

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

July 13, 2021

**Global Positioning System (GPS) & Attitude Heading
Reference System (AHRS) Device**

**Specialist's Factual Report
By Sean Payne**

1. EVENT

Location: Richmond, IN
Date: April 25, 2021
Aircraft: Aerostar CZ A240
Registration: N417R
Operator: Private
NTSB Number: CEN21LA200

2. DETAILS OF INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following device:

Device Manufacturer/Model:	Appareo Stratus 3
Serial Number:	Unknown

2.1. Device Description

The Appareo Status device is a self-contained battery powered unit that contains an internal AHRS, GPS/WAAS receiver, and ADS-B receiver in one compact unit.^{1, 2, 3} The unit communicates wirelessly with the pilot's iPad or iPhone ("iOS Device") to display all of the acquired information. The pilot needs to have a particular software application

¹ The Attitude Heading Reference System consists of a set of 3-axis gyroscope, accelerometers and heading reference sensors that enable the unit to compute pitch, roll, and yaw motions.

² The Wide Area Augmentation System (WAAS) is an air navigation aid to augment the Global Positioning System (GPS), by improving its accuracy, integrity, and availability.

³ Automatic Dependent Surveillance-Broadcast (ADS-B) is a surveillance technology deployed throughout the national airspace system. The ADS-B system is composed of aircraft avionics and a ground infrastructure. Onboard avionics determine the position of the aircraft by using the GNSS and transmit its position along with additional information about the aircraft to ground stations for use by ATC and other ADS-B services. This information is transmitted at a rate of approximately once per second. Operators equipped with ADS-B realize additional benefits from ADS-B broadcast services: Traffic Information Service - Broadcast (TIS-B) (traffic information) and Flight Information Service - Broadcast (FIS-B) (weather information).

installed on their iOS Device to view the Stratus data.⁴ In addition to communicating with the iOS Device, the Stratus device records GPS position and AHRS information internally on a non-volatile flash memory chip.⁵ Internal memory has the space to store over 13 hours of data.

2.2. Device Condition

Upon arrival at the Vehicle Recorder Laboratory, an examination revealed the unit had sustained light impact damage. The unit is shown in figure 1.



Figure 1. Photo of unit.

2.3. Data Recovery

The device powered normally and was able to connect via Wi-Fi to a surrogate Apple iPad.

This device is capable of storing data in non-volatile memory (NVM). This feature can be activated or deactivated by the user within the device's associated software. The flight data recording option was found to be enabled, and a tracklog consistent with the accident flight was recovered.

⁴ iOS Device app (program) that communicates wirelessly with the Appareo Status unit to display aircraft's attitude, navigation, weather, and traffic information.

⁵ Type of solid state memory that does not require electrical power to retain information.

2.4. Data Description

The unit contained recorded data from a number of flights. Only one set of converted data was determined to be pertinent to the accident investigation and was found to be associated with the accident flight. Only these data are discussed in the report. The accident data were recorded at 5 Hz. The data used to create the figures was downsampled to 1Hz to accommodate displaying the information on Google Earth. Attachment 1, which is discussed below, contains the full 5 Hz data.

All times are expressed as Universal Coordinated Time (UTC).

Reliable GPS data began around 11:17:52, showing the recording device near a hangar at Richmond Municipal Airport (KRID), Richmond, IN. By 11:24:00, the aircraft had entered a taxiway and recorded tracklog data showed the aircraft heading toward runway 24. The recording device changed recording sessions. One session ended and another session began. This typically indicates the recording device's power was reset. Around 11:40:23, the aircraft crossed the hold short line for runway 24. Around 11:40:55, the aircraft began a takeoff roll on runway 24. Around 11:41:34, the aircraft was airborne and no longer over the centerline for runway 24. The aircraft continued to climb to a maximum altitude of around 2045 feet GPS altitude by 11:42:14. By that time, the aircraft was in a right bank turn of about 40 degrees right roll. The aircraft began descending, in what would become a tightening spiral. Data near the end of the recording indicated at one point the aircraft had rolled almost 90 degrees right. Data recording ended around 11:42:38, data show the aircraft was nose low with a right roll of about 40 degrees.

Figure 2 is a north-up Google Earth overlay of the accident tracklog recording. Times in the narrative above are highlighted. Note that the weather and lighting conditions depicted in Google Earth are not similar to the weather conditions at the time of the accident.

Figure 3 is a Google Earth overlay oriented in such a way to highlight the aircraft's variance in altitude and heading during the final portion of the accident recording.

Figure 4 is a screen capture take from CloudAhoy, an Electronic Flight Instrumentation System (EFIS) animation and flight debriefing tool. The screen capture was taken around 11:42:14, as the aircraft had achieved its maximum altitude during the accident flight. The aircraft had also become dynamic in pitch and roll. Note, that the CloudAhoy software interpolates between data points when creating an animation. As such, the animation is an approximation of the aircraft's flightpath. Note that the weather and lighting conditions depicted in CloudAhoy are not similar to the weather conditions at the time of the accident.

Attachment 1 is a record of all recorded data discussed in this report from the Appareo Stratus Device. The data is provided in electronic comma separated value format (.CSV).





Figure 3. A Google Earth overlay that highlights the aircraft's variance in altitude and groundtrack during the final portion of the accident recording.

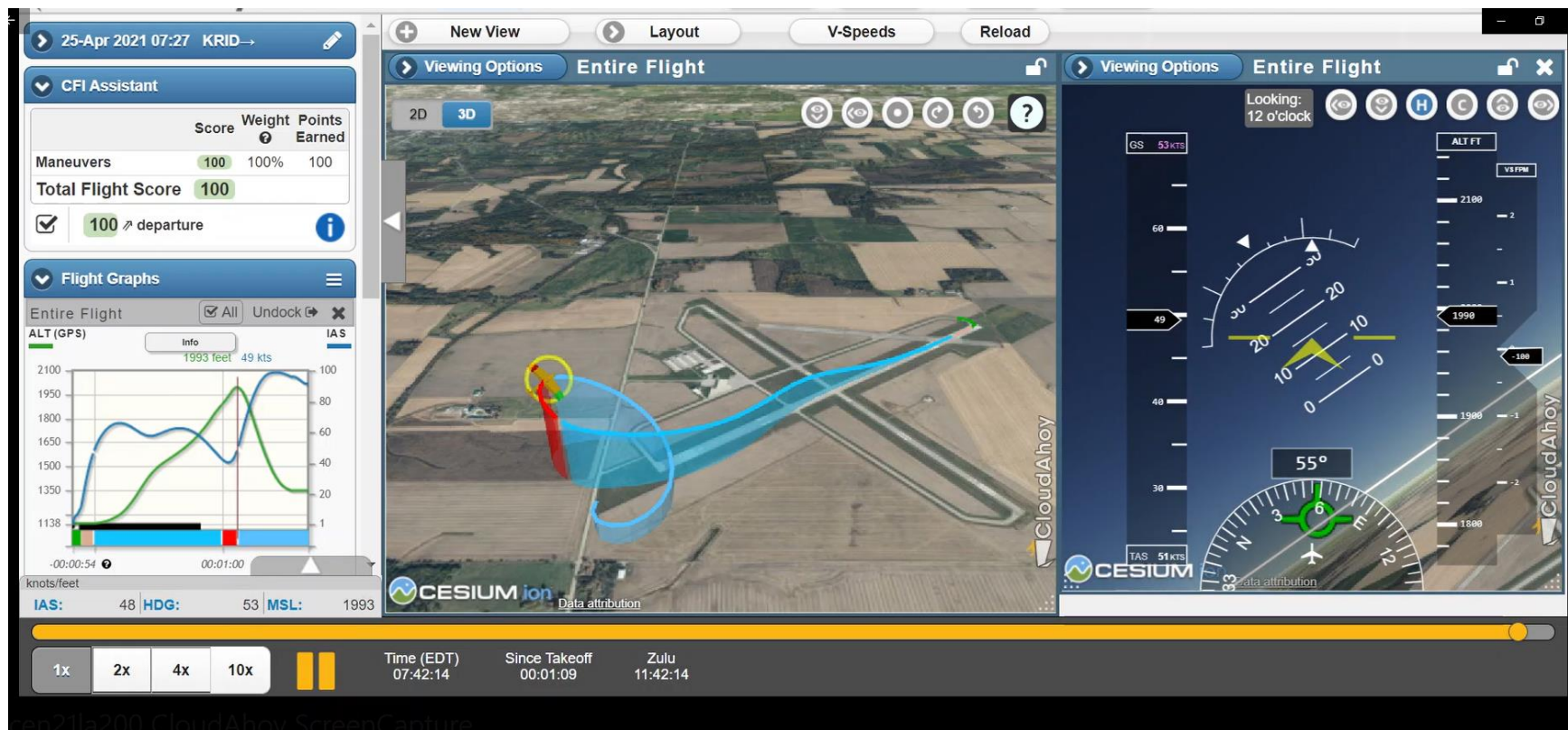


Figure 4. A screen capture taken from the CloudAhoy software flight debriefing tool.