

NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, DC 20594

September 23, 2020

Onboard Image, Audio, and Data Recorder

Group Chairman's Factual Report
By Sean Payne

1. EVENT

Location:	Brainerd Lakes, Minnesota
Date:	June 28, 2019
Aircraft:	Agusta Spa A109S, N11NM
Operator:	North Memorial Healthcare
NTSB Number:	CEN19FA185

2. SUMMARY

On June 28, 2019, about 0040 central daylight time, an Agusta Spa A109S helicopter, N11NM, impacted terrain while landing at Brainerd Lakes Regional Airport (BRD), Brainerd Lakes, Minnesota. The pilot and flight nurse were fatally injured, the flight paramedic was seriously injured, and the helicopter sustained substantial damage. The helicopter was registered to and operated by North Memorial Healthcare under the provisions of Title 14 *Code of Federal Regulations* Part 135. Instrument meteorological conditions prevailed at BRD for the instrument flight rules (IFR) flight, which departed from North Memorial Heliport (MY77), Robbinsdale, Minnesota, about 2348.

3. GROUP

A group was convened on August 7, 2019, at the Vehicle Recorder Laboratory at NTSB headquarters in Washington, D.C. The group consisted of the following members:

Chairman:	Sean Payne Investigator – Mechanical Engineer National Transportation Safety Board (NTSB)
Member:	Michael Folkerts Investigator-In-Charge (IIC) NTSB

Member: Scott Tyrrell
Accident Investigator, Rotorcraft Standards Staff
Federal Aviation Administration (FAA)

Member: Christopher Hyder
Test Pilot
AgustaWestland/Leonardo

Member: Joshua Jones
Director of Operations/Pilot
North Memorial Healthcare

4. DETAILS OF INVESTIGATION

On July 1, 2019, 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-FH4U**

4.1. 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 of an aircraft's cockpit and records a cockpit image at a rate of four times per second. In addition to cockpit images, the device is also capable of recording two tracks of audio that are synchronized with the image data. The unit also contains a GPS receiver that receives GPS satellite-based aircraft time, position, altitude, and speed. In addition to the GPS position, the Appareo unit also has a self-contained real-time inertial measuring unit that provides 3-axis accelerations as well as aircraft pitch, roll and yaw data.

The two recorded audio tracks can be wired to record the following inputs: an external audio source such as the aircraft's intercom or radios and audio picked up by a microphone mounted internal to the Vision 1000 unit. In this installation one input was determined to be external aircraft audio that was wired to 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 SD¹ memory card that is inserted into the unit. Depending on card size, this removable memory retains approximately the last three 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

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

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.

4.2. Appareo Vision 1000 Damage

Upon arrival at the NTSB Vehicle Recorder Division, it was evident that the Vision 1000 device had not sustained any obvious damage. The device is pictured below in figure 1 in the condition it was received.



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

4.3. Appareo Vision 1000 Data Recovery

The device's SD card was removed and was read on a PC. In this scenario, a write-blocking device was not used as it could affect the SD card's operation in this particular installation. The SD card, when functioning properly, and when not read via a write-blocker will show two partitions. One partition will contain raw data files, and a second partition will contain parsed flight files. When the accident card was read via the PC, only the raw data file partition was apparent and the partition containing the parsed flight files was not available.

Using the information from the partition that was functioning, the raw data file partition, the raw data files were attempted to be copied from the card. Six of the seven raw data files were copied successful, and an error persisted from copying the seventh raw data file. Multiple attempts were made to copy all raw data files

and did not result in success. Should all of the raw data files had been successfully copied, the manufacturer's software contains a provision to create parsed flight files from the raw data files, however, without the seventh file, creating parsed flight files from the raw data files were unsuccessful.

A representative from Appareo was contacted about this issue. The representative stated that the manufacturer of the SD card they utilized obsoleted an older lot of SD cards and now provided Appareo a newer lot of SD cards. Furthermore, the SD card manufacturer no longer published information related to endurance of the SD card write/erase cycles. In 2013, when the SD card manufacturer made this change between old and new lots of SD cards, Appareo had performed testing on the write-cycle endurance of both the new and old lots of SD cards that they procured. In summary, Appareo tested a quantity of four old lot SD cards and a quantify of four of the new lot SD cards. Their testing showed that the old SD cards performed for approximately 1,800 hours before failing. Of the four new lot SD cards test, two of the four failed at 1,800 hours and the remaining two were still functional at the end of the test at a total of 2,235 hours.

It was determined from maintenance records that the Vision 1000 system in the accident helicopter had been installed 1740.3 hours prior to the accident. Using the consideration that for each rotorcraft operating hour, the Vision 1000 system runs for 1.3 hours, the operating time of the SD card was approximately 2262 hours.

A representative from Appareo stated that they have not formally issued a service bulletin or any guidance to Vision 1000 operators regarding the failure of SD cards. Continued airworthiness guidance for the system does, however, require operators of Vision 1000 systems to do a periodic download of the system to insure proper operation.

According to the Director of Maintenance (DOM) for the operator, the original intention was to have annual inspections that verified the functionality of the SD card and the mechanics were supposed to upload the information to Appareo software so the successful capture of flights could be verified. The operator then stated that mechanics and pilots did not have access to the Appareo software for reviewing the data, and were then instructed to perform a "visual inspection" and have "base pilots rotate the SD cards to [their] aviation safety officer for review and monitoring." The DOM went on to explain that this particular process had no oversight and the inspections of the SD cards and subsequent verification of recorded flight data "quickly fell apart."

Since the accident, the DOM was informed of the failure of the Appareo SD card and took corrective actions across the fleet to ensure verification and monitoring of the Vision 1000 unit. The DOM talked to the STC holder and "found out" there were firmware updates available for the unit, as well as "larger SD cards [that would] increase record time." Additionally, the DOM took the following actions:

- All Vision 1000 units in the fleet were inspected, updated and verified to be operational.
- Contacted Appareo to obtain software that would allow maintenance technicians that would allow remote uploading of data.
- Informed maintenance staff that the SD cards will be uploaded at “50 hour/30 day” intervals, if possible.
- Obtained access to an Appareo interface which allows monitoring of each SD card by aircraft and serial number, showing date of last upload and the health of each upload.

The SD card was assumed to be non-functional and a read of the device’s internal memory was pursued.

To read the internal memory, the Appareo software is used to format a surrogate SD card to stop the unit from writing new data when powered on and to dump the internal memory. A surrogate SD card was formatted specifically for the accident unit’s serial number. The surrogate SD card was installed and the unit successfully dumped flight data to the surrogate SD card.

During normal operation, each time power is applied to the unit, a set of data files is created. The downloaded files from the internal memory contained over 244 power cycles worth of data. By design, approximately the last three hours of files will contain image, audio and parametric data. Files outside of the last three hours of operation contain parametric data only.

The entire accident flight was recorded and included image, audio and parametric data. A few previous flights to the accident, the previous three power cycles included the accident pilot, were also recorded and included image, audio and parametric data. Overall, the images and audio are recorded for about two hours previous to the accident flight, prior to that only parametric data is recorded. Parametric data existed back until June 2019, about two months prior to the accident.

Figure 2 is a screenshot taken from the recorder that shows an example of the camera’s image from a power cycle previous to the accident where the accident pilot was conducting a preflight inspection.



Figure 2. A capture from the Appareo image recorder, serial number VIS-FH4U installed on N11NM.

4.4. Timing and Correlation

Timing information was recorded as UTC. The time recorded by the device was offset to CDT, which was the local time of the accident. CDT is five hours different from UTC.

To convert the Appareo recorded time to CDT, the following formula is applied:

$$\text{Appareo Vision 1000 Time} - 18,000 \text{ seconds} = \text{CDT}$$

The format given for this report is HH:MM:SS.00, where HH stands for the number of hours, MM, the number of minutes and SS.00, the number of seconds to the nearest hundredth.

4.5. Appareo Vision 1000 Parametric Data Description

As discussed in section 4.3 of this report, parametric flight data was available all the way back to June 2019. The last few sets of files associated with the last three power cycles of the camera also contained audio and video data.

Parametric data containing information from the accident flight was extracted and provided in .CSV format as attachment 1.

Using parametric data from the accident flight provided in attachment 1, a KML² of the accident flight was created. The figures 3 through 8 are GPS overlays that describe the accident flight. Figures 9 and 10 are plotted GPS recorded, GPS derived and recorded inertial data relevant to the accident flight.

² KML – Keyhole Markup Language – a filetype for use with Google Earth.

Figure 3 is a Google Earth overlay oriented north-up. The overlay shows the entire accident flight.

Figure 4 is a Google Earth overlay oriented north-up. The overlay shows the helicopter's departure from MY77.

Figure 5 is a Google Earth overlay oriented north-up. The overlay shows the overall vector and approach phase of the helicopter on the ILS 23 at BRD.

Figure 6 is a Google Earth overlay oriented north-up. The helicopter's GPS tracks are overlaid on the published approach procedure for the ILS 23 approach at BRD.

Figure 7 is a Google Earth overlay showing the final portion of the approach phase of flight.

Figure 8 is a Google Earth overlay showing the final portion of the approach phase of flight. The orientation is looking toward the arrival end of runway 23 at BRD.

Figure 9 is a plot of all relevant recorded parameters from the Appareo Vision 1000 for the entire flight.

Figure 10 is a plot of all relevant recorded parameters from the Appareo Vision 1000 for the time interval between 00:34:00 and 00:40:00.

Figure 11 is a plot of all relevant recorded parameters from the Appareo Vision 1000 for the time interval between 00:39:20 and 00:40:00.

4.6. Summary of Recording Contents

The Director of Operations of North Memorial Healthcare indicated the Appareo Vision 1000 system was wired to the battery side of the helicopter's master switch. As such, the Appareo Vision 1000 would activate when the battery master was set to "ON."

Third Previous Power Cycle to the Accident (Aircraft on Ground)

The pilot conducted a preflight of the aircraft. The preflight was very thorough. The pilot checked exceedances as well as DAU mis-compare. The recording ended when the pilot powered down the helicopter.

Second Previous Power Cycle (Second Previous Flight to the Accident)

Only EFIS display brightness was noted, the overall flight appeared to be unremarkable.

The pilot set both the pilot side and co-pilot side EFIS screens to a medium brightness level.

First Previous Power Cycle (Previous Flight to the Accident)

Only EFIS display brightness was noted, the flight appeared to be unremarkable.

The pilot's EFIS screen was set to a medium setting and the copilot's side EFIS screen was set to a bright setting. Approximately 9 minutes and 40 seconds into the flight, the pilot lowered the copilot's side EFIS screen to a low level of brightness.

Accident Flight

The Vision 1000 unit provided a field of view as shown in figure 2. The recording was captured at night, as such, the image was dark, most of the instrument panel indications could be distinguished and were backlit. For specific conditions related to the brightness of the backlighting, refer to the summary and transcript below.

The recording began at 23:46:51.750. The start sequence, preflight, takeoff and enroute portion of the accident flight are summarized below. A full transcript began at 00:27:41.8 CDT and terminates at the end of recording at 00:39:55.7 CDT. The full transcript is two columns, the left is all transcribed audio and the right is all transcribed video actions. Unremarkable video actions were not transcribed.

At 23:46:51.750, the pilot was conducting a startup procedure. The pilot was holding a checklist. The pilot discussed weather with the crew. The pilot discussed radio usage with the crew and filed an IFR flight plan. The EFIS screens powered on. The pilot dimmed his EFIS screens to a low level and then reached over and dimmed the copilot side EFIS screen to a medium brightness level. The pilot began programming the GNS-530 and GNS-430 for the flight. The startup and preflight operations appeared nominal. The fuel level indication at the start of the flight showed 221 kilograms on the left tank and 290 kilograms on the right tank. The pilot conducted a VFR departure and the nurse recorded a time off of 23:49 CDT (04:49 GMT). The pilot made a traffic call during departure. The pilot picked up the weather from the ASOS at Crystal Airport, Minneapolis, Minnesota, (KMIC).

The pilot coupled to vertical speed [VS] to heading mode [HDG] on the flight director and performed an en-route climb to the northwest. Some ground lighting was visible through the visible portion of the windscreen during the en-route climb portion of flight.

Around 23:54, the pilot picked up an IFR clearance from Minneapolis center. The route given cleared the helicopter "direct BRD as filed, climb maintain 6000 feet."

Around 23:56, the pilot was holding an iPad and then commented on weather conditions at BRD; and "1 mile, looks good."

Around 23:56:30, the pilot was holding an iPad. An IFR approach plate was visible on the screen, the device appeared to be running Foreflight. The pilot programmed 250 feet AGL as minimums into the HTAWS (Helicopter Terrain Awareness System). The pilot called his company communications center and reported 2 hours and 10 minutes of fuel and 40 minutes estimated time en-route.

Around 23:57, the pilot commented to another crew member that he would utilize runway 23 versus runway 34 at BRD.

Around 23:58, the pilot made an unintelligible comment related to ground visibility, "** * * be able to see the ground in this thing." The medic stated, "that's a good point."

Around 23:59:30 the helicopter was handed off to another Minneapolis Center and leveled at 6000 feet MSL. The pilot was holding an iPad running Foreflight which showed a geo-referenced approach plate which was overlaid over an electronic VFR sectional chart.

Around 00:12, the pilot was visible holding an iPad running Foreflight. The display was consistent with airport information and an approach plate for BRD.

Around 00:13, the pilot called the company's communication center and report they were 19 minutes out from arrival at BRD.

Around 00:14:30 the helicopter was handed off to another Minneapolis Center controller. The pilot checked in level 6000 feet MSL and requested the ILS 23 approach to Runway 23 at BRD. The pilot reported he had the current weather at BRD.

Between 00:15:30 and 0017:45 the Appareo Vision 1000 system failed to record all image frames. Most image frames during this period of time could not be reviewed, the camera's image froze for most of this time period. The recorded audio track remained uninterrupted.

Around 00:17:20, the pilot was in contact with Minneapolis Center and asked for a straight in ILS approach to runway 23. The center controller assigned radar vectors and a right turn to 010 to radar vectors to intercept localizer ILS 23 at BRD.

Around 00:19:20, the pilot set the barometric pressure setting on the co-pilot side altimeter.

Around 00:20, the pilot was visible holding an iPad running Foreflight. The display was consistent with airport information and an approach plate for BRD.

The transcript now begins below and is a detailed record of the image and audio recording recovered from the device. The transcript starts at 00:27:41.8 CDT.

Transcript of an Appareo Vision 1000 recorder installed on a N11NM, an Agusta Spa A109S, that crashed in Brainerd Lakes, Minnesota, on April 26, 2018.

LEGEND

AWS	Aural Warning System
CAM	Cockpit Area Microphone
CNTR	Minneapolis Center Controllers
HOT	Prefix for a Hot Microphone
HTAWS	Helicopter Terrain Awareness System
NURSE	Flight Nurse
RDO	Transmission over VHF radio
-1	Voice identified as the pilot
-?	Voice unidentified
*	Unintelligible word
#	Expletive
@	Non-pertinent word
()	Questionable insertion
[]	Editorial insertion

Note 1: Times are expressed in Central Daylight Time.

Note 2: Only radio transmissions to and from the incident aircraft were transcribed.

Note 3: Words shown with excess vowels, letters, or drawn out syllables are a phonetic representation of the words as spoken.

Note 4: A non-pertinent word, where noted, refers to a word not directly related to the operation, control or condition of the aircraft. Typically a person's name.

Time and Source	Intra-Aircraft & Over-the-Air Communication	Time and Source	Video Events
2346:48.2			
START OF RECORDING START OF TRANSCRIPT			
		0027:14	The helicopter was level at 6,000 MSL and the airspeed indicator read 140 knots. The pilot was in vertical speed mode with the roll steering on heading on the flight director. The VSI bug was at zero. The landing gear was up. All engine instruments were nominal for this phase of flight. The Garmin GNS-530 was set to the map page with an ILS approach selected with radar vectors. The Garmin GNS-430 was set to the flight plan page. Both devices were crossfilled ³ .
00:27:41.8 CNTR	helicopter one one november mike turn left heading three six zero.		
00:27:46.0 RDO-1	left to three six zero and uh I'd like to descend when - uh as soon as possible for one one november mike.		
00:27:51.2 CNTR	one november mike descend and maintain four thousand.		
00:27:54.4 RDO-1	'kay leaving six thousand for four thousand one one november mike.		

³ Crossfilled – When entering information on one unit, the other unit would populate the appropriate field. This is an automatic operation, whereas an available manual mode would require the pilot either input field manually or manually “push” to initiate a crossfill.

		0028:06	The pilot set the VSI bug to -500 fpm and the helicopter responded. After an initial airspeed increase, the pilot slightly lowered the collective. Around the same time, the pilot made BRD ASOS active in comm 1 of the GNS-430. The pilot then moved his hand over to the GNS-530 and the frequency for Minneapolis Center (118.05 MHz) showed active in comm2.
00:28:26.6 ASOS	four zero at zero five - visibility - one quarter - fog - sky condition - overcast - two hundred - temperature one eight - celsius - dewpoint one six - celsius - altimeter three zero zero eight		
		0029:14	The GNS-430 was inadvertently shutdown by the pilot, and was quickly re-initialized by the pilot.
00:29:54.0 CNTR	helicopter one one november mike turn left to heading three two zero.		
00:29:57.9 RDO-1	left to three two zero one one november mike.		
		0030:02	The pilot's body position indicated that he had selected a new heading with the heading bug on the HSI.
		0030:06	The pilot completed re-initializing the GNS-430 by pressing the enter button. The pilot appeared to check the frequencies on the GNS-430, left BRD ASOS in the active comm 1 and left the GNS-430 on the satellite page.
		0030:43	The pilot set the barometric pressure in the co-pilot's altimeter.
		0031:00	The GNS-430 now showed a map page.

		0031:32	The pilot adjusted the left knob of the GNS-430, but it was unclear what action was performed.
		0031:45	The pilot hovered his left index finger over the ILS button on the flight director.
00:31:57.6 CNTR	helicopter one one november mike turn left two six zero (intercept) localizer report established.		
00:32:02.0 RDO-1	left to two six zero accept the localizer report established for one one november mike.		
		0032:03	The pilot's body motion suggested he changed the heading bug and or the vertical speed bug. The instruments appeared to show the helicopter leveling around 4,100 MSL. The helicopter started in a left bank turn.
		0032:07	The pilot depressed the ILS button on the flight director, arming the "NAV" and "GS" functions.
		0032:38	The pilot put the gear down and shortly thereafter got a three green indication. The vertical speed bug was set to zero. The helicopter appeared to be flying at 4,100 feet.
		0033:05	The pilot selected the flight plan page on the GNS-430, then manually initiated a crossfill of the flight plan from the GNS-530. The crossfill was successful.
		0033:16	The flight director captured the localizer. The flight director was still in vertical speed mode.
00:33:20.9 RDO-1	and center helicopter one one november mike uh-established.		

00:33:25.2 CNTR	helicopter one one november mike (time now) from LAREW cleared I-L-S runway two three approach to Brainerd Airport change to advisory frequency is approved report your cancelation back to me.		
00:33:32.8 RDO-1	'kay uhh cleared for I-L-S runway uhh two three Brainerd report cancelation back to you and switch over to advisory at this time one one november mike.		
		0033:51	The pilot was established on the localizer for the ILS 23 at BRD. The helicopter was flying level at 4,000 MSL.
00:33:53.1 BRD-ASOS	...visibility one half - haze		
00:33:56.7 HOT-1	awesome - one half - we're legal.		
00:34:00.3 HOT-1	one two two seven. perrrfect.	0034:03	The pilot manipulated the GNS-530 and the Unicom frequency for BRD was set active in comm2.
00:34:09.9 RDO-1	aaand Brainerd traffic helicopter one one november mike - is I-L-S two three - we're at LAREW inbound – Brainerd.		
00:34:21.7 RDO-1	[Sound similar to seven VHF mic clicks.]		
		0034:35	The flight director captured the glideslope. The helicopter began a descent. The airspeed increased slightly. The pilot was moving his hand near the top of the collective.

		0034:40	The pilot appeared to turn on either the landing light, search light or both. These switches were located on the collective, the pilot manipulated switches in this area.
		0035:10	The TRQ gauge indicated the power was reduced. The pilot's hand was near the collective. The airspeed reduced back to 90 knots and the descent stabilized around 400 fpm.
		0036:03	The pilot moved his left hand near the GNS-430 and appeared to put ASOS in standby on comm 1.
		0036:15	The pilot made BRD ASOS active in comm 1.
00:36:16.4 ASOS	...altimeter three zero zero eight - remarks - density altitude one thousand nine hundred - Brainerd Lakes Regional Airport - automated weather observation zero five three five zulu - wind - zero four zero at zero four - visibility one quarter [0536:37] - haze - sky condition - vertical visibility two hundred - temperature one nine celsius - dewpoint one seven celsius - altimeter three zero zero eight. (remarks) - density altitu— [The visibility report was received at 0536:37. This was after the pilot had crossed the FAF for ILS 23 at LAREW.]		
		0036:30	The instruments indicated that the helicopter had passed LAREW (FAF ILS 23 BRD). The helicopter was at 2,920 ft and 93 knots indicated. The published glideslope intercept altitude was 2,976 ft MSL. The fuel status showed 156 kilograms on the left tank and 191 kilograms on the right tank.
		0036:56	The pilot took BRD ASOS out of the active on comm 1.

00:37:04.9 RDO-1	and Brainerd traffic helicopter one one november mike is four mile final runway two three full stop Brainerd traffic		
00:37:14.3 HOT-1	Burnette Country - Brainerd - eh it's close.		
00:39:02.1 AWS	three hundred.		
00:39:04.2 HTAWS	minimums – minimums.		
		0039:08	The pilot moved his left hand over to the flight director and guarded the ALT button.
00:39:10.5 HTAWS	minimums – minimums.		
		0039:14	The helicopter arrived at decision height (DH) (1,424 ft MSL). The airspeed was about 100 knots indicated. The pitch attitude was about 2 degrees nose up and there was a very slight right bank. By all instrument indications the helicopter was stable as it arrived at the DH. All engine instruments were nominal for this stage of flight.
00:39:15.1 AWS	two hundred.		
		0039:17	The pilot pressed the “ALT” button on the flight director. The flight director was now in “ALT” and “NAV” mode. In less than a second later, the autopilot was decoupled via the cyclic, the pilot’s left hand was near the cyclic. The radar altimeter read 130 feet AGL.

		0039:20	The helicopter's pitch angle became more positive (passing through 6 degrees nose up) and continued to trend in the positive pitch direction. At the same time the radio altimeter increased to show 150 feet AGL. The helicopter's power setting was less than 30% torque. The airspeed began trending slower. At this time, white colored lights were visible near the corner of the image frame (outside the windscreen) as well as in the copilot's chin bubble. It is uncertain if this was ground lighting or a reflection of the helicopter's lights on visible moisture.
		0039:28	The helicopter's pitch attitude continued to trend positively, the pitch attitude was now about 15 degrees nose up. The helicopter was in an increasing right bank. The helicopter's power setting was less than 20% torque. The radar altimeter showed 170 feet AGL. The VSI was slightly positive. The GNS-530 was in a close zoom range and indicated the helicopter was just short of the runway's threshold.
00:39:30.5 AWS	glideslope.		
		0039:31	The helicopter was 20 degrees nose up. The bank angle had become slightly left now (left roll). The airspeed indicator was sweeping past 50 knots toward lower airspeed. The helicopter's power setting was still less than 30% torque. Radar altimeter now read 230 feet AGL. The VSI showed a 500 fpm climb. The pilot selected on "VS" and "HDG" on the flight director. The helicopter continued rapidly decelerating in regard to indicated airspeed.
00:39:33.9 CAM	[sound similar to increase in engine power.]		
00:39:35.9 AWS	glideslope.		

		0039:36	Airspeed continued trending down quickly and the airspeed indicator showed about 25 knots IAS. The pitch continued to stay around 18 degrees nose up. The power setting was coming up now past 40% torque and was trending in an increase rapidly.
00:39:38.0 HOT-1	* (go 'round) guys.		
00:39:41.1 AWS	glideslope.		
		0039:42	The airspeed indicator indicated 0 knots. Pitch had lessened to around 6 degrees. Power was still trending in an increase and was now at 80% torque and moving upward. Instruments indicated that the helicopter had begun spinning to the right, while in a left bank. The radar altimeter read 300 feet AGL.
00:39:43.8 HOT-1	sorry guys.		
00:39:45.0 CAM	[Sound of two medium frequency beeps - 600 Hz]		
		0039:46	The helicopter began to accelerate into a rapid spin to the right. The power setting was above 110% torque. The airspeed remained around 0 knots indicated. The GNS-530 showed a groundspeed of about 9 knots. The front seat occupants appeared to be affected by G force.
00:39:46.2 NURSE	*.		
00:39:46.7 HOT-1?	[Sound similar to grunt.]		

00:39:49.0 AWS	glideslope.		
00:39:49.7 ?	[Sound similar to grunt.]		
		0039:51	The airspeed remained at 0 knots IAS. The movement of the front seat occupants blocked large portions of the instrument panel. The front seat occupants appeared to be affected by G force. The pilot's body moved in such a manner in which the flight controls could have been impacted by pilot induced oscillations. At times, the power indicator was visible and it appeared to be varying dramatically. The instruments continued to indicate that the helicopter was in a rapid spin to the right.
00:39:51.3 HOT-1	(sorry) guys. [shouted.]		
00:39:52.0 HTAWS	[dual whooping sound] pull up.		
		0039:53	The HTAWS instrument's display was red indicating that the helicopter was approaching terrain in a non-approach environment. The airspeed remained at 0 knots indicated. The movement of the front seat occupants blocked large portions of the instrument panel. The visible instruments continued to indicate that the helicopter was in a rapid spin to the right. The engine power indicator varied throughout the time the front seat occupants showed rapid upper body movement. There was no indication that the pilot was manipulating the collective at this time.
00:39:53.8 AWS	[sound of three high frequency beeps - 2500 Hz - rotor RPM alarm.]		

00:39:54.7 HTAWS	[dual whooping sound] pull up.		
00:39:55.7		0039:55.7	Last frame of the recording. The engine power indicator was visible below 30% torque. The pilot's left finger was near the "ALT" button the flight director. The pilot had selected "ALT" on the flight director.
END OF TRANSCRIPT END OF RECORDING			

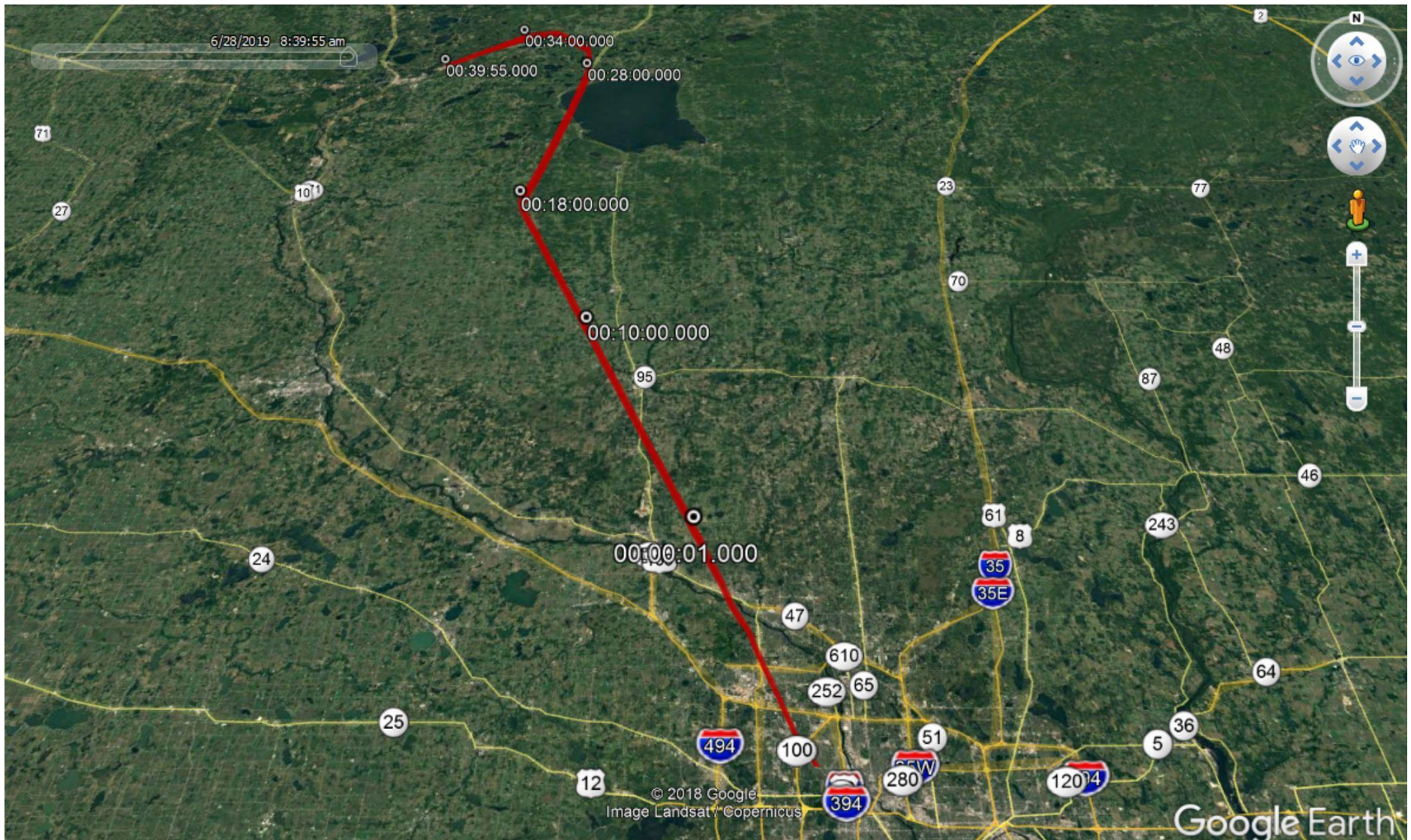


Figure 3. A Google Earth overlaying showing recorded GPS data for the entire accident flight. Times are in CDT.

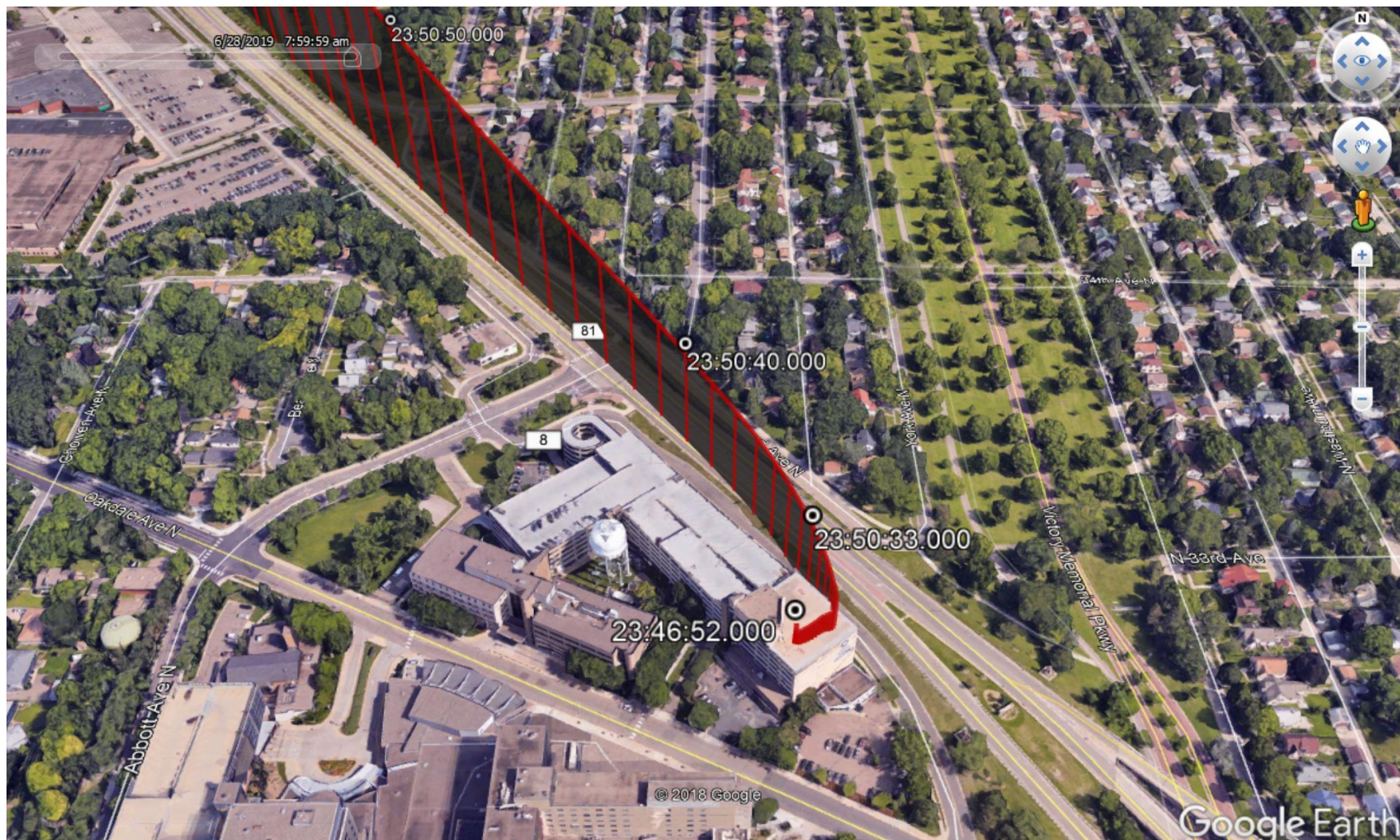


Figure 4. A Google Earth overlaying showing recorded GPS data for the departure portion of flight. Times are in CDT.

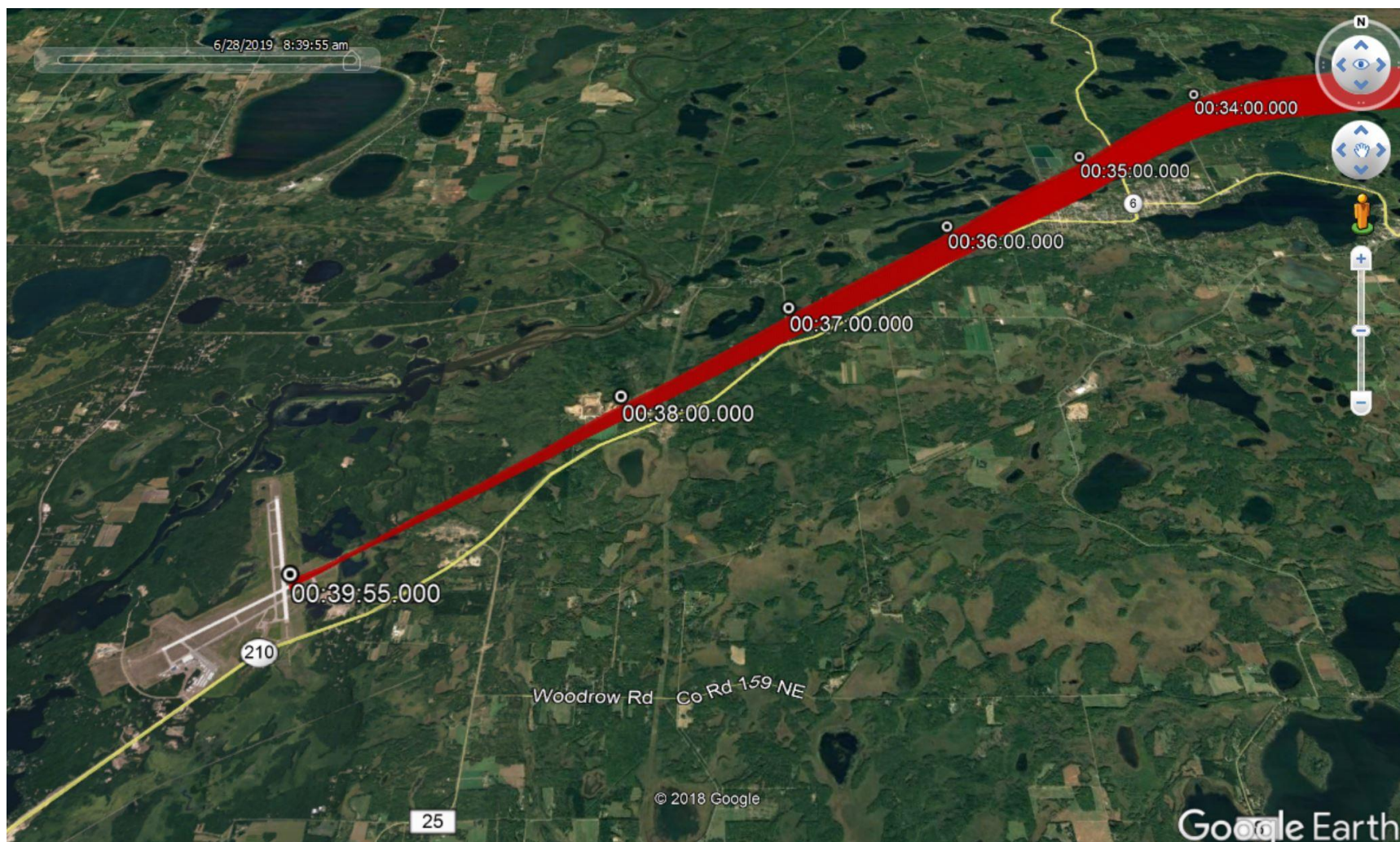


Figure 5. A Google Earth overlaying showing recorded GPS data for the overall approach portion of flight. Times are in CDT.

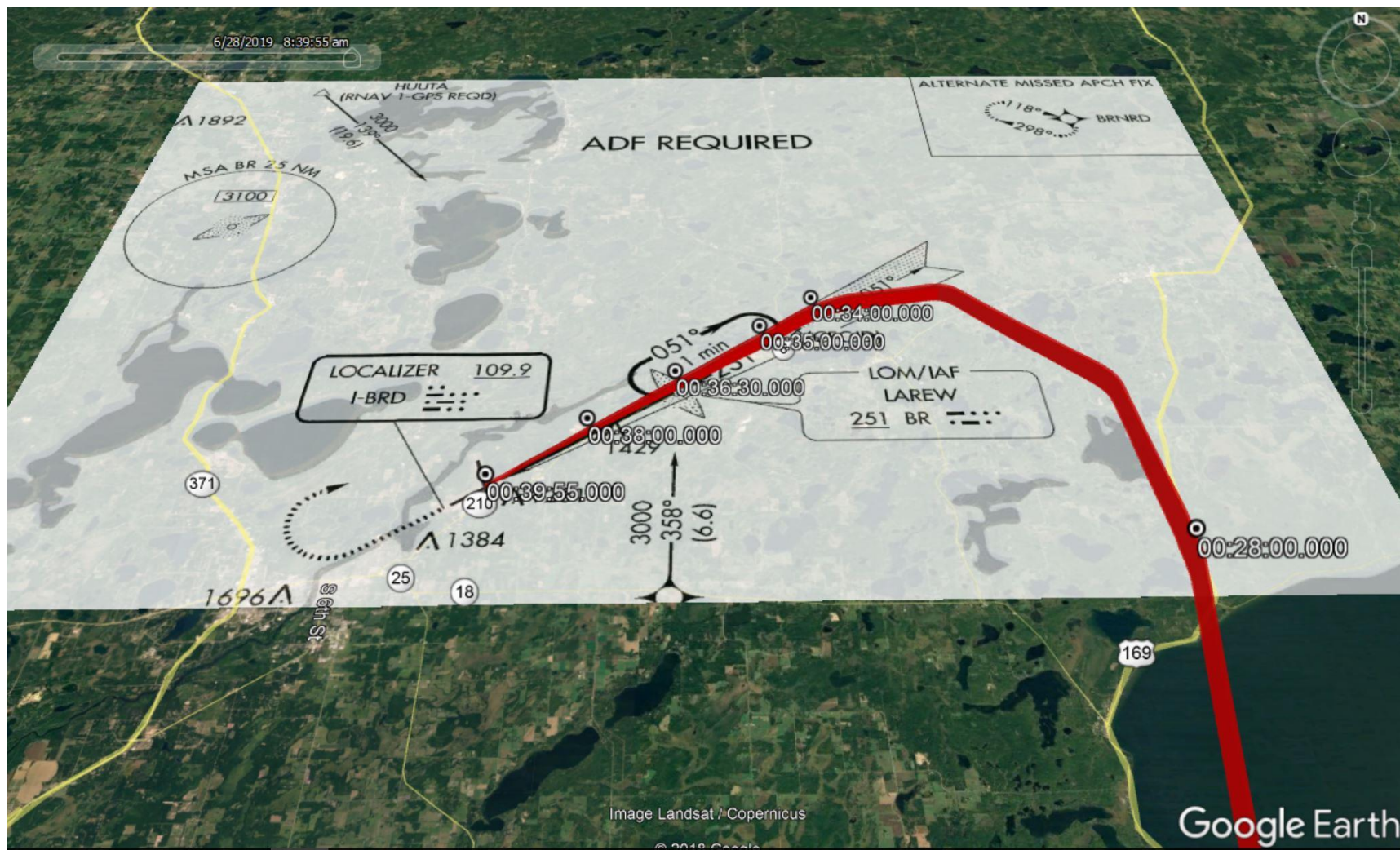


Figure 6. A Google Earth overlaying showing recorded GPS data overlaid on the ILS 23 Approach Plate for KBRD. Times are in CDT.



Figure 7. A Google Earth overlaying showing recorded GPS data for the final portion of the approach phase of flight. Times are in CDT.



Figure 8. A Google Earth overlaying showing recorded GPS data for the final portion of the approach phase of flight. The orientation is looking toward the arrival end of Runway 23. Times are in CDT.

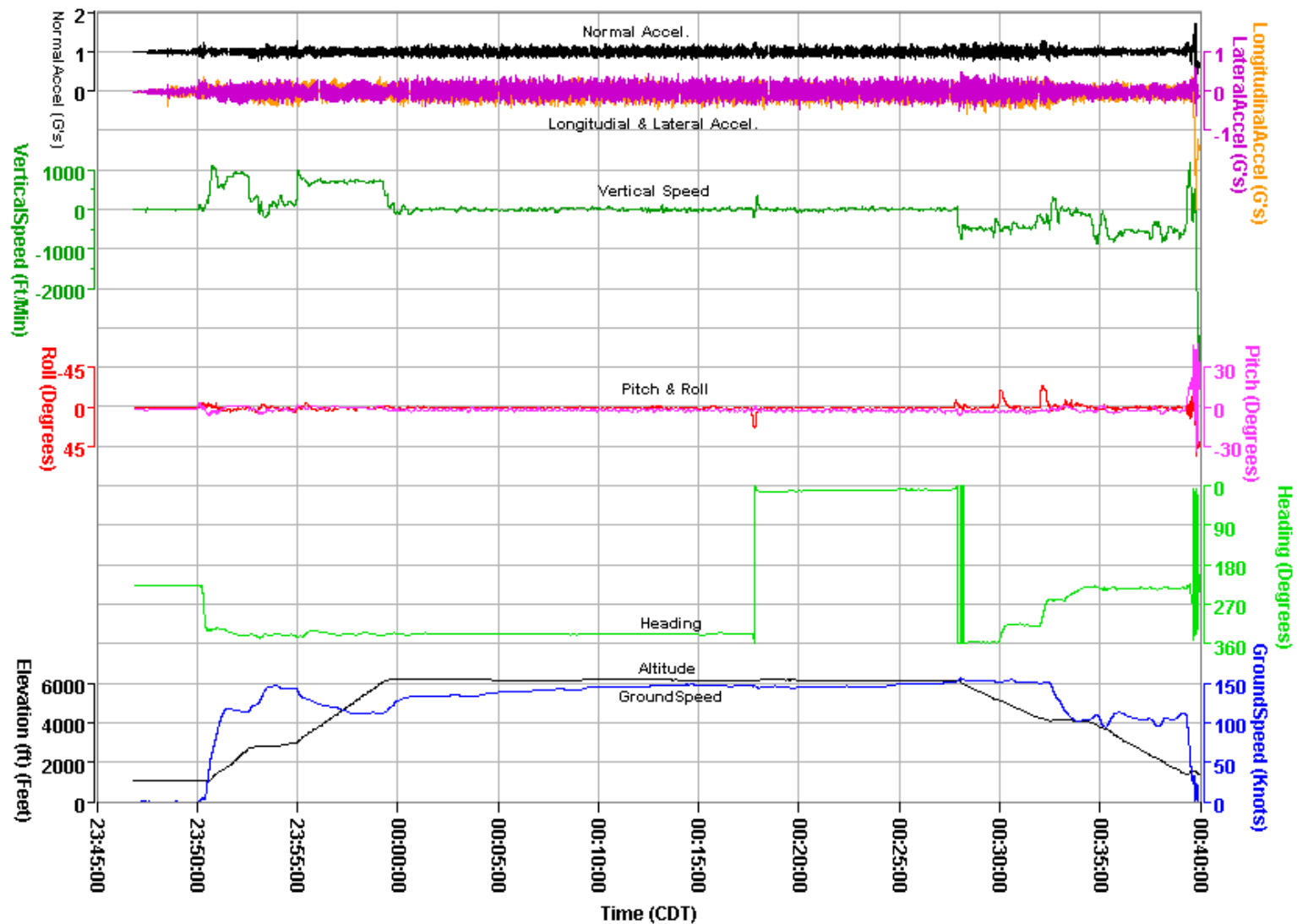


Figure 9. A plot of GPS recorded parameters, GPS derived parameters as well as AHRS recorded parameters for the entire flight.

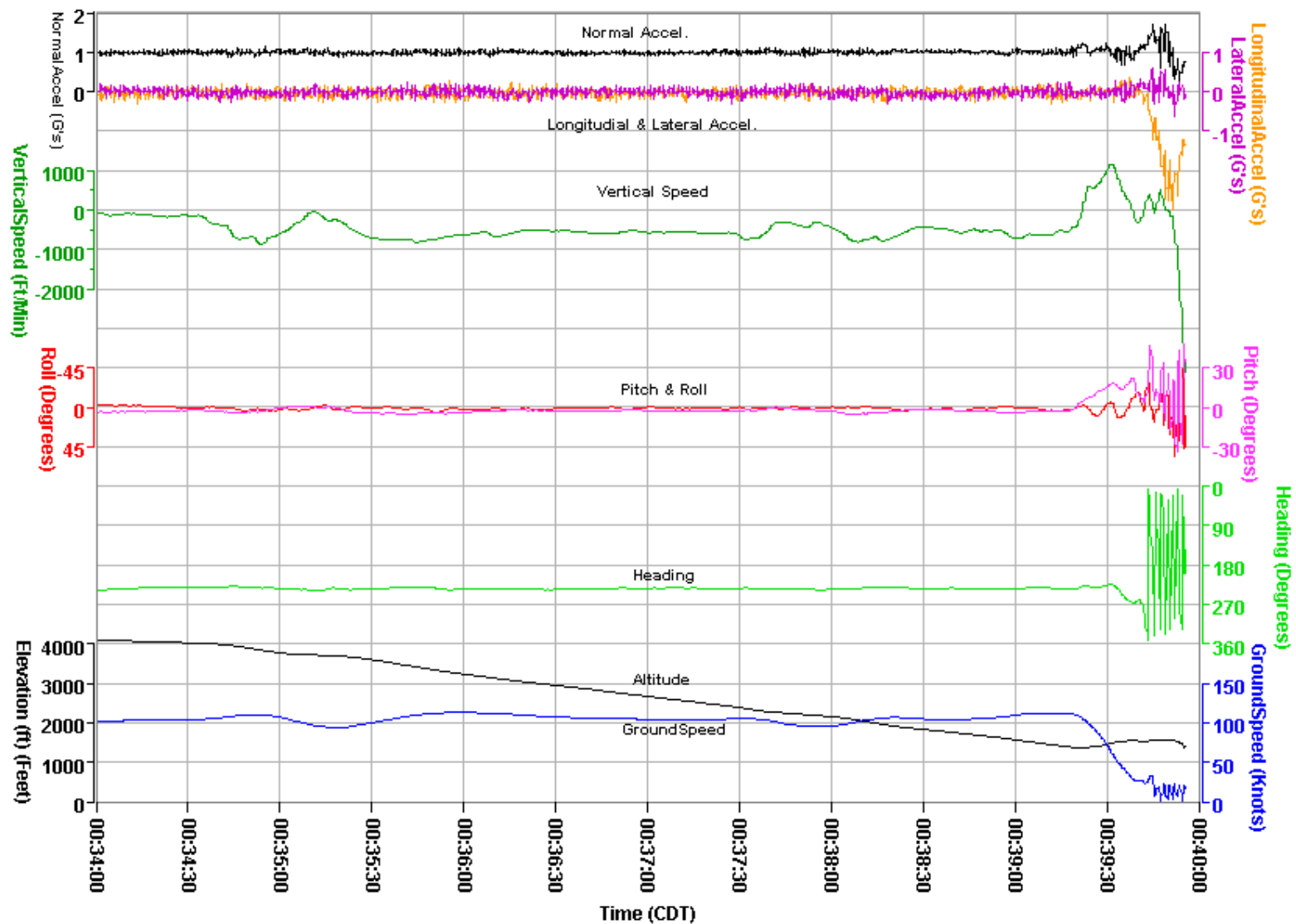


Figure 10. A plot of GPS recorded parameters, GPS derived parameters as well as AHRS recorded parameters for the approach phase.

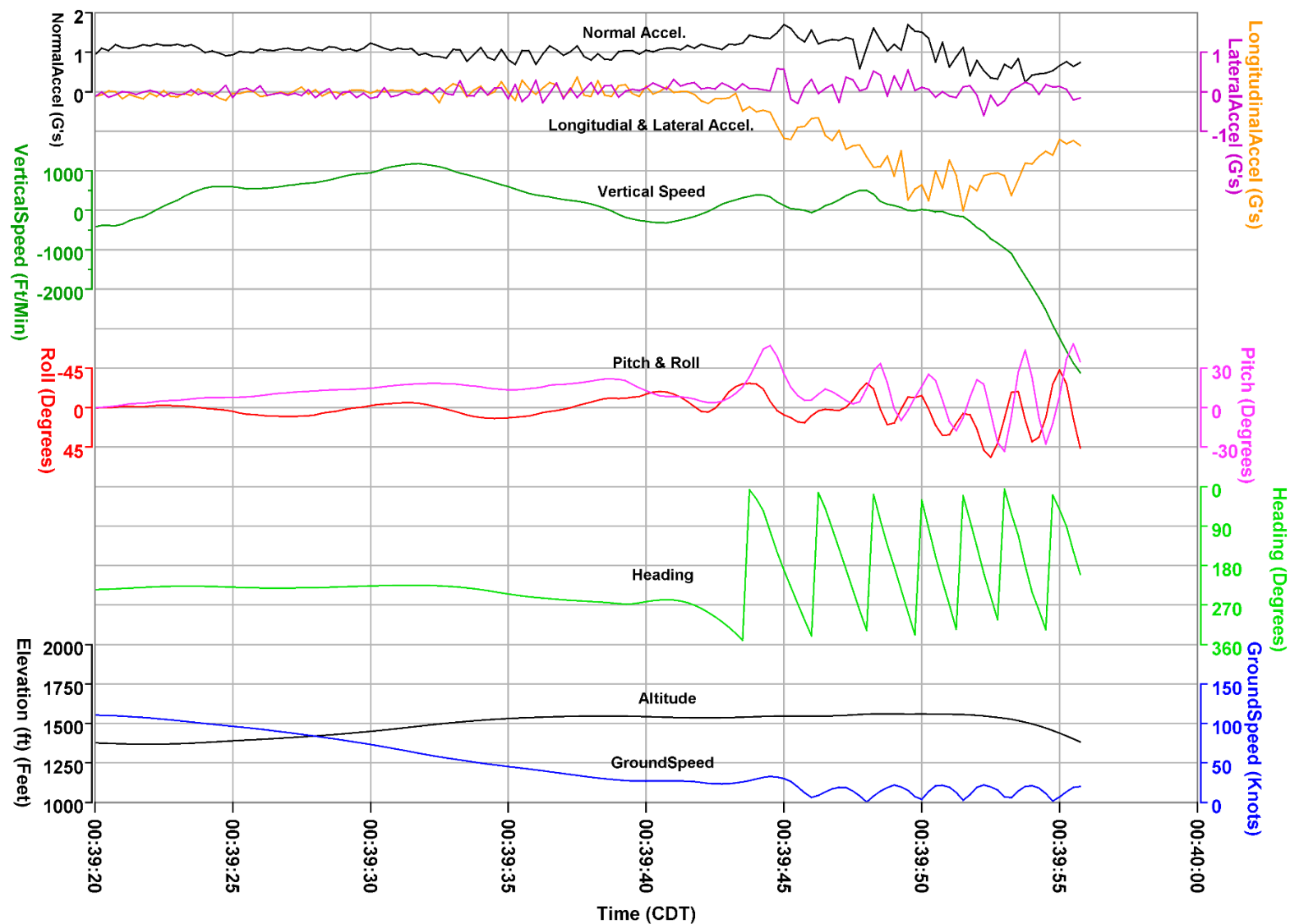


Figure 11. A plot of GPS recorded parameters, GPS derived parameters as well as AHRS recorded parameters for the accident portion.

APPENDIX A

This appendix describes the parameters provided and verified in this report. Table A-1 lists the parameters and table A-2 describes the unit abbreviations used in this report.

Table A-1. Verified and provided parameters.

Parameter Name	Parameter Description
Latitude	Latitude
Longitude	Longitude
Elevation	Altitude
GroundSpeed	Groundspeed
VerticalSpeed	Vertical Speed
Course	Ground Track
Heading	Heading
Pitch	Pitch
Roll	Roll
RollRate	Roll Rate
YawRate	Yaw Rate
NormalAccel	Normal Acceleration
LateralAccel	Lateral Acceleration
Slip	Slip/Skid Indication
TurnRate	Turn Rate
NormalField	Magnetic Field (Z Direction)
LongitudinalField	Magnetic Field (X Direction)
LateralField	Magnetic Field (Y Direction)
Fix	Fix Quality
HAcc	Horizontal Fix Accuracy
VAcc	Vertical Fix Accuracy

Table A-2. Unit abbreviations.

Units Abbreviation	Description
Degrees	degrees
Degrees/Sec	degrees per second
G's	g
Gauss	gauss
2D	two-dimensional fix
3D	three-dimensional fix
DGPS	differential GPS fix
Millimeters	millimeters