ahead of the helicopter.



Figure 8. A screenshot of the GoPro recording at 2:23:00

By 2:23:56, metadata show the helicopter continued to climb as it approached rising terrain. The metadata showed the helicopter was at 77 knots and 2150 feet. The helicopter was over *Arrow Creek Campground* (State Road 321). There was rising terrain and mountain top obscuration ahead of the helicopter. Figure 9 is a screenshot at this time.



Figure 9. A screenshot of the GoPro recording at 2:23:56

By 2:24:22, the helicopter had climbed and continued ahead on State Road 321. Metadata show the helicopter groundspeed was 82 knots and altitude was 2287 feet. The helicopter had entered the base of the overcast layer. Objects on the ground appeared as if they were closer to the helicopter (terrain had risen). The helicopter was in a slight left bank. Note that the camera's point of view is angled downward and may not be representative of the helicopter pilot's field of view. Figure 10 is a screenshot at this time.



Figure 10. A screenshot of the GoPro recording at 2:24:22.

At 2:24:34, there was a decreasing trend beginning in the helicopter's airspeed and groundspeed metadata. The metadata show the groundspeed was 64 knots and the altitude was 2320 feet. At this time, the manifold pressure indicator was reduced and displayed about 13 inHg. The helicopter appeared to be in the base of the overcast cloud layer. The helicopter was approaching Pittman Volunteer Fire Department on State Road 321. Figure 11 is a screenshot at this time.



Figure 11. A screenshot of the GoPro recording at 2:24:34.

At 2:24:48, power was increased to 19 inHg, indicated airspeed had slowed to less than 20 knots and altitude appeared to have been maintained (around 2320 MSL). GoPro GPS Metadata show 25 knots of groundspeed and 2347 feet. The helicopter was solidly in the base of the overcast layer. As the indicated airspeed decreased to less than 20 knots, the attitude indicator at first showed the helicopter was rotors level but in a slight nose up pitch, indicating the helicopter was in a slowing attitude but maintaining altitude. Manifold pressure began holding about 19 inHg. The yaw string on the windscreen was pointing hard right (indicated a left yaw trend). Figure 12 is a screenshot at this time.



Figure 12. A screenshot of the GoPro recording at 2:24:48.

In the next 12 seconds, indicated airspeed increased to above 20 knots, the yaw string came into line with the windshield bow (no slip condition), indicated altitude appeared the same as noted previously. The helicopter tracked to the left of State Road 321. During this time, the manifold pressure reached 22 inHg. The attitude indicator suggested the helicopter was slightly nose down as if the helicopter was accelerating in forward flight.

Figure 13 is a screenshot taken at 2:25:00 local time. Manifold pressure decreased to 17 inHg. indicated airspeed had a decreasing trend, and the altimeter showed altitude remained around 2350 MSL. The helicopter was in a slight left bank. The helicopter was enveloped in the base of the overcast layer. Note that the camera's point of view is angled downward and may not be representative of the helicopter pilot's field of view.

Around this time, the pilot's iPad was visible. The pilot's iPad was running ForeFlight. There appeared to be a flight plan entered that consisted of four airport identifier waypoints. The airport waypoints were unable to be determined. The ForeFlight app also appeared to display a NEXRAD radar overlay. The overlay showed areas of green and yellow precipitation.



Figure 13. A screenshot of the GoPro recording at 2:25:00.

Figure 14 is a screenshot taken at 2:25:07. The manifold pressure gauge showed an increased power setting to 28 inHg (beyond the red arc), the attitude indicator showed an increasing left bank trend and a nose down attitude. Airspeed increased slightly to about 35 knots indicated. The yaw string was pointing slightly right. The group characterized the outward and forward visibility based on the camera's point of view as "zero visibility."



Figure 14. A screenshot of the GoPro recording at 2:25:07.

Figure 15 is taken 4 seconds later at 2:25:11. Indicated airspeed had increased (57 knots indicated), altitude had increased slightly, manifold pressure had increased beyond 27 inHg (beyond red arc zone). The helicopter had a significant left bank angle and a nose down pitch attitude (referencing the attitude indicator).



Figure 15. A screenshot of the GoPro recording at 2:25:11.

For the next approximately 11 seconds, the manifold pressure indicator stayed at about 27 inHg (beyond the red arc). Airspeed during this time, increased to about 74 knots indicated, altitude had showed a climb to about 2500 feet MSL. The helicopter was now in a right bank, slightly nose down (referenced to the attitude indicator). There appeared to be no visual references available outside the windscreen (based on the camera's field of view). Figure 16 is presented below at time 2:25:18.



Figure 16. A screenshot of the GoPro recording at 2:25:18.

At 2:25:20, airspeed continued to increase to almost 80 knots indicated, altitude stayed around 2500 feet MSL and manifold pressure was still maintained around 27 inHg (beyond the red arc). The low rotor RPM warning light illuminated and the low rotor RPM horn was audible on the audio track. The engine and rotor rpm tach needles indicated around 90%. Figure 17 is a screenshot at this time, an arrow points to the low rotor RPM warning light.



Figure 17. A screenshot of the GoPro recording at 2:25:20. An arrow points to the low rotor RPM warning light.

In the next few seconds, the airframe appeared to vibrate, shaking the magnetic heading indicator on the windshield bow. The altimeter indicated the helicopter was starting to descend. The VSI began sweeping into a descent indication very rapidly. The pitch and roll on the attitude indicator displayed helicopter nose down and to the right. Airspeed reached approximately 90 knots indicated and then suddenly swept back to a 0 knot indication by 2:25:26. As the airspeed indicator swept to zero rapidly, the yaw string was visible full deflection left (helicopter yawing right indication). The altimeter continued to show a rapid descent.

The airframe continued to shake, the low rotor rpm light and horn remained activated. Because of the stabilization mechanism of the GoPro, the view of the instrument panel was lost from now (2:25:27) until impact.⁷

The airframe continued to shake as the helicopter descended.

As the helicopter first emerged from the cloud base, based on the now visible horizon, it appeared to be reversing a right yaw with a right bank component, quickly to a left yaw with a left bank component. The direction of yaw and bank appeared to quickly reverse (from right to left as noted above) at this time as the helicopter rapidly descended.

Figure 18 is a screen capture taken at 2:25:30. As the helicopter continued to break out of the overcast layer, terrain suggested the helicopter was yawing rapidly to the left (yaw and roll had just reversed from the right).



Figure 18. A screenshot of the GoPro recording at 2:25:30.

⁷ Later model GoPro cameras use internal sensor data to stabilize the image frame. This may result in the image frame shifting digitally while the camera remains in a fixed mounted position.

The helicopter continued to descend rapidly for the next 2 seconds. During the descent, the helicopter continued to yaw to the left. Moments before impact, the left yaw ceased and the helicopter descended nearly vertically and skids level into a tree line.

Figure 19 is a screenshot taken at 2:25:32. The helicopter's fuselage had appeared to impact the tree line. There was an amber light present in the reflection of the windshield. An arrow has been added to show the location of the light in the screenshot.



Figure 19. A screenshot of the GoPro recording at 2:25:33. An arrow has been added to show the location of the light in the screenshot.

Figure 20 is a screenshot taken at 2:25:32 (a few frames after figure 19). The impact sequence continued, at times the helicopter's main rotor blades were impacting tree trunks and branches. There were two amber lights and one red light present in the reflection from the windshield. The upper amber light in the reflection, in conjunction with configuration of the other lights in the reflection (lower amber and lower red), suggested that these lights are the low rotor rpm light (amber), alternator light (amber) and oil pressure light (red).



Figure 20. A screenshot of the GoPro recording at 2:25:33.

The camera appeared to tumble and came to rest after rolling outside of the cockpit. The recording captured debris and helicopter parts settling around the camera. A male voice was detected shortly after the camera came to rest.

A male voice was heard for the next approximate 12 minutes. The male voice was heard stating repeatedly, "what happened?" and "I don't know what happened." The male voice also stated he was looking for his phone but could not move.

Around 12 minutes after the impact, the male's voice was consistent with being on a phone call. The pilot stated, "I crashed a helicopter and I don't know what happened."

Around 14 minutes after impact, voices of bystanders and sirens appeared to be approaching the wreckage. The pilot continued to yell, "what happened?" and "I don't even remember."

Around 19 minutes after the impact, voices consistent with first responders appeared to have arrive at the wreckage site. The first responders remarked, "we got fuel leaking bad." The first responders' voices were audible stating they

performed an “emergency move” on the helicopter pilot due to the fuel leaking from the helicopter. The first responders continued to state, “it’s leaking bad.” Around 24 minutes after the accident, the audio was consistent with moving the pilot out of the immediate wreckage area. No other information was summarized from the recording and the recording ended as what was likely a result of exhaustion of the GoPro’s battery.

Summary of Accident Sequence

As the helicopter approached an area ahead of low visibility and rising terrain, the helicopter continued in a gradual ascent. At the time in which visibility started to greatly decrease 2:24:34, the helicopter’s groundspeed (and indicated airspeed) at first showed a decreasing trend. By 2:24:48, the manifold pressure was reduced and the groundspeed and indicated airspeed decreased and reached a minima of less than 20 knots.

As the indicated airspeed reached a minimum, manifold pressure then increased, the helicopter pitched forward and airspeed increased slightly. Visible landmarks under the helicopter suggested it again had a forward component of speed. As the helicopter continued to fly forward, visibility decreased even further, eventually to “zero” at 2:25:07. Around the time this occurred, the manifold pressure went through the red arc range to a maximum of around 27 inHg (beyond the red arc range). The helicopter pitched forward and airspeed rapidly increased to about 85 knots. During this time, the manifold pressure indicated steadily above the red arc (above 27 inHg). The helicopter then appeared to yaw rapidly to the right, the airspeed indicator suddenly displayed 0 knots and the altitude decreased. The low RPM warning light and aural horn alerted.

The helicopter then emerged from the cloud layer, first in a right roll and right yaw condition which quickly reversed to a left roll and left yaw condition. The helicopter descended rapidly into a tree line, impacting the top of the tree line in a left yaw but level roll condition. As the helicopter descended into the tree line, the main rotor blades struck tree branches and tree trunks. Reflections in the windshield suggested the low rotor RPM light (yellow), the alternator light (yellow) and the oil pressure (red) light were illuminating during impact. The helicopter came to rest amongst the trees at ground level.

There was no evidence reviewed in the recording that suggested that there were pre-impact, mechanical malfunctions or failures that would have precluded normal operation prior to the helicopter entering an extremely low visibility condition.

Additional Figures

Figure 21 is a KML constructed of the helicopter’s flightpath from the available GoPro data. The KML presenting the flightpath is overlaid on Google Earth. Note the weather depiction on Google Earth does not depict the weather and lighting

conditions at the time of the accident. Under the depiction of the helicopter's groundtrack data, is the helicopter's elevation data as presented in Google Earth. The data used to generate the figure is attached as attachment 1 to this report.

Figure 22 is a Google Earth presentation of the final recoded tracklog points from the GoPro metadata. An arrow has been added to show the vicinity of the wreckage.

Figure 23 is a plot of the helicopter's altitude, groundspeed and groundtrack. The data is from the GoPro. The time interval has been set to illustrate the entire accident recording. The red line indicates the time at which the helicopter impacted terrain, the GoPro continued to operate and collect metadata although the helicopter had crashed.

GoPro Metadata

Additional GoPro metadata was recovered and reviewed during the group activity for this investigation. Only metadata that recorded the GoPro's latitude and longitude, GPS altitude, GPS derived groundspeed and GPS derived groundtrack are discussed in this report. Other GoPro parameters were extracted from the metadata, but were not validated and are not discussed in this report. The data used to generate the figure is attached as attachment 1 to this report.

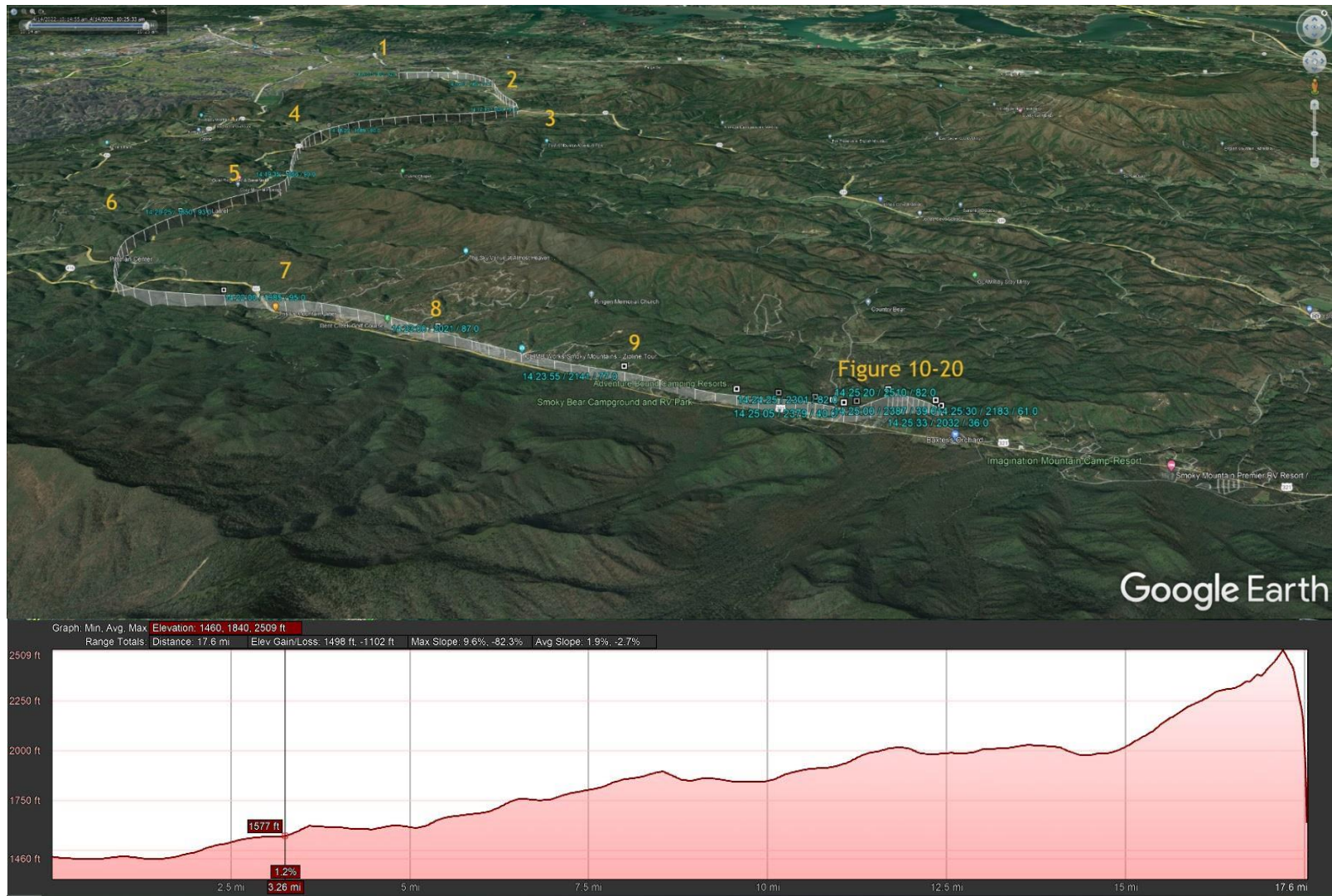


Figure 21. The helicopter's groundtrack created from the GoPro's metadata. Figure numbers associated with this report have been added for reference. The helicopter's altitude history is also presented as represented in Google Earth. The altitude is presented in feet MSL.



Figure 22. The helicopter's groundtrack created from the GoPro's metadata. This figure shows the last recorded points leading up to the impact with terrain. An arrow has been added to show the vicinity of the wreckage.

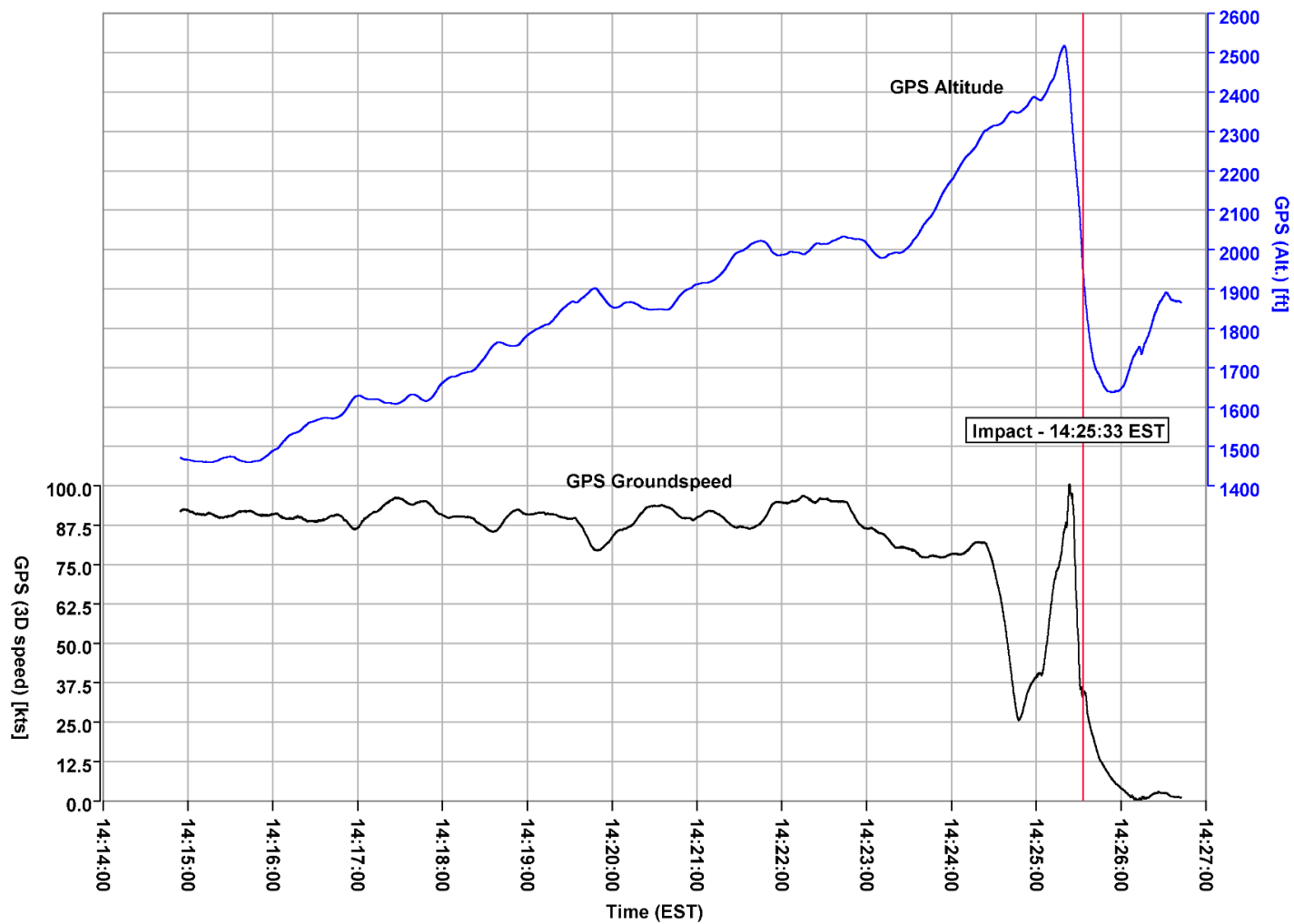


Figure 23. A plot of GoPro metadata providing GPS altitude and GPS derived groundspeed. Red line indicates the time at which the helicopter impacted terrain.