

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, DC 20594

December 21, 2022

Onboard Image, Audio, and Data Recorder

Specialist's Factual Report
By Sean Payne

1. EVENT

Location: Camp Dwyer, Afghanistan
Date: April 20, 2020
Aircraft: Sikorsky S-61N
Registration: N908CH
Operator: Construction Helicopters Incorporated (CHI)
NTSB Number: ERA20LA100

2. SUMMARY

On April 20, 2020, at approximately 0800 local time, a Sikorsky S-61N, N908CH, experienced a loss of control in flight and rolled on its side during an emergency landing at Camp Dwyer, Afghanistan. The three crew members onboard were seriously injured and the helicopter sustained substantial damage. The flight was operating under the provisions of Title 14 *Code of Federal Regulations* Part 135 as a cargo flight under contract to the Department of Defense.

3. GROUP

A group was convened on August 11, 2020, at the headquarters of the National Transportation Safety Board. The group consisted of the following members:

Chairman: Sean Payne
Sr. Mechanical Engineer // Investigator
National Transportation Safety Board (NTSB)

Member: Chihoon "Chich" Shin
Aerospace Engineer
NTSB

Member: William Witzig
Manager of FAA Northeast Flight Test Section
Federal Aviation Administration

Member: Dave Blair
Chief Pilot for Safety
Sikorsky Helicopters

Member: Rod Manogue
Director of Maintenance
Carson Helicopters

Member: Dan Veider
Helicopter Pilot
CHI Helicopters

4. DETAILS OF INVESTIGATION

On May 14, 2020, 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-FHVR**

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 the 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 and records 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 crew audio was connected to track one (external source) and the track two microphone only picked up very loud engine and/or transmission sounds from the helicopter (internal source).

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 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.

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

4.2. Appareo Vision 1000 Damage

Upon arrival at the NTSB Vehicle Recorder Division, the Vision 1000 unit was noted to have light impact damage, but was otherwise in good condition. The unit did not have its associated SD card installed. The associated SD card was not located in the wreckage.

Figure 1 is a photograph of the Vision 1000 device upon arrival to the NTSB laboratory.



Figure 1. The Appareo Vision 1000 device as received. The associated SD card is not pictured.

4.3. Appareo Vision 1000 Data Recovery

The Vision 1000 device was inspected and powered on with a surrogate SD card installed. The surrogate SD card was formatted as per the manufacturer's procedures to extract data from the unit's internal memory. The extraction process produced the expected raw data files; however, the manufacturer's software could not translate the extracted raw datafiles into a useable format. Instead, a separate software provided by the manufacturer was used to convert the raw files to useable files. This resulted in a number of useable files, including the accident flight.

The accident recording consisted of parametric data, still images and audio. The audio included a cockpit area microphone recording (internal microphone as described in 4.1) as well as audio panel information that recorded the pilot and co-pilot's voices over the audio panel interchange (external audio source as described in section 4.1). There were areas of the recording where both tracks of audio did not play back and periods of time where no images were playable. Figure 2 is an example screenshot of the field of view of the camera with the crew redacted.



Figure 2. An example image recorded by the Vision 1000 in the accident helicopter from the accident flight. The crew is redacted.

A review of the flight data showed an offset in the recorded pitch and roll values for the dataset. This is likely a result of the camera being installed at a downward angle and the proper offset not being entered when the unit was configured. To correct this, a new offset was created based on pitch and roll readings when the helicopter was stationary on the ground. Subsequently, the manufacturer reported that an offset would also affect the axis of the unit's accelerometer recordings. An offset to correct the accelerometer recordings was created in Matlab and the data was exported. The offset was created by using the direction of cosines formula to sum the forces in each body axis direction.

Video Data

The video data is given three ways: as an executive summary, as a detailed transcript and as a video instrument data summary.

Parametric data is given in attachment 1. Figures 3-5 describe the parametric data.

Figure 3 is a plot of basic recorded parametric data for the entire accident flight.

Figure 4 is an expanded time range plot of basic recorded parametric data for the time interval between 03:31:10 UTC and the end of the accident recording.

Figure 5 is an expanded time range plot of basic parameters for the final moments of the accident recording.

All times are given in UTC.

Executive Summary

The transcription review began at 03:21:44.000 where the aircraft was descending slightly at 70 knots and 110% Nr, around 20% matched torque at a normal flight regime attitude. All engine and transmission instruments appeared normal. Primary and auxiliary hydraulics displayed normal values around 1500 psi. No warnings, cautions or advisories were observed on the caution/warning panels until the final frames near impact. Flight control movements were nominal for the phase of flight prior to the left pedal movement described in the next paragraph.

At 03:31:57.750, the auxiliary hydraulic pressure dipped slightly to the low portion of the green range around 1300 psi, followed immediately by the left pedal traveling abruptly forward. The left seat pilot's (LSP) left foot was resting on the left pedal prior to the abrupt forward movement of the left pedal, but subsequently the LSP's left foot lost contact with the left pedal due to the latter's abrupt forward movement.

Soon after the left pedal movement, the altimeter indicated a slight climb and the aircraft yawed left. The aircraft continued to yaw left, accompanied by pitch and roll changes which are described both in the transcript and the parametric data. Torque indications fluctuated. Engine and transmission instruments, when they were visible, remained within normal ranges. The aircraft continued to yaw left as it became closer to the area of impact. In the final few frames, transmission low oil pressure and auxiliary hydraulic pressure caution lights illuminated. In the final portion of the recording, there was no sound of impact recorded and a flight bag had entered the cockpit area and contacted the instrument panel.

Detailed Transcript

The video transcript review began at 03:21:44.000.

03:21:44.000. Video playback paused. Audio was still available.

At 03:29:52:249. The video information returned. The helicopter was in a shallow descent from 3,650 feet MSL wings level RPM 110% Nr and no needle split. Torque was 20% and there was no needle split. Airspeed was 90-95 knots. The VSI indicated -1000 fpm². The ADI was level. Ng1 displayed 87%. Ng2 displayed 87%. T5 was 431 and 413 Deg C, respectively engine 1 and 2. Fuel pressure was 300-320 psi for both engine 1 and 2. Engine oil temperatures were about 90 deg C for both engine 1 and 2. Engine oil pressures were about 30-35 psi for both engine 1 and 2. Transmission oil pressure was 45 psi and transmission oil temperature was between 60-70 deg C. Primary and right auxiliary

² The VSI in this aircraft is an IVSI. An IVSI is an instantaneous vertical speed indicator.

hydraulic pressure were within the green range³, at about 1500 psi. There were no obvious caution or warning lights light, however, the caution and warning lights were obscured with sun glare at this time. The left seat pilot's (LSP) left and right feet were on the rotor pedals. The right pedal was slightly forward than the left. The right side pedals were not visible until later in the recording when the right seat pilot (RSP) changed his body position. The left cyclic was slightly stick forward⁴. Left and right collective sticks were not visible. The right cyclic was not visible.

03:30:56.750. The helicopter continued a shallow descent from 3,000 feet MSL, the wings were generally level. RPM indicated 110% Nr with no needle split. Torque indicated 25% with no needle split. Airspeed indicated around 80 knots and the VSI indicated -500 fpm. The ADI indicated level. Ng1 indicated 88% and Ng2 indicated 87%. T5 gauges indicated 437 deg C. and 415 Deg C., respectively. Primary and auxiliary hydraulic pressure were within the green range. There were no obvious caution or warning lights lit, however, the caution and warning lights were obscured with sun glare at this time. The LSP left and right feet were on the rotor pedals. The right pedal was slightly forward than the left. The cyclic was slightly stick forward. The RSP's feet were not visible on the rotor pedals and his left arm was reaching in the vicinity of hand hold position in the vicinity of the rotor brake line.

03:31:11.000. The pilots made commentary about light activity at a shooting range in which they flew near.⁵

03:31:17.000. The helicopter continued a shallow descent, now at 2,850 feet MSL, the wings were generally level. There were no appreciable changes in anything noted above. The RSP had taken his hand down from the vicinity of hand hold position in the vicinity of the rotor brake line.

03:31:51.500. The helicopter continued a shallow descent, now at 2,700 feet MSL, the wings were generally level. The torque gauge needle began trending a slight increase in torque. There were no appreciable changes in anything noted above. The RSP had begun to position his left hand in the vicinity of the speed selectors.

03:31:54.250. The helicopter continued a shallow descent, now at 2,600 feet MSL, the wings were generally level. The torque gauge indicated around 30% with no needle split. The VSI had decreased to -400 and -300 fpm (the descent rate had shallowed slightly). RPM indicated 110% Nr with no needle split. Airspeed was 70 knots. The RSP's left arm obstructed Ng and T5 gauges; however, hydraulic pressures were visible within the green range. The LSP's left and right feet were on the rotor pedals. The right pedal was slightly forward than the left.

03:31:56.500. There was an unknown utterance by an unidentified flight crew member.

³ Green range is 1300-1600 psi. The red radial markings appear at 1300 and 1600 psi.

⁴ The CG trim knob on the AFCS control panel could have influence where the stick rests longitudinally in normal flight.

⁵ Please refer to the Cockpit Voice Recorder Specialist's factual report which can be found in the public docket for this accident.

Between 03:31:57.000 and 03:31:57.250, the aux hydraulic pressure gauge dropped from the 1500 psi (within the center of the green arc) to approximately the 1300 psi position (at the bottom limit of the green arc). The primary hydraulic pressure gauge did not move.

03:31:57.250. The helicopter continued a shallow descent, now at 2,600 feet MSL, the wings were generally level. The VSI showed -300 fpm, the airspeed indicator showed 70 knots and the heading was about 185 degrees. RPM was 110% Nr with no needle split. Torque 1 was at 32 % and Torque 2 was at 28 % (needles were split). Ng 1, Ng2 and T5 gauges were not visible because RSP's hand was obscuring this area. There were no obvious caution or warning lights light, however, the caution and warning lights were obscured with sun glare. The LSP's left and right feet were on the rotor pedals. At this moment, the LSP's left pedal began to move forward with no obvious input from the LSP. The cyclic was in a similar position as it had been seen previously in the shallow descent. The RSP's feet were not visible on the rotor pedals and his left arm was reaching in the vicinity of the ceiling mounted speed selector.

03:31:57.750. The heading had changed slightly left. The LSP's left pedal moved forward significantly and stopped traveling forward. The LSP's left foot remained in the same position it was previously, the left pedal had moved forward from the LSP's left foot to a well forward position and the left pedal remained there. Between the previous frame and 03:31:57.750, the primary hydraulic pressure gauges moved downward slightly (lower in the green arc). The aux hydraulic gauge remained at 1300 psi (at the bottom limit of the green arc).

03:31:58.000. The sound of a staccato noise was audible. The group could not determine the source of this noise.

03:31:58.750. Within the next second, the LSP's left foot came off the pedal area entirely and was then returned by the next few frames. Torque increased to 65% (needles still slightly split). The aircraft's heading continued to come left. The LSP's VSI showed about 0 fpm and the RSP's VSI showed a value of around -350 fpm. All other gauges that were visible remained the same (the center stack of gauges was blocked by the RSP's left arm which was still reaching upward in the vicinity of the speed selectors).

03:31:59.250. Both pilots were jostled in their seats. The LSP pilot placed his left foot on the left pedal again and for a moment made a forward cyclic stick motion. The cyclic grip and LSP's hand were then out of the camera's view. The RSP's left pedal was seen unoccupied by the RSP's left foot. The LSP's VSI showed almost a 2,000 fpm climb, the altimeter displayed 2,800 msl. The airspeed indicator displayed about 28 knots. The heading indicator indicated a left yaw. RPM was in the green range and the gauges were not split. The torque gauge indicated about 63% with no needle split. The Ng gauges displayed 95% and 93%. Left and right T5 gauges showed 555 and 525 deg C, respectively. Fuel pressure gauges showed about 600 psi, engine oil pressures around 90 psi. Engine oil pressure showed 38 psi. Transmission oil pressure and temp showed, 40-45 psi and 60-70 deg C, respectively. Both primary and aux hydraulic pressure gauges were indicating near the bottom of the green arc (similar to the previous observation).

In the next three seconds, the heading indicator indicated a left yaw. The RSP had briefly removed his hand from the speed selector. The LSP's cyclic inputs seemed generally aft. The ADI showed the aircraft was about 15 degrees nose low. Airspeed was below 20 knots. Altimeter showed about 2,700 msl. Torque decreased to 45%. All other gauges showed no appreciable differences from the last observation. There were no caution or warning lights illuminated.

03:32:00.000. The LSP stated, "alright – (do) you have controls(?)" Both the LSP and RSP's left feet were visible on their respective left pedals.

03:32:02.750. The RSP had returned his left arm to the vicinity of the speed selectors. The LSP stated, "let's get us down on the ground."

03:32:04.750. The phrase "# # #" was audible.⁶ At this time the primary and auxiliary hydraulic pressure gauges were visible again. Both primary and auxiliary hydraulic pressure gauges were within the green ranges, with primary showing around 1400 psi and auxiliary showing around 1350 psi (slightly above the red radial). The hydraulic pressure gauges were last visible in the following frame and the above positions were observed.

03:32:05.500. A maroon pilot bag entered the center pedestal area from an unknown aft position and struck the center of the instrument panel. Most instruments were obscured. An annunciator light for transmission oil pressure illuminated on the master warning panel.

03:32:06.000. An annunciator light for auxiliary hydraulic pressure illuminated on the master warning panel. The auxiliary hydraulic pressure gauge was not visible at this time and for the remainder of the recording. The pilot bag was still against the center of the instrument panel. Nr showed within the normal range and torque was slightly split, with Ng1 at 92% and Ng2 at 88%.

The image and audio recording ended at 03:32:07.500 UTC. There was no audible sound of impact and loose objects in the cockpit suggested the aircraft was at some value less than 1 g vertical acceleration. The torque gauge displayed 80%. The radar altimeter displayed 0 feet. The LSP's left foot was on the left pedal and the left pedal was forward. The LSP's right foot location was unclear, but he had a 90 degree bend in his right knee.

During the accident sequence, from the completion of the left pedal forward stroke movement at 03:31:57.750 until the end of the recording, the left pedal did not move appreciable from that position until impact.

Although the above transcript reflects observed torque values at certain times, in general, torque fluctuated throughout the above defined data points. Other engine parameters were noted to trend correspondingly to changes in torque.

Prior to the left pedal motion described which began at 03:31:57.750, there was no significant vibration noted on the camera recording.

⁶ # - NTSB terminology for a spoken expletive.

Video Instrument Data Summary

If "N/A" is entered, the group either didn't make an observation, or the instrument was obscured.

The video transcript review began at **03:21:44.000**.

03:29:52:249

ADI – N/A
Altimeter – 3650 fpm descent
VSI – -1000 fpm
Airspeed – 90-95 knots
Heading – N/A
RPM – 110% Nr no needle split
Torque – 20% no needle split
Ng1, Ng2 – 87%, 86%
T5 – 341 deg C, 413 deg C
Fuel pressure – 300-320 psi (both)
Engine Oil Pressure – 30-35 psi (both)
Transmission oil pressure – 45 psi
Transmission oil temperature – 60-70 deg C
PRI and AUX Hydraulics – Green range (1500 psi both)
CAWS – NONE

03:30:56.750

ADI – N/A
Altimeter – 3000 feet (descent)
VSI – -500 fpm
Airspeed – 80 knots
Heading – N/A
RPM – 110% Nr no needle split
Torque – 25% no needle split
Ng1, Ng2 – 88%, 87%
T5 – 437 deg C, 415 deg C
Fuel pressure – N/A
Engine Oil Pressure – N/A
Transmission oil pressure – N/A
Transmission oil temperature – N/A
PRI and AUX Hydraulics – green range (1500 psi both)
CAWS – NONE

03:31:17.000

ADI – N/A
Altimeter – 2850 feet (descent)
VSI – -500 fpm
Airspeed – 80 knots

Heading – N/A
RPM – 110% Nr no needle split
Torque – 25% no needle split
Ng1, Ng2 – 88%, 87%
T5 – 437 deg C, 415 deg C
Fuel pressure – N/A
Engine Oil Pressure – N/A
Transmission oil pressure – N/A
Transmission oil temperature – N/A
PRI and AUX Hydraulics – green range (1500 psi both)
CAWS – NONE

03:31:51.500

ADI – Level
Altimeter – 2700 feet (descent)
VSI – -500 fpm
Airspeed – 80 knots
Heading – N/A
RPM – 110% Nr no needle split
Torque – Slight increase trend
Ng1, Ng2 – 88%, 87%
T5 – 437 deg C, 415 deg C
Fuel pressure – N/A
Engine Oil Pressure – N/A
Transmission oil pressure – N/A
Transmission oil temperature – N/A
PRI and AUX Hydraulics – green range (1500 psi both)
CAWS – NONE

03:31:54.250

ADI – N/A
Altimeter – 2600 feet (descent)
VSI – -400 fpm (descent shallowing)
Airspeed – 70 knots
Heading – N/A
RPM – 110% Nr no needle split
Torque – slight increase in trend
Ng1, Ng2 – 88%, 87%
T5 – N/A
Fuel pressure – N/A
Engine Oil Pressure – N/A
Transmission oil pressure – N/A
Transmission oil temperature – N/A
PRI and AUX Hydraulics – green range (1500 psi both)
CAWS – NONE

Between **03:31:57.000** and **03:31:57.250**, the aux hydraulic pressure gauge dropped from the 1500 psi (within the center of the green arc) to approximately the 1300 psi position (at the bottom limit of the green arc). The primary hydraulic pressure gauge did not move.

03:31:57.250

ADI – N/A
Altimeter – 2600 feet (descent)
VSI – -300 fpm (descent shallowing)
Airspeed – 70 knots
Heading – 185 degrees
RPM – 110% Nr no needle split
Torque – 32%, 32%
Ng1, Ng2 – N/A
T5 – N/A
Fuel pressure – N/A
Engine Oil Pressure – N/A
Transmission oil pressure – N/A
Transmission oil temperature – N/A
PRI and AUX Hydraulics – green range (PRI – 1500 psi, AUX 1300 psi)
CAWS – NONE

03:31:57.750

ADI – N/A
Altimeter – N/A
VSI – N/A
Airspeed – N/A
Heading – changing left
RPM – N/A
Torque – N/A
Ng1, Ng2 – N/A
T5 – N/A
Fuel pressure – N/A
Engine Oil Pressure – N/A
Transmission oil pressure – N/A
Transmission oil temperature – N/A
PRI and AUX Hydraulics – PRI moved lower in the green arc (less than 1500 psi, AUX remained at 1300 psi.)
CAWS – NONE

03:31:58.750

ADI – N/A
Altimeter – N/A
VSI – 0 fpm (LSP), -300 fpm (RSP)
Airspeed – N/A
Heading – changing left
RPM – N/A
Torque – 65% slightly split

Ng1, Ng2 – N/A
T5 – N/A
Fuel pressure – N/A
Engine Oil Pressure – N/A
Transmission oil pressure – N/A
Transmission oil temperature – N/A
PRI and AUX Hydraulics – N/A
CAWS – NONE

Pilot inputs - The left pedal had moved forward from the LSP's left foot to a well forward position and the left pedal remained there for the remainder of the recording. The RSP's feet were not in the camera field of view at this time.

03:31:59.250

ADI – N/A
Altimeter – 2,800 ft
VSI – 2000 fpm (LSP), N/A (RSP)
Airspeed – 28 knots
Heading – changing left
RPM – green range, no needle split
Torque – 63% no needle split
Ng1, Ng2 – 95%, 93%
T5 – 555 deg C, 525 deg C
Fuel pressure – 600 psi
Engine Oil Pressure – 40-45 psi
Transmission oil pressure – 38 psi
Transmission oil temperature – 60-70 deg C.
PRI and AUX Hydraulics – near bottom of green range (1300 both)
CAWS – NONE

The next three seconds,

ADI – 15 deg nose low
Altimeter – 2,700 ft
VSI – N/A
Airspeed – less than 20 knots
Heading – changing left
RPM – green range, no needle split
Torque – 63%, no needle split
Ng1, Ng2 – 95%, 93%
T5 – 555 deg C (1), 525 deg C (2)
Fuel pressure – 600 psi
Engine Oil Pressure – 40-45 psi
Transmission oil pressure – 38 psi
Transmission oil temperature – 60-70 deg C.
PRI and AUX Hydraulics – near bottom of green range (1300 both)
CAWS – NONE

03:32:00.000 Both the LSP and RSP's left feet were visible on their respective left pedals.

03:32:02.750 The RSP had returned his left arm to the vicinity of the speed selectors.

03:32:04.750

ADI – N/A
Altimeter – N/A
VSI – N/A
Airspeed – N/A
Heading – N/A
RPM – N/A
Torque – N/A
Ng1, Ng2 – N/A
T5 – N/A
Fuel pressure – N/A
Engine Oil Pressure – N/A
Transmission oil pressure – N/A
Transmission oil temperature – N/A
PRI and AUX Hydraulics – 1400 (PRI), 1350 (AUX)
CAWS – NONE

03:32:05.500

ADI – N/A
Altimeter – N/A
VSI – N/A
Airspeed – N/A
Heading – N/A
RPM – N/A
Torque – N/A
Ng1, Ng2 – N/A
T5 – N/A
Fuel pressure – N/A
Engine Oil Pressure – N/A
Transmission oil pressure – N/A
Transmission oil temperature – N/A
PRI and AUX Hydraulics – N/A
CAWS – Transmission oil pressure

03:32:06.000

ADI – N/A
Altimeter – N/A
VSI – N/A
Airspeed – N/A
Heading – N/A
RPM – green range
Torque – 92% (1), 88% (2)
Ng1, Ng2 – N/A
T5 – N/A

Fuel pressure – N/A
Engine Oil Pressure – N/A
Transmission oil pressure – N/A
Transmission oil temperature – N/A
PRI and AUX Hydraulics – N/A
CAWS – Transmission oil pressure, auxiliary hydraulic pressure

03:32:07.500 – End of recording – The following information persisted on the final frame.

ADI – N/A
Altimeter – N/A
VSI – N/A
Airspeed – N/A
Heading – N/A
RPM – N/A
Torque – 80%
Ng1, Ng2 – N/A
T5 – N/A
Fuel pressure – N/A
Engine Oil Pressure – N/A
Transmission oil pressure – N/A
Transmission oil temperature – N/A
PRI and AUX Hydraulics – N/A
CAWS – Transmission oil pressure, auxiliary hydraulic pressure

4.4. Plots and Corresponding Tabular Data

The following three figures contain Appareo Vision 1000 parametric data for the accident event. Where applicable, changes to the conversions have been made to ensure the parameters conform to the Safety Board's standard sign convention that climbing right turns are positive (CRT=+).⁷ The data has been corrected for the installation error of the Appareo.

Figure 3 is a plot of select recorded parameters for the entire accident flight.

Figure 4 is a plot of select recorded parameters for the last minute of the accident flight.

Figure 5 is a plot of select recorded parameters for the last 17.500 seconds of recorded data.

The corresponding tabular data used to create these three plots are provided in electronic (*.csv⁸) format as Attachment 1 to this report.

⁷ CRT=+ means that for any parameter recorded that indicates a climb or a right turn, the sign for that value is positive. Also, for any parameter recorded that indicates an action or deflection, if it induces a climb or right turn, the value is positive. Examples: Right Roll = +, Left Aileron Trailing Edge Down = -, Right Aileron Trailing Edge Up = +, Pitch Up = +, Elevator Trailing Edge Up = +.

⁸ Comma Separated Value format.

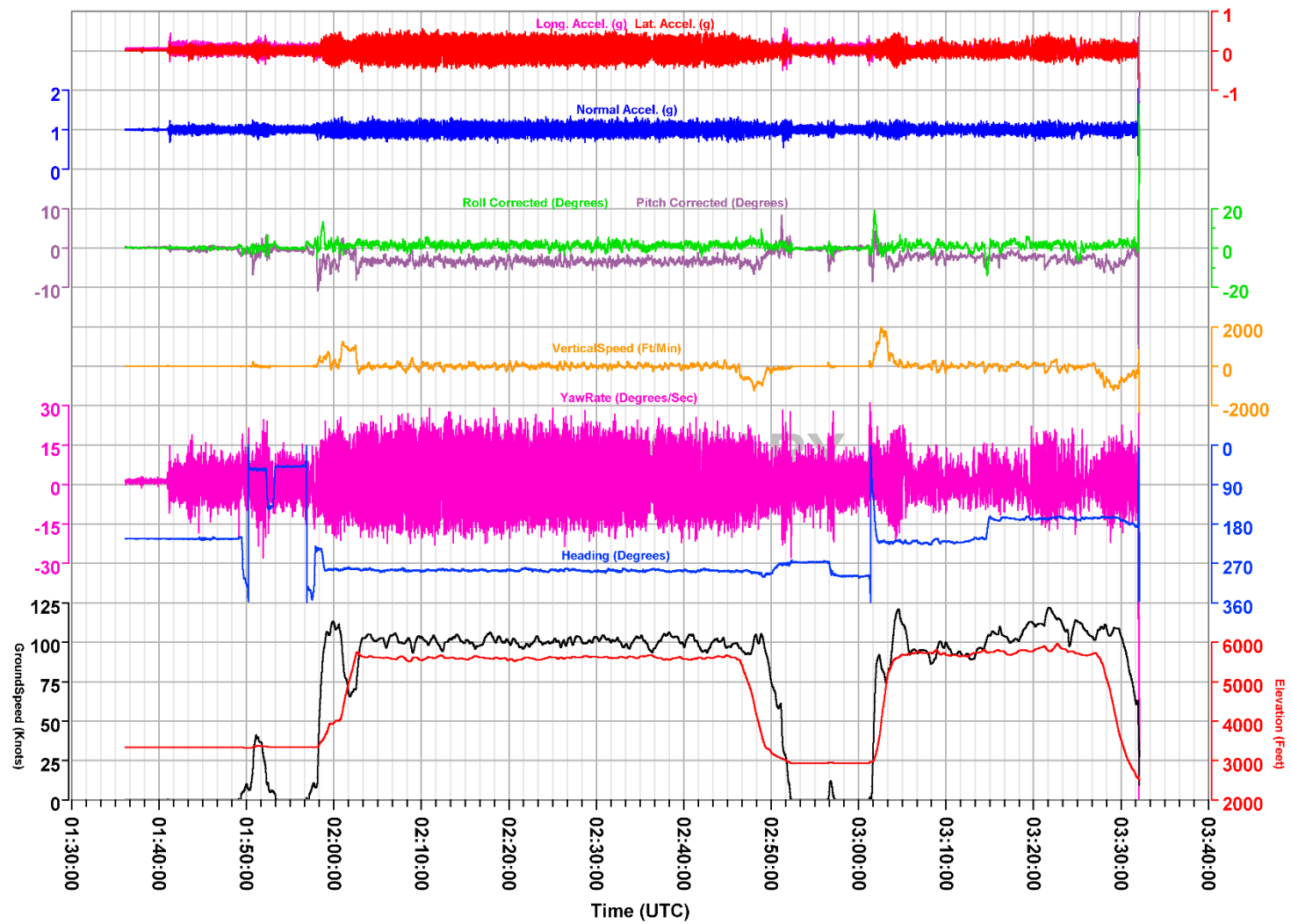


Figure 3. A plot of basic recorded parametric data for the entire accident flight.

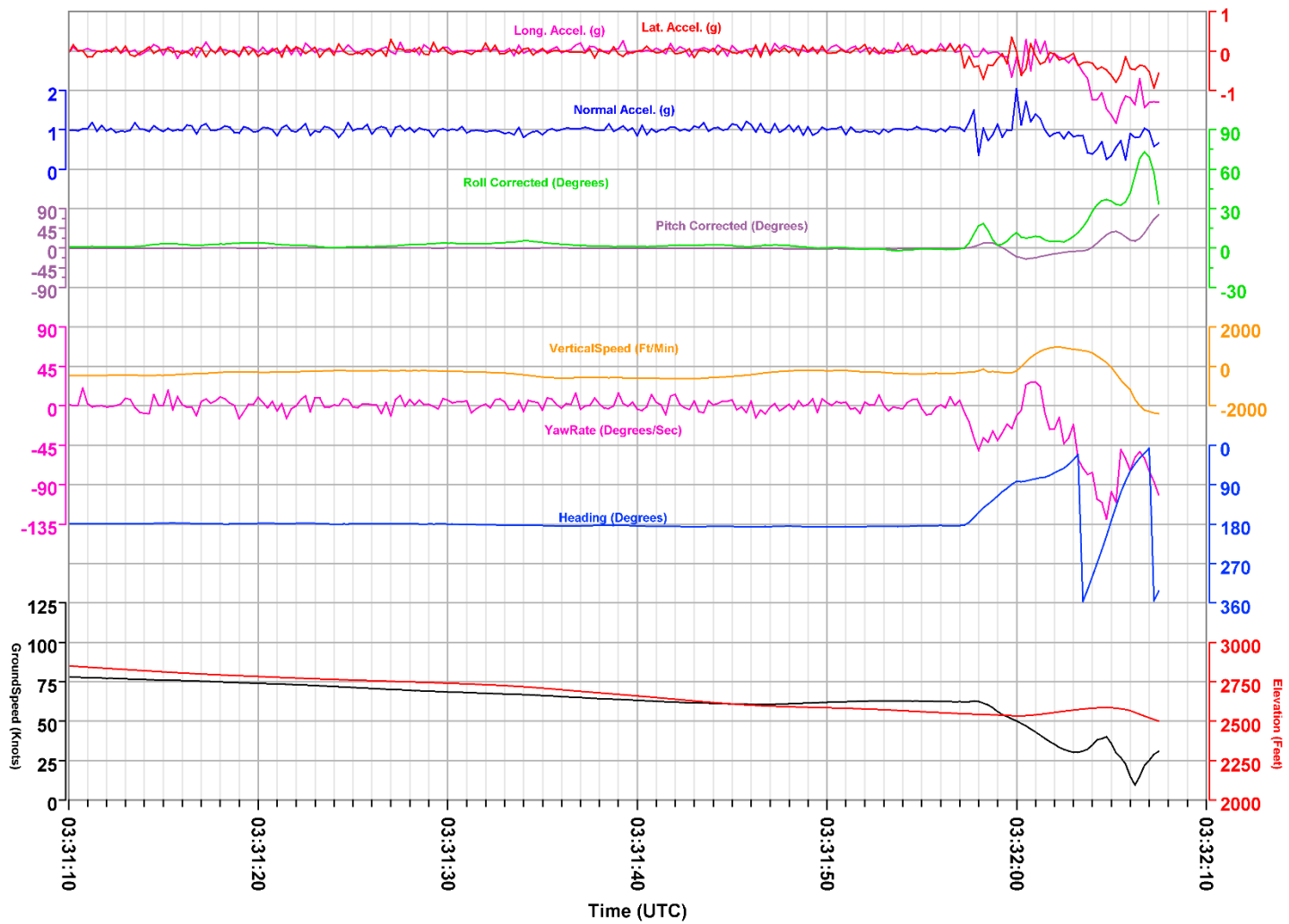


Figure 4. An expanded time range plot of basic recorded parametric data for the time interval between 03:31:10 UTC and the end of the accident recording.

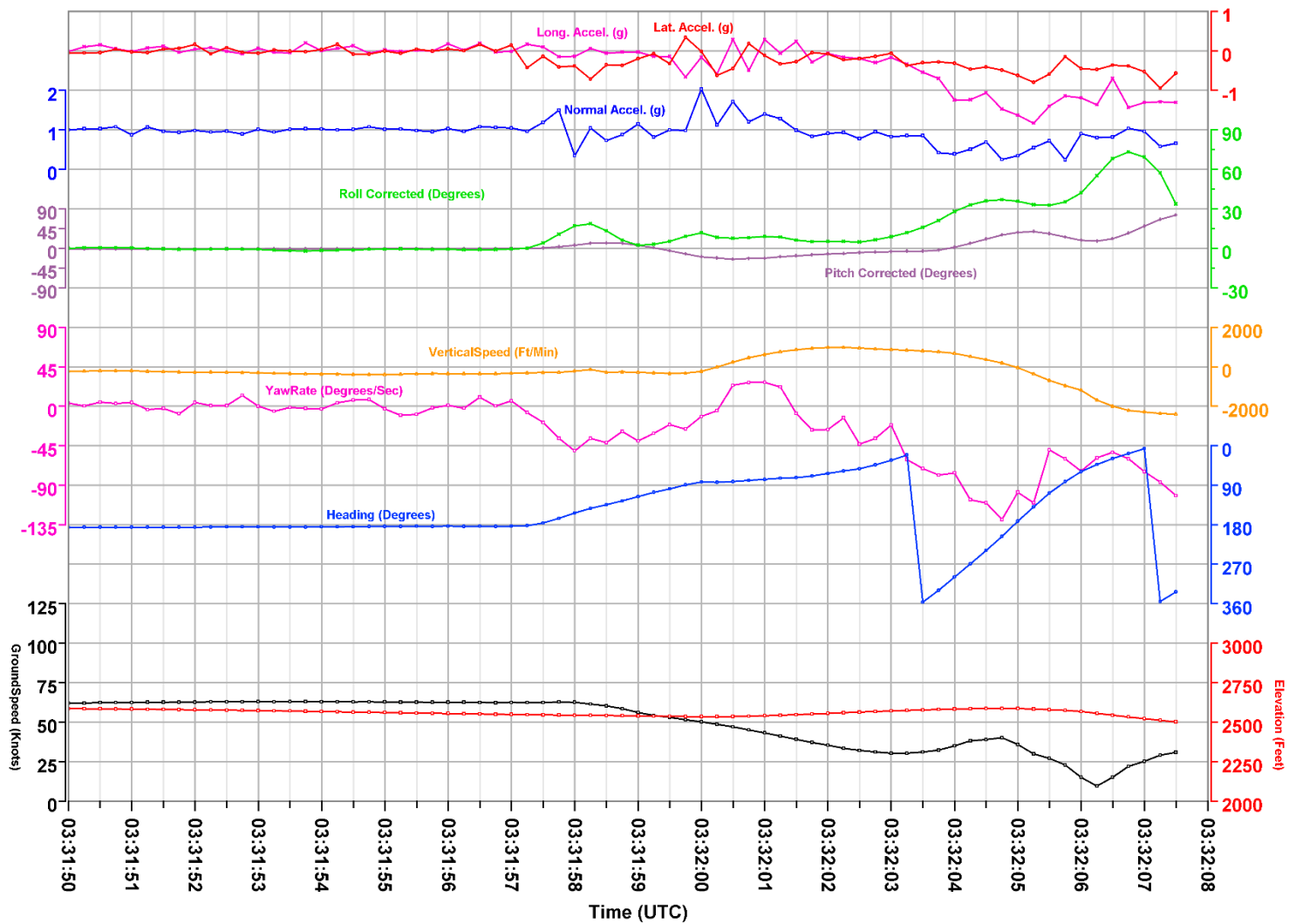


Figure 5. An expanded time range plot of basic parameters for the final moments of the accident recording.