National Transportation Safety Board
Office of Research and Engineering
Washington, DC 20594

ERA24FA058

ONBOARD IMAGE RECORDER

Specialist's Factual Report

January 2, 2024

ACCIDENT

Location: Pulaski, Tennessee
Date: December 7, 2023
Time: 1103 central standard time (CST)
Airplane: Beech 35-C33, N5891J

Onboard Image Recorder Specialist

Specialist: Sean Payne
Branch Chief – Vehicle Recorder Division
National Transportation Safety Board (NTSB)

DETAILS OF THE INVESTIGATION

In agreement with the Investigator-In-Charge, an Onboard Image Recorder group was not convened, and a summary was prepared.

The NTSB Vehicle Recorder Division received the following electronic devices:

Device Manufacturer/Model: GoPro Hero 8 Black
Device Serial Number: C3331352469137
Associated Card: SanDisk Ultra 256 GB

Device Manufacturer/Model: GoPro MAX
Device Serial Number: C-23492
Associated Card: SanDisk Ultra 128 GB

1.0 Device Condition

GoPro Hero 8 Black

The GoPro Hero 8 Black is pictured in Figure 1, as received. The GoPro exhibited some impact damage and thermal damage. A 256 GB microSD type memory device was found seated in the memory socket location (Figure 2). A 256 GB SanDisk Ultra microSD card was extracted. The microSD card exhibited impact damage and was cracked in multiple locations. Figure 3 is an annotated stereoscopic photograph of the cracked areas of the card. Figure 4 is a magnified stereoscopic image of one of the damaged areas of the card. Figure 5 is an x-ray of a portion of the microSD card. The figure is annotated with blue arrows to show a cracked area. An overall review of x-ray images taken of the card do not reveal any obvious bond wire damage. Cracks were present in other areas of the card that were x-ray imaged, but are not included in this report.

Cracks on monolithic memory devices can extend through the component's plastic packaging and into the silicon die. These cracks can also affect the bondwires that interface the silicon die to the chip's architecture as well. Bondwire damage, in some instances, can be repaired, or bypassed altogether by reading the silicon die directly using the chip's test pins. As noted above, no obvious bondwire damage was noted from the x-ray inspection. Cracks to the silicon die, however, cannot be repaired. There is no known repair method for cracked silicone dies at the time of this report's publish date.

Despite these findings, the card was inserted into a forensic write blocker and was attempted to interface with a PC. The memory device did not mount and no data was accessed.[1]

The memory device was sent to a third-party data recovery lab. The third-party lab has the capability to read the device through its factory test pins. The third-party lab determined that data was unable to be recovered from the device.

No data was recovered from the memory device.

Figure 1. Device as received by the lab.

[1] A method for a computer operating system to access files and directories.

Figure 2. The microSD memory device seated in the camera's memory card chassis. The yellow arrows show the location of the seated microSD card.

Figure 3. Annotated image showing the cracked areas of the device's associated microSD card.

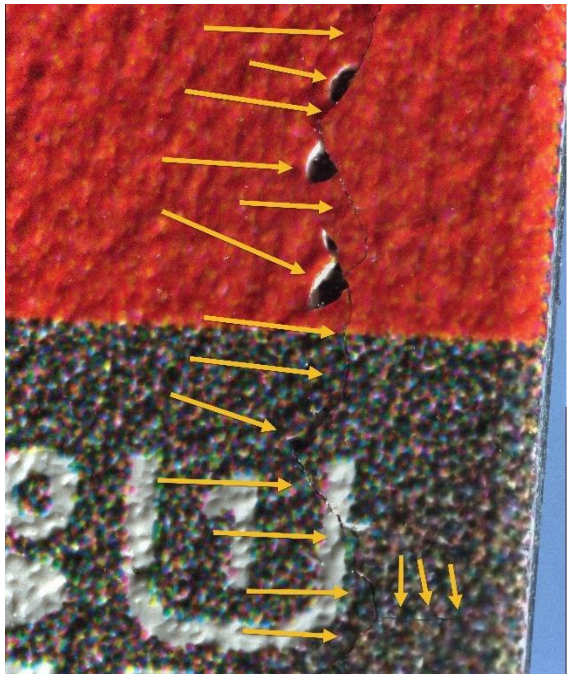

Figure 4. Magnified image of a cracked area of the device's associated microSD card.

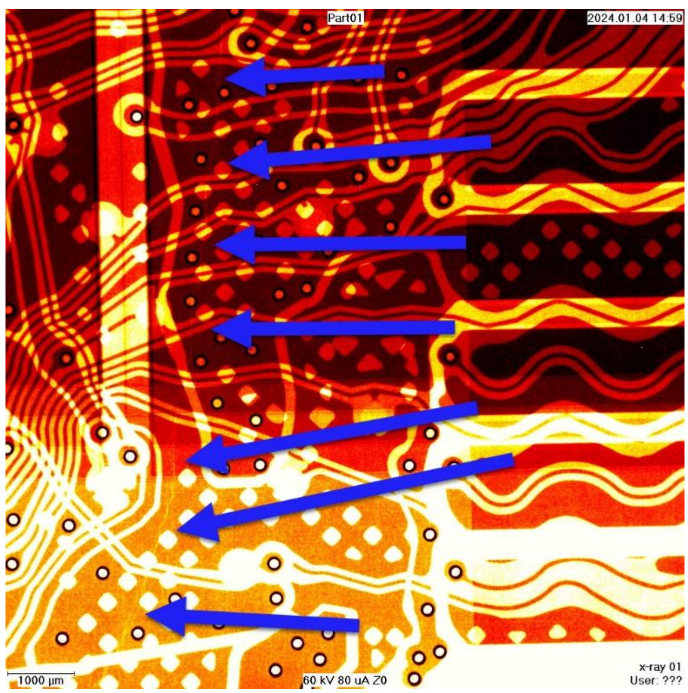

Figure 5. An x-ray image with a color filter applied showing a cracked area of the microSD card.

GoPro MAX

The GoPro MAX is pictured in Figure 6. The GoPro MAX exhibited some impact damage and thermal damage. A 128 GB microSD type memory device was found seated in the memory socket location (Figure 7). The microSD card was extracted. The microSD card exhibited some thermal damage but did not appear to be cracked (Figure 8).

The device was read via a forensic write blocker and was able to mount as an accessible drive in a PC. The mounted drive revealed a folder structure consistent with the operation of a GoPro product. The drive contained two folders, DCIM and MISC (Figure 9). The DCIM folder which holds recordings made on the device was empty (Figure 10).

The user has a few options on how to configure recording on the MAX. In general, the user can elect to record either 360-degree video files, or traditional (typically 16:9) .MP4 video files.[2] During normal operation in a 360 mode, the GoPro MAX creates three files for each recording session: a .360 file which is a full resolution video containing imagery from both of the camera's lenses, an .LRV (low resolution video file) which facilitates playback via the associated mobile application and a .THM (thumbnail) which is used to generate a thumbnail preview on the MAX's built in screen as well as the mobile application.[3] During a normal recording session, when the file size of the .360 file reaches approximately just under 3.72 GB (approximately 7 minutes in length using the base settings), a new set of .360, .LRV and .THM files are created. These files are enumerated in a sequential chronology, where the next file increments by the next number. Similarly, when operated in a non-spherical format (typically 16:9), the MAX will produce three files: a full resolution .MP4 file, an .LRV video file and a .THM. During a normal recording session in 16:9 format, when the file size of the .MP4 file reaches approximately just under 3.72 GB (approximately 12 minutes in length), a new set of .MP4, .LRV and .THM files are created.[4]

The MAX recovered from the accident was able to be powered and its settings were explored. The MAX was configured to record in "One Touch Mode" at a resolution of 1920 x 1080 at 60 frames per second (fps). Separately, an internal video resolution menu setting was also set to "Video 1080, 60, W" (1080p resolution at a frame rate of 60 frames per second (fps) at the wide setting in a format of 16:9). Using the accident camera with a surrogate microSD card showed that the camera produced 1920 x 1080 60p 16:9 format files when activated in "One Touch Mode." Additionally, when the camera was activated from its power button and then a file was started using the record button, it also produced files that were 1920 x 1080 60p 16:9 format. It was likely that any potentially video file recorded on the MAX during the accident flight would have been made at these settings, and would have produced 16:9 format video as .mp4 files as opposed to .360 files

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[2] 16:9: A reference to the video's aspect ratio, now typically a TV format.
[3] Using the correct software this file (.360) can be manipulated in several ways to provide a specified field of view.
[4] A setting of "Video 1080, 60, W" was used for this test file operation.

Image recorders exposed to high impact scenarios have the potential to produce corrupted, missing, or unplayable media files due to abrupt cessation of power or the ejection of the device's removable media card. In this case, the memory device was found seated in the appropriate socket, but an abnormal power operation related to impact could not be ruled out. In the past, the NTSB has recovered missing data from similar scenarios and has developed laboratory methods to forensically search filesystems from point of view (POV) type cameras.

If the camera were started at the start of the flight, numerous .MP4 files would have been produced. Specifically, the preliminary report states that the aircraft departed Knoxville Downtown Island Airport (KDKX), Knoxville, TN, at about 0948 CST. The reported time of the accident was 1103 CST. Assuming the duration of the flight was approximately 1 hour and 15 minutes, at least six .16:9 files would have been created had the camera been functioning since the start of the flight. If the camera was recording at the start of the flight, 6 files would have been produced and the seventh file, which presumably captured the accident sequence, had the potential to be corrupted due to an unexpected cessation of power. Alternatively, if the camera was only started near the end of the flight (within the last 12 minutes of flight), the file containing the accident sequence could have also been corrupted. When this occurs, previous NTSB investigations have found that the corrupted file may not be accessible by a Windows file system, and a forensic search of the memory card's contents must be conducted.

To search for a corrupted video fragment of the accident, a forensic image file was created from the 128 GB microSD card and the image file was searched for video files and video file fragments manually using a HEX editor as well as commercial software used for recovering deleted and corrupted files. This search produced a number of fragmented videos files and thumbnails. These files were reviewed in an attempt to identify the accident flight.

The majority of the reviewed recovered files were not consistent with the accident flight and were perhaps consistent with deleted recordings from previous flights.[5] For example, some of these recovered files included a passenger that was not an occupant on the accident flight. Some of the recovered file fragments produced, however, showed both occupants who were involved in the accident flight.

To determine if these file fragments were consistent with a potential recovered accident flight recording, the clothing being worn by the occupants of the accident on the day of the accident were compared to the clothing displayed in the recovered video fragments. A security video was obtained of the pilot and the passenger entering airport property on the day of the accident. The passenger's clothing on the day of the accident did not match that of any of the recovered video fragments. The

[5] The method for recovering corrupted video will also recover fragments of previously deleted files.

pilot, however, was shown wearing a jacket in the security video. The jacket the pilot was wearing was not present in the recovered video file fragments. Additionally, documents of the pilot's clothing made by the coroner were compared to the recovered video file fragments. The clothing of the pilot documented by the coroner did not match the clothing in any of the recovered video file fragments.

No accident flight data was recovered from the 128 GB card associated with the GoPro MAX.

Figure 6. GoPro MAX as received by the lab.

Figure 7. Memory card seated in the GoPro MAX.

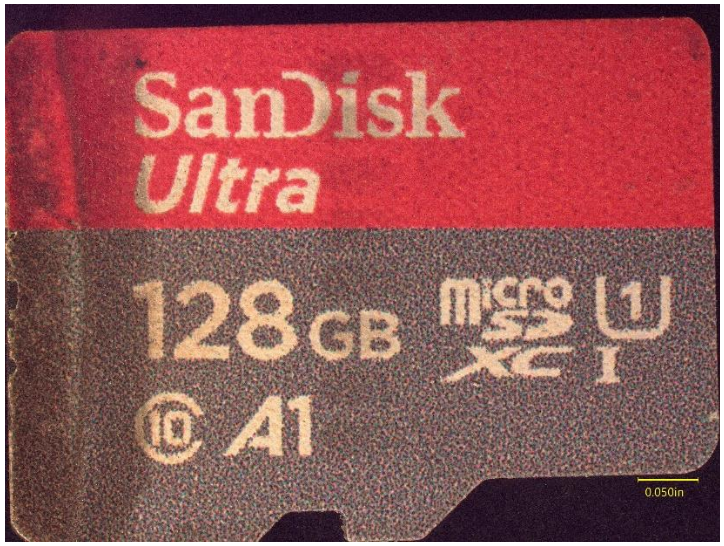

Figure 8. Memory card recovered from the GoPro MAX.

Figure 9. Folder structure associated with the GoPro MAX.

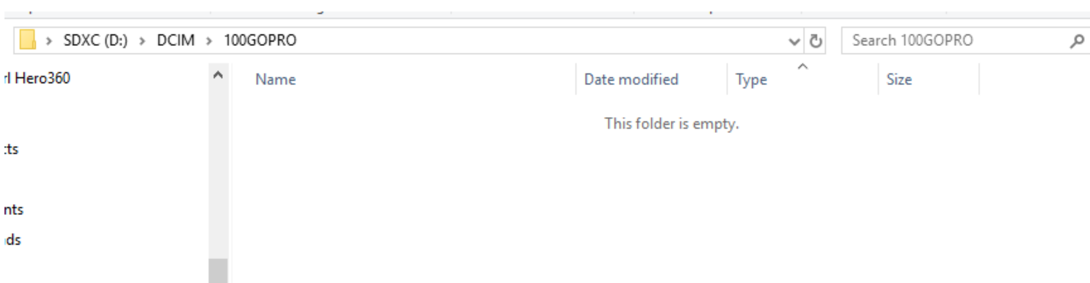

Figure 10. Empty DCIM folder from the card associated with the GoPro MAX from the accident.

Summary of Data Recovery

The memory card associated with the GoPro Hero 8 was destroyed in the accident and is unable to be repaired as an examination shows it likely contains a cracked silicon die. The memory card associated with the GoPro MAX contained an empty file structure. Upon conducting a forensic search for potentially corrupted video that would have resulted from the MAX operating during a high impact, no files were recovered that were consistent with the accident flight.

In summary, the accident recording could have been made with the Hero 8, but the camera’s memory card was destroyed. The GoPro Max was likely not operating during the accident flight.

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