NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, DC 20594

May 3, 2022

Onboard Image, Audio, and Data Recorder

Specialist's Factual Report
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1. EVENT

Location: Pioche, NV
Date: July 29, 2020
Aircraft: Airbus Helicopters AS350B3, N755AE
Operator: St. Louis Helicopters
NTSB Number: WPR20LA244

2. DETAILS OF INVESTIGATION

On July 6, 2021, the National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following image, audio and parametric data recording device:

Recorder Manufacturer/Model: **Appareo Vision 1000**
Recorder Serial Number: **VIS-FFDK**

2.1. Appareo Vision 1000 Recorder Description

The Appareo Vision 1000 device is a small self-contained image, audio, and data recorder. The unit is typically mounted in the overhead panel of the aircraft's cockpit and records an image at a rate of four times per second with its internal camera. The device is also capable of recording two tracks of audio that are synchronized with the image data. A GPS receiver is included that receives GPS satellite-based aircraft time, position, altitude, and speed. The Appareo unit also has a self-contained real-time inertial measuring unit that records 3-axis acceleration, and derived pitch, roll and yaw data.

Two independent audio tracks can be recorded. One track is the internal microphone for the device. The second track can be wired to an external microphone. In this installation one input was determined to be the helicopter's intercom and recorded pilot and crew communication. The other track only picked up very loud engine and/or transmission sounds from the helicopter and was determined to have been recorded by the Vision 1000's internal microphone.

The Appareo unit records the image, audio and parametric data on a removable SD[1] memory card that is inserted into the unit. Depending on card size, this removable memory retains approximately the last two hours of image and audio data and about the last 100 hours of parametric data. In addition to the removable memory the Vision 1000 is also equipped with a memory module that is mounted internal to the unit. This internal memory contains an exact duplicate of the data stored on the removable card.

The Appareo unit on this aircraft was connected to the aircraft's electrical bus. Any time the battery switch is turned on the Appareo unit will start to record audio, images and data. The Vision 1000 unit creates a new file for every electrical power application and can create multiple files for the same power cycle if the recording time exceeds a certain time limit.

2.2. Appareo Vision 1000 Damage

Initial inspection of the device indicated no obvious major component damage. The unit was shipped with an removable SD card, which was not congruent with the type of SD card that is shipped with the unit by the manufacturer (Appareo).

Figure 1. The Appareo Vision 1000 device and the associated SD card, as received.

2.3. Appareo Vision 1000 Data Recovery

The device has two memory storage devices. One memory storage device is the removable SD card and the other memory storage device is the unit's internal memory. A properly functioning Appareo Vision 1000 device will write data simultaneously to the removable SD card as well as the internal memory device.

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[1] SD – Secure Digital – A type of nonvolatile memory card used extensively in portable devices.

Removable SD Card

A properly functioning removable SD card associated with this device should contain a drive consisting of a raw version of the recorded data, as well as a virtual drive of converted files that are playable within the manufacturer's software playback utility.

The removable SD card associated with the accident device, pictured on the right of figure 1, was read with a PC. No obvious data was found on the removable SD card.

The removable SD card was then imaged forensically with a PC to further understand the potential contents of the memory device. The forensic image revealed that all blocks of the memory device returned "00" when viewed in a hex editor. This indicated that the card was not only lacking a filesystem, but was also completely blank. No historical flight data, or any data, was found on the removable SD card.

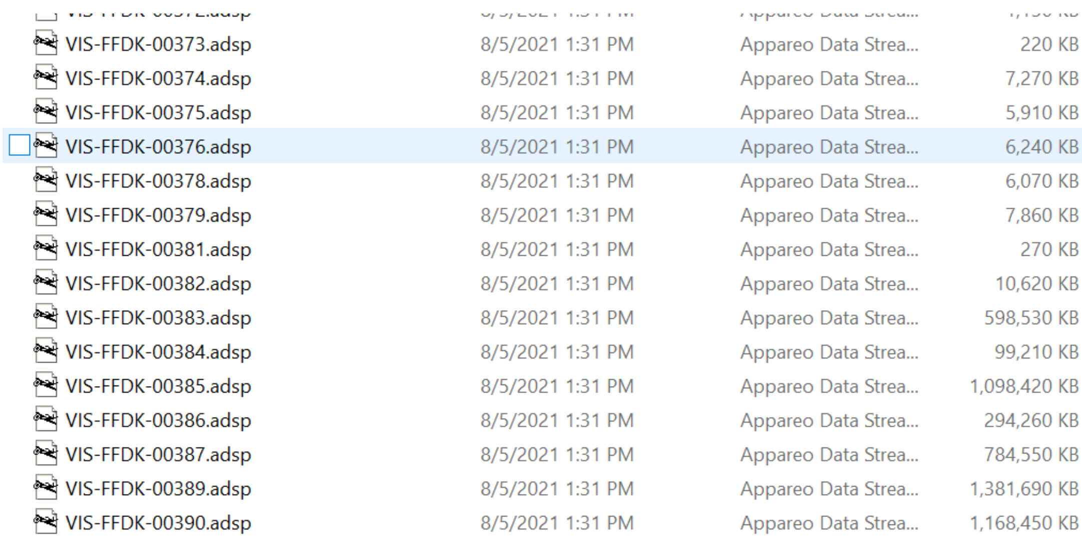
Internal Memory

The manufacturer has specified a procedure to pull data from the unit's internal memory. This process consists of formatting an exemplar "surrogate" removable SD memory card with a software file that commands the unit's internal memory to write to removable SD memory card. For this exercise, a manufacturer supplied and branded (Appareo Brand) removable SD card was formatted with a dump file commanding the accident unit to dump its internal memory. The device was powered on a test bench and appeared to function normally. The process lasted approximately two hours, and the unit indicated that successful transfer of the internal memory contents to the removable surrogate SD card had taken place.

The removable surrogate SD card was then read on a PC. The contents were congruent with a successful memory dump and consisted of a number of raw files of .vfs format (figure 2). These raw files were then "merged" in manufacturer provided software which provided a number of converted flight files (figure 3).

APVNF000.vfs	12/31/1979 11:00 PM	VFS File	64 KB
APVNF001.vfs	12/31/1979 11:00 PM	VFS File	2,060,800 KB
APVNF002.vfs	12/31/1979 11:00 PM	VFS File	2,060,800 KB
APVNF003.vfs	12/31/1979 11:00 PM	VFS File	2,078,720 KB
APVNF004.vfs	12/31/1979 11:00 PM	VFS File	1,935,360 KB
force.memorydump	8/5/2021 11:54 AM	MEMORYDUMP File	0 KB

Figure 2. The windows file structure resultant of a successful internal memory dump of raw files (.vfs) from the accident unit.



VIS-FFDK-00373.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	220 KB
VIS-FFDK-00374.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	7,270 KB
VIS-FFDK-00375.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	5,910 KB
VIS-FFDK-00376.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	6,240 KB
VIS-FFDK-00378.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	6,070 KB
VIS-FFDK-00379.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	7,860 KB
VIS-FFDK-00381.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	270 KB
VIS-FFDK-00382.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	10,620 KB
VIS-FFDK-00383.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	598,530 KB
VIS-FFDK-00384.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	99,210 KB
VIS-FFDK-00385.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	1,098,420 KB
VIS-FFDK-00386.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	294,260 KB
VIS-FFDK-00387.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	784,550 KB
VIS-FFDK-00389.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	1,381,690 KB
VIS-FFDK-00390.adsp	8/5/2021 1:31 PM	Appareo Data Strea...	1,168,450 KB

Figure 3. The windows file structure resultant of a successful "merge" of the unit's extracted internal memory raw files (.vfs).

File VIS-FFDK-00390.adsp was the last file constructed from the converted memory files. When selected for playback, the manufacturers software provided the following error message: "AS Flight Analysis Software cannot find any data in the file to display." When attempting to play the other files, the same error message is returned.

The manufacturer then suggested a method of unzipping the files and manually interpreting the data. The following is summarized:

Files from VIS-FFDK-00390.adsp – Showed the aircraft in a maintenance hangar at an unknown date and time.

VIS-FFDK-00389.adsp – Imagery similar to VIS-FFDK-00390.adsp

VIS-FFDK-00387.adsp – Recording of the aircraft in flight with a timestamp indicating the imagery was created on January 25, 2020.

All previous files were determined to be from recorded sessions which occurred earlier than January 25, 2020. The accident occurred on July 29, 2020 and was not captured in these files.

Testing of the Accident Device

First, an NTSB owned surrogate Vision 1000 device was bench tested in the laboratory to confirm the unit's functionality and integrity of the download and data extraction processes. A number of successful test downloads were conducted.

The accident unit was then bench tested. First, the accident unit was bench tested with an Appareo branded surrogate removable SD card. An extraction of data from the surrogate Appareo branded removable SD card showed successful test imagery. A download of the unit's internal memory also showed the unit was functioning properly on the test bench.

The accident removable SD card was then inserted into the accident unit and the accident unit was given power on the bench. This resulted in no data recorded to the removable SD card, but successful imagery downloaded from the unit's internal memory.

The accident removable SD card was then tested for proper functionality by writing a test file to the card. This was successful. The accident removable SD card was then formatted FAT32 with a 64kb unit allocation size and re-tested. This resulted in a blank accident removable SD card, but a functioning download of the unit's internal memory.

In summary, the following was noted:

- The unit's internal memory functioned on the test bench.
- The accident removable (non-Appareo branded) SD card did not function in the unit (did not receive live flight data).
- A surrogate Appareo branded removable SD card functioned on the test bench.

Further Examination

An investigator who had traveled to the accident site provided photos (figure 4) that showed the unit was found plugged in at the time of the accident.

Figure 4. The accident unit, as noted in the wreckage, post-accident.

On September 29, 2021, a representative from Appareo stated there were no records of the accident operator having updated the camera's firmware. In previous instances, older firmware had shown to result in the camera not recording. Appareo had released an updated (R15) firmware that corrected bugs in previous firmware releases. Appareo ran a campaign where they sent a representative to different operators to update units to firmware R15 free of charge. The Appareo representative indicated that this unit likely had not been updated since there was no record of the update taking place.

Reading older files from the accident unit in a hex editor revealed the following ASCII string: *VIS-FFDK 2012VR3.3.33.4.8.R1.0.0R1.0.0*. According to Appareo, this ASCII string indicated that the camera had been upgraded to version R15 of the firmware software, which is known to have solved previous software issues of other Vision 1000 camera systems, including the camera becoming non-functional.

Appareo was informed that this Vision 1000 unit was functioning on firmware version R15. An Appareo representative commented that the following scenarios may have contributed to an instance of a Vision 1000 not recording:

- The accident helicopter's circuit breaker panel should be examined to see if the breaker associated with the Vision 1000 was tripped.
- The unit's power connector, while plugged in, could have had a bent power pin. Other Vision 1000 units have encountered a bent power pin scenario. Appareo suggested that the power pin should be examined, but noted that observing if any damage was related to the crash would be difficult to determine.
- A test of the wiring harness from the circuit breaker to the Vision 1000 should be conducted.

A return trip to the accident helicopter at the wreckage facility was attempted, however due to COVID-19 travel restrictions, and other factors, it was not conducted by the time this report was published.

Use of Non-Appareo Branded SD Cards in Vision 1000 Units

Appareo was again contacted regarding the use of non-Appareo branded SD cards in Vision 1000 units. Recall that the accident helicopter's Vision 1000 unit was found with a non-Appareo branded SD card inserted into the Vision 1000 unit, and that bench testing showed that the non-Appareo branded SD card did not function in either the accident unit, or the NTSB test unit.

Appareo stated that, *"Any SDHC, Class 10, Fat 32 formatted card should work, however, we have noticed more consistent and longer life (more write/erase cycles) in the brand of cards we source."*

There are numerous speed ratings defined by the SD Association[2]. The SD Association also agrees upon a standard format for marking the specifications of memory devices. Capacity, bus speed and speed class are some of the defined components of the standardized specification markings of an SD device. Figure 5 is an annotated SD card showing the various definitions for the markings of an SD device, the definitions of which are found in the footnotes to this section.

Figure 5. Standardized performance markings on an SD device (source: https://www.amateurphotographer.co.uk/)

The accident SD card in figure 1 shows that it has a label that suggests it is a 16 GB capacity Class 10[3] SDHC U1[4] UHS I[5] SD card.

The card was tested with a speed testing software available for removable media. The results of the test are copied below:

Writing speed: 35.5 MByte/s
Reading speed: 25.7 MByte/s

[2] SD Association | The SD Association (sdcard.org)
[3] Speed Class – Speed class symbol comprises of the letter "C" with a number inside. A "C10" symbol indicates a "class 10" card capable of reading and writing at 10 MB/sec.
[4] UHS Speed Class – Ultra High Speed. A "U1" symbolizes a UHS Speed Class 1 which should support a minimum of 10 MB/sec read/write speed. Typically, the UHS speed class refers to the minimum sustained read/write performance of the card.
[5] UHS Bus Speed – A roman numeral "I" indicates theoretical short-term maximum read and write speed, which is always higher than the UHS Speed Class rated speed.

The test indicated that the read and write speed of the tested accident card exceeded the class 10 standard. The printed specification on the card showed the device was a "UHS-I" card. A representative from Appareo confirmed that a UHS-I card would work with the unit.

Appareo was also asked if it does issue, or has in the past, issued guidance to operators for using/not using non-Appareo branded removable media. Appareo stated that for simplicity they recommend using Appareo branded cards. Appareo cards meet the standard they have defined above. Appareo also pointed out that the pilot's guide[6] for the Vision 1000 device defines the following: "*The flight crew need only ensure that an Appareo SD card is in the Vision 1000 prior to flight operations.*" A representative from Appareo stated that they do not recommend against using non-Appareo cards, but they do specifically call out Appareo branded cards in other documentation. Installation instructions[7] referenced by the Appareo representative state the following, *"Vision 1000 Ultra II SD Card Assembly 104030-000019"* The Appareo representative further stated, *"our SD card kit is called out with no substitute. Again though, we are not specifically calling out to not use non-Appareo cards either."*

Following up with Appareo regarding the called out *"Vision 1000 Ultra II SD Card Assembly 104030-000019"* part number, Appareo was asked if *"Ultra II"* in the specification referred to UHS-II memory. An engineer from Appareo stated that *"Ultra II"* did not refer to the UHS-II standard, and stated that a UHS-I spec card would work with the unit. The SD device found installed in the accident unit was of UHS-I specification and was found to be blank.

The general makeup of the commercial flash memory industry consists of relatively few manufacturers who produce flash memory and control production lines. These chip manufacturers mostly sell chips to other companies who then repackage and sell the flash memory under different brand names. Another issue in the flash memory industry is the use of fraudulent components, fraudulent branding, fraudulent advertising and fraudulent product specifications. The discussion of the flash memory product supply chain and fraudulent behavior of various players in the industry is outside the scope of this report, however, it is widely known in the computer industry that quality control issues, mis-branding, and fraudulent sales of flash memory devices is commonplace. This activity is so prevalent that fraudulent memory devices have even penetrated the supply chains of well known and reputable product suppliers. For these reasons, the only way to verify the quality of a flash memory device is to test the device to ensure it meets the required specifications.

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[6] 606586-000017 Vision 1000 Pilots Guide

[7] 600840-000025 Vision 1000 Installation Instructions

Summary

It is not known why the camera did not record to the internal memory during the accident flight. It is possible that the issues suggested by Appareo (circuit breaker continuity or wiring harness/power continuity) could have been the reason for the camera to have not been powered for the accident flight.

If the camera were powered during the accident flight, the removable SD memory device could have been of the wrong specification to receive live flight data from the Vision 1000. The removable SD card, however, passed the speed test which would indicate it was of satisfactory performance to receive flight data but did not contain flight data. The removable SD memory card was found to be completely forensically blank (as if no data of any type was ever written to the card) and contained no historical flight data.