

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

August 9, 2022

Multiple Electronic Devices

Specialist's Factual Report
by Sean Payne

1. EVENT

Location: Steamboat Springs, CO
Date: December 10, 2021
Aircraft: Piper PA-46-500TP
Registration: N744Z
Operator: Private
NTSB Number: CEN22FA069

2. DETAILS OF INVESTIGATION

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

Device 1: **Garmin GTN 750**
Device 1 Serial Number: **1ZA015181**

Device 2: **Second Garmin GTN 750**
Device 2 Serial Number: **N/A (SD Card Only)**

Device 2: **Garmin G500 Displays**
Device 2 Serial Number: **N/A (Multiple SD Cards Only)**

2.1. Garmin GTN 750 Device Description

The Garmin GTN 750 is a panel-mounted GPS receiver featuring a 6.9-inch color liquid crystal (LCD) display. It has a GPS/SBAS engine and is TSO-C146c approved for primary domestic, oceanic, and remote navigation including en route, terminal, and non-precision approaches, and approaches with vertical guidance, such as LPV and LNAV/VNAV. The unit can simultaneously give display approach information and weather and traffic data in relation to their position on a large, color moving map display. Its color moving map features a built-in database that shows cities, highways, railroads, rivers, lakes, and coastlines. The unit has a slot on the front for a Jeppesen database containing all airports, VORs, NDBs, Intersections, FSSs, Approaches, DPs/STARs and SUA information. A flight plan composed of multiple waypoints, including user-defined waypoints, can be programmed in the unit. The GTN 750 also

includes a TSO approved airborne VHF communications transceiver and TSO approved airborne VOR/Localizer and Glideslope receivers. The unit contains an internal SD card storing flight log data, which can be accessed through the slot in the right side of the unit. If the unit is equipped with a firmware v6.50 or later, the internal SD card will store a limited set of flight data information.

2.1.1. Garmin GTN 750 Data Recovery

The lab received one full Garmin GTN-750 unit (hereinafter referred to as Unit A), and one internally mounted, removable data card from a second GTN-750 unit (hereinafter referred to as Unit B) installed in the accident airplane. Upon arrival at the Vehicle Recorder Division, an exterior examination revealed that Unit A had sustained impact damage. Unit A is pictured in figure 1 (left image). Unit A was inspected and its internally mounted, removable SD memory card was removed from the right side of the unit. The internally mounted, removable SD memory card was in good condition, and was read out normally using a PC via a forensic write blocker.

The second internally mounted, removable SD memory card from Unit B is pictured in figure 1 (right). The internally mounted, removable SD memory card from Unit B was in good condition, and was read out normally using a PC via a forensic write blocker.

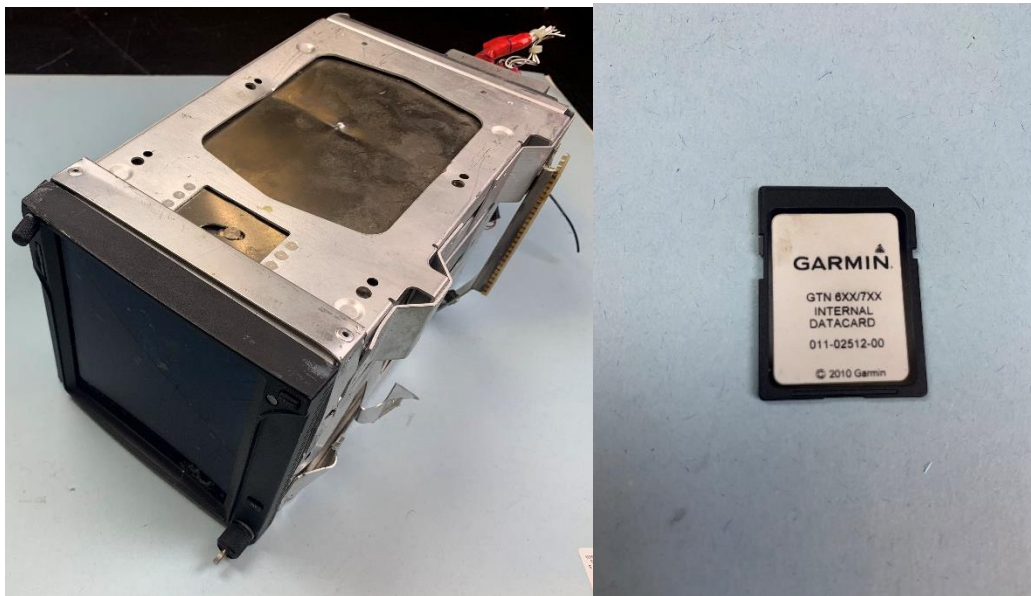


Figure 1. The Garmin GTN-750 (Unit A), left, and the internally mounted, removable SD memory card from Unit B, right.

2.2. Garmin G500 Device Description

The Garmin G500 is a product derived from the Garmin G1000. The G500 is a versatile Electronic Flight Instrument System (EFIS) that can serve as a primary flight display (PFD), Multi-Function Display (MFD), Engine Information System (EIS), or a combination of all, depending on the configuration. The unit comes in a variety of

display sizes and orientations and utilizes a color, touch-screen interface. The unit contains an Attitude Heading Reference System (AHRS) device and is capable of providing attitude information and air data information. The unit interfaces with a number of other compatible products and can display navigation, terrain, engine, weather, traffic and other parametric data streams. The unit can be synthetic vision capable. The unit can record to an externally removable SD card (if configured and installed).

2.2.1. Garmin G500 Data Recovery

The accident aircraft contained two Garmin G500 devices. The laboratory was sent a set of 5 SD cards, each set of cards was labeled as being from either the left or right G500 unit. Figure 2 is a photograph of the SD cards received associated with the two G500 units.

Each card was examined with a PC via a write blocker. Only one card appeared to have flight data. That flight data was in a format consistent with having been produced from a Garmin GTN series navigator, and not a G500. The data present on that card ranged in date from October 6, 2019, to January 27, 2021. The accident occurred in December 2021 and no data relevant to the accident was recorded on this SD card. The report does not discuss any data from this card.



Figure 2. The SD cards associated with both G500 units from the accident aircraft.

2.1.2. Garmin GTN 750 Data Description

Both units recorded flight log data in a .CSV format standard to this unit. Data extracted from Unit A contained 32 flight log files. These files ranged in date from September 30, 2021, to December 10, 2021 (the accident flight). The card from Unit B

contained 32 flight log files. These files ranged in date from September 30, 2021, to December 10, 2021 (the accident flight). The number of flight log files was essentially a mirror between the two cards.

Both units recorded the accident flight. A review of the flight data from each unit showed the following: Unit A recorded the accident flight from a time interval from 16:56:03 mountain standard time (MST) to 18:08:36 MST. Unit B recorded the accident flight from a time interval from 16:56:05 MST to 18:08:34 MST. Both data from Unit A and B were plotted as part of this report. Data from each unit is identified by using the prefix "A_" or "B_" in the parameter name where necessary.

Table 1 is a list of all recorded parameters on the GTN 750 and their definitions. Parameters that did not record information during the accident flight, or that were not validated by the specialist were removed.

Attachment 1 is provided in comma-separated format (.CSV) and contains all validated and relevant parameters from Unit A and Unit B that were used in this report.

All times are given in mountain standard time (MST).

Table 1. Garmin GTN-750 Parameters

Parameter Abbreviation	Description (units)
AtvWpt	Active Waypoint Selection (Waypoint Name)
Latitude	Latitude (degrees)
Longitude	Longitude (degrees)
AltB	Barometric Altitude (feet)
AltMSL	Altitude above Mean Sea Level (feet)
OAT	Outside Air Temperature (degrees F)
IAS	Indicated Airspeed (knots)
GndSpd	Groundspeed (knots)
VSpd	Vertical Speed (feet per minute)
HDG	Heading (degrees)
TRK	Track (degrees)
FQtyC	Fuel Quantity (gallons)
AltGPS	GPS Altitude (feet)
TAS	True Airspeed (knots)
HSIS	Horizontal Situation Indication Source (GPSS, VLOC, NAV)
CRS	Course (degrees)
NAV1	Active Navigation Frequency (MHz)
NAV2	Standby Navigation Frequency (MHz)
COM1	Active Communication Frequency (MHz)
COM2	Standby Communication Frequency (MHz)
HCDI	Horizontal Course Deviation Indicator (dots)
VCDI	Vertical Course Deviation Indicator (dots)
WndSped	Calculated Wind Speed (knots)
WndDr	Calculated Wind Direction (degrees)
WptDst	Distance to Selected Waypoint (nautical miles)
WptBrg	Bearing to Waypoint (degrees)
MagVar	Magnetic Variation (degrees)
GPSfix	GPS Fix Type (fix type)
HAL	Horizontal Alert Limit (meters)
VAL	Vertical Alert Limit (meters)
HPLwas	Horizontal Protection Limit (meters)
HPLfd	Horizontal Protection Limit (meters)
VPLwas	Vertical Protection Limit (meters)
AltPress	Pressure Altitude (feet)
RAIMalarm	Receiver Autonomous Integrity Monitor Alarm (discrete)
RAIMfault	Receiver Autonomous Integrity Monitor (discrete)

The unit was set to record data at one second intervals. Each set of data was preceded with a timestamp in MST. All data in this report is presented in MST.

Figure 3 is a Google Earth plot showing the accident aircraft's ground track and recorded altitude data during the entire accident flight. The data show GPS began showing a position around 16:57 in the vicinity of a ramp area at Yellowstone Regional Airport (KCOD), Cody, Wyoming. Data show the aircraft had departed KCOD and began climbing on a south-easterly track around 17:05. The aircraft continued on a south-easterly track for the next approximately hour. Around 18:00, the aircraft was maneuvering in the vicinity on a ground track consistent with a published segment of the RNAV (GPS)-E approach for Steamboat Springs Airport (KSBS), Steamboat Springs, CO. Data continued be recorded showing the aircraft maneuvering in the vicinity of KSBS. Data ended at 18:08:36 in the vicinity of Quarry Mountain, west of the village of Steamboat Springs, CO. Note that additional figures and plots below discuss the aircraft's position on the RNAV (GPS)-E approach segment in further detail below.

Figure 4 is a Google Earth plot showing the accident aircraft's ground track in the vicinity of the terminal area of KSBS. An FAA published approach plate is overlaid for the RNAV (GPS)-E approach into KSBS. Times are given in MST of the points in which the GTN-750 data sets showed sequencing of waypoints on the published approach. For reference to the attached data sets, the times are as follows: HABRO (IAF) - 18:00:58, MABKY (IF) - 18:03:30, BUSTE - 18:05:07, PEXSA (FAF) - 18:06:19, WAKOR - 18:07:59.

Figure 5 is a Google Earth plot showing the accident aircraft's ground track and recorded altitude data in the vicinity of KSBS. Just prior to 18:07:59 (sequence from WAKOR), the aircraft made a left turn into rising terrain west of the village of Steamboat Springs, CO. The wreckage location is denoted as a yellow pin. Note that the weather and lighting conditions represented in Google Earth do not depict the conditions of that day.

Figure 6 is a Google Earth plot showing the accident aircraft's ground track and recorded altitude data in the vicinity of KSBS. The orientation is similar to that of figure 5, except the FAA published approach plate for the RNAV (GPS)-E is overlaid in a 50% opacity. Note that the weather and lighting conditions represented in Google Earth do not depict the conditions of that day.

Figure 7 is a Google Earth plot showing a view of the aircraft's ground track centered around Quarry Mountain. The wreckage location is indicated with a yellow pin. An FAA approach plate for the RNAV (GPS)-E approach has been overlaid with a 50% opacity. Note that the weather and lighting conditions represented in Google Earth do not depict the conditions of that day.

Figure 8 is a Google Earth plot showing an alternate view of the aircraft's tracklog in the vicinity of Quarry Mountain, west of Steamboat Springs, CO. The view of this image is oriented to the south-east (toward Quarry Mountain from the west side

of the approach course to KSBS). Note that the weather and lighting conditions represented in Google Earth do not depict the conditions of that day.

Figure 9 is the FAA published approach plate for the RNAV (GPS)-E approach at KSBS (pictured on the left of the figure) and the Jeppesen published approach plate for the same approach (pictured on the right of the figure). Both approach plates depicted in this figure were the versions current at the time of the accident. This figure is NOT TO BE USED FOR NAVIGATION.

Figure 10 is a plot of select GTN-750 parameters for the entire accident flight. The data show the aircraft departed KCOD around 17:05 and began a climb to an altitude of 25,000 MSL (Barometric Altitude). The airplane reached 25,000 MSL around 17:19 and continued in an enroute/cruise phase for the next approximate 30 minutes. During cruise, the GTN-750 showed the aircraft's calculated true airspeed at around 250 knots. Around 17:51, the data show the aircraft began a descent into the KSBS terminal area. Details of the remainder of the flight are discussed below in further detail in the remaining figures.

Figure 11 describes the last approximate 20 minutes of the aircraft's flight in the KSBS terminal area in greater detail. During the descent phase, the data show the aircraft had a varying descent rate. The maximum recorded descent rate was around -2,400 feet per minute as the aircraft was descending out of 19,000 feet (barometric altitude). Details of the remainder of the flight are discussed below in further detail in the remaining figures.

Figure 12 shows the last approximately one minute and 35 seconds of the accident flight. The plot begins with the aircraft descending from 8,700 feet on a heading of about 313 degrees magnetic and an airspeed of around 90 knots indicated. Around 18:07:40, the aircraft had descended to approximately 8,300 feet (barometric altitude). The aircraft continued at around 8,300 feet for the next 10 seconds, the indicated airspeed at this time varied between 103 knots indicated and 89 knots indicated. The aircraft then continued a descent to a minimum of around 7930 feet (barometric altitude), during this portion of the flight and during this descent, the indicated airspeed climbed from 89 knots indicated to around 111 knots indicated. At this time, altitude trend began increasing, the data show the aircraft was continuing in a left turn. Altitude roughly stabilized between 18:08:10 and 18:08:27 at around 8,000 feet (barometric altitude), the data show the aircraft's heading and groundtrack still changing to the left. The recorded data ended at 18:08:36. At this time, altitude and airspeed were in a slight increasing trend and the aircraft's pitch was decreasing to level. The last altitude record was 8,218 feet (barometric altitude).

Figure 13 is a plot of GPS quality-related data from GTN-750 Unit A. Nothing anomalous was detected in the GPS quality dataset. Additionally, the data indicate that unit was set to "GPS" as the Horizontal Situation Indication Source (HSIS). This did not change for the duration of the flight.

Figure 14 is a plot of GPS quality-related data from GTN-750 Unit B. Nothing anomalous was detected in the GPS quality dataset. Additionally, the data indicate that unit was set to "GPS" as the Horizontal Situation Indication Source (HSIS). This did not change for the duration of the flight.

Figure 15 is a plot of communication and navigation frequency recorded data from both Unit A and Unit B. Note that communication and navigation frequencies in this plot are rounded to the nearest hundredth of a megahertz.

The data show that communications frequencies for Unit B were changed during the flight. As the aircraft approached KSBS, the active communication frequency for Unit B was set to 120.475 MHz (a published frequency for Denver Center). As the aircraft approached KSBS and was in a descent phase, the active communication frequency for Unit B was set to 118.325 MHz (a published frequency for the AWOS-3 at KSBS). Data show the active communications frequency for Unit B was then set back to 120.475 MHz. As the aircraft descended out of approximately 12,000 feet, Unit B's active communication frequency was recorded as 122.8 MHz (a published frequency for KSBS UNICOM).

Data show that communication frequencies for Unit A were unchanged for the duration of the accident flight.

Data show that Unit B's active navigational frequency was recorded as 109.9 MHz and remained unchanged for the entire flight.

Data show that Unit A's active navigational frequency was recorded as 112.2 MHz and remained unchanged for the entire flight.

Figure 16 is a plot of select parameters related to IFR navigation for the entirety of the accident flight. Data for both Unit A and Unit B show the following selected waypoints were recorded as "AtvWpt" (Active Waypoint) throughout the flight. The waypoints are listed in chronological order as follows: KSBS, CHE (Hayden VOR), HABRO, MABKY, BUSTE, PEXSA, WAKOR, KSBS. Note that the RNAV (GPS)-E approach terminates as KSBS, and not a runway. Data does not show any other active waypoints captured by the dataset.

Figure 17 is a plot of select parameters related to IFR navigation for the last approximate 20 minutes of the accident flight. Table 1 shows altitudes related to each fix and are displayed as follows: Fix Name (Published Altitude), (Recorded Barometric Altitude), (Recorded GPS Altitude).

Table 1. Approach fixes and recorded altitudes from accident flight.

Fix	Published Altitude (ft)	Baro. Altitude (ft)	GPS Altitude (ft)
HABRO	11300	13571	13261
MABKY	11300	11212	11039
BUSTE	10300	10020	9889
PEXSA	9700	9292	9194
WAKOR	8740	8131	8019

Figure 18 is a plot of select parameters related to IFR navigation for the last approximate 13 minutes of a flight conducted on November 12, 2021, in which the aircraft also flew an RNAV approach to KSBS. Table 2 shows altitudes related to each fix and are displayed as follows: Fix Name (Published Altitude), (Recorded Barometric Altitude), (Recorded GPS Altitude).

Table 2. Approach fixes and recorded altitudes from a RNAV approach to KSBS on November 12, 2001.

Fix	Published Altitude (ft)	Baro. Altitude (ft)	GPS Altitude (ft)
TILLI	11300	13007	13082
MABKY	11300	11289	11360
PEXSA	9700	9521	9557
WAKOR	8740	8028	8046

Figure 19 is a plot of select parameters related to IFR navigation for the last approximate 10 minutes of a flight conducted on December 4, 2021, in which the aircraft also flew an RNAV approach to KSBS. Table 3 shows altitudes related to each fix and are displayed as follows: Fix Name (Published Altitude), (Recorded Barometric Altitude), (Recorded GPS Altitude).

Figure 20 is a Google Earth plot showing the accident aircraft's ground track in the vicinity of the terminal area of KSBS for a flight conducted on November 11, 2021. An FAA published approach plate is overlaid for the RNAV (GPS)-E approach into

KSBS. Note that the aircraft's departure profile is also shown in this image. The flight's origin was KSBS and the aircraft completed the flight returning to KSBS.

Table 3. Approach fixes and recorded altitudes from a RNAV approach to KSBS on December 4, 2001.

Fix	Published Altitude	Baro. Altitude	GPS Altitude
HABRO	11300	11993	12136
MABKY	11300	11296	11425
BUSTE	10300	10364	10459
PEXSA	9700	9780	9858
WAKOR	8740	8318	8330

Figure 21 is a Google Earth plot showing the accident aircraft's ground track in the vicinity of the terminal area of KSBS for a flight conducted on December 4, 2021. An FAA published approach plate is overlaid for the RNAV (GPS)-E approach into KSBS. Note that the aircraft's departure profile is also shown in this image. The flight's origin was KSBS and the aircraft completed the flight returning to KSBS.

Figure 22 is a photograph of the accident aircraft's instrument panel as described in an undated sales listing. The advertisement states, "New dual Garmin 500 glass package New pilot side synthetic vision."

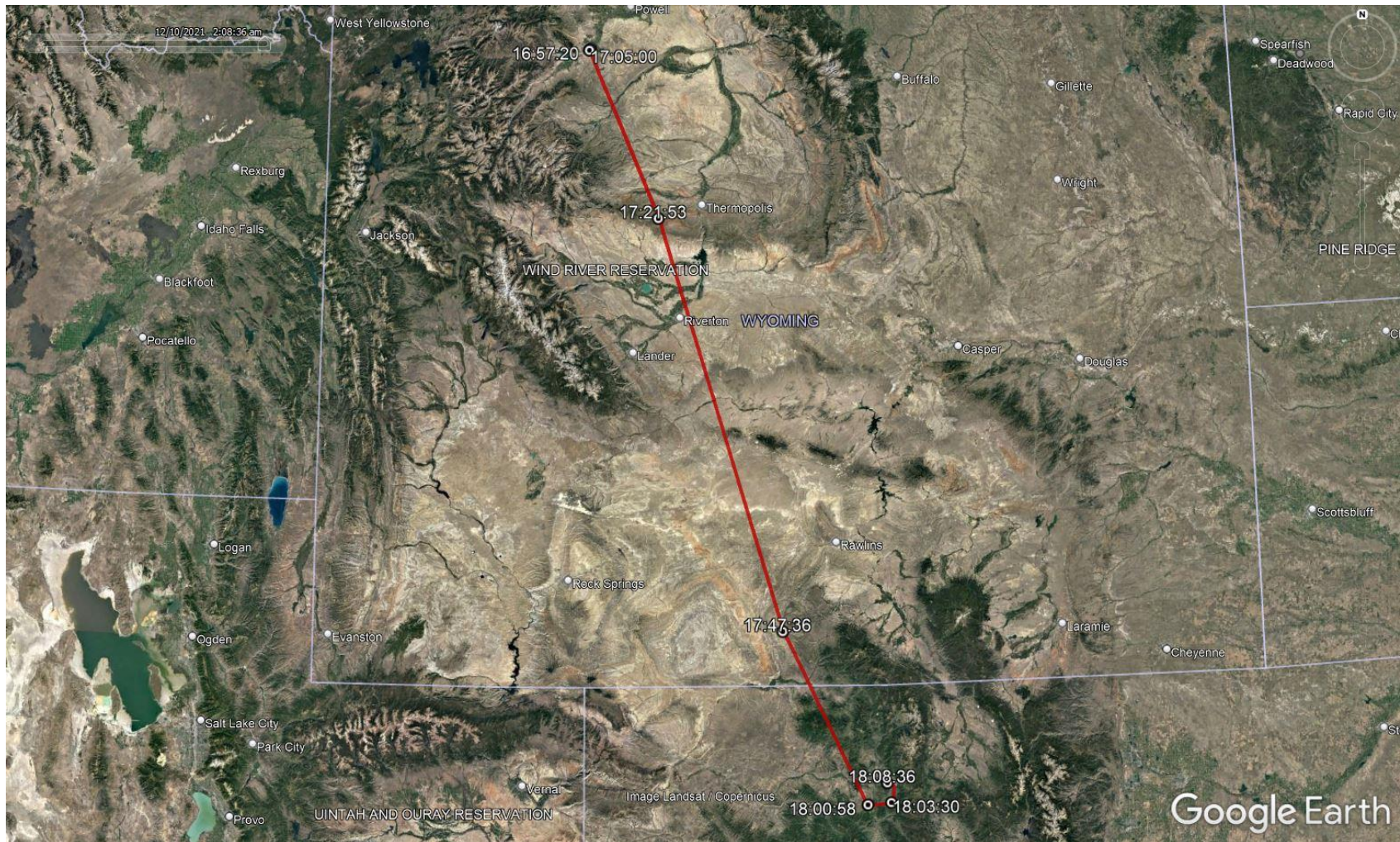


Figure 3. A Google Earth plot showing the accident aircraft's ground track for the entire accident flight on December 10, 2021.

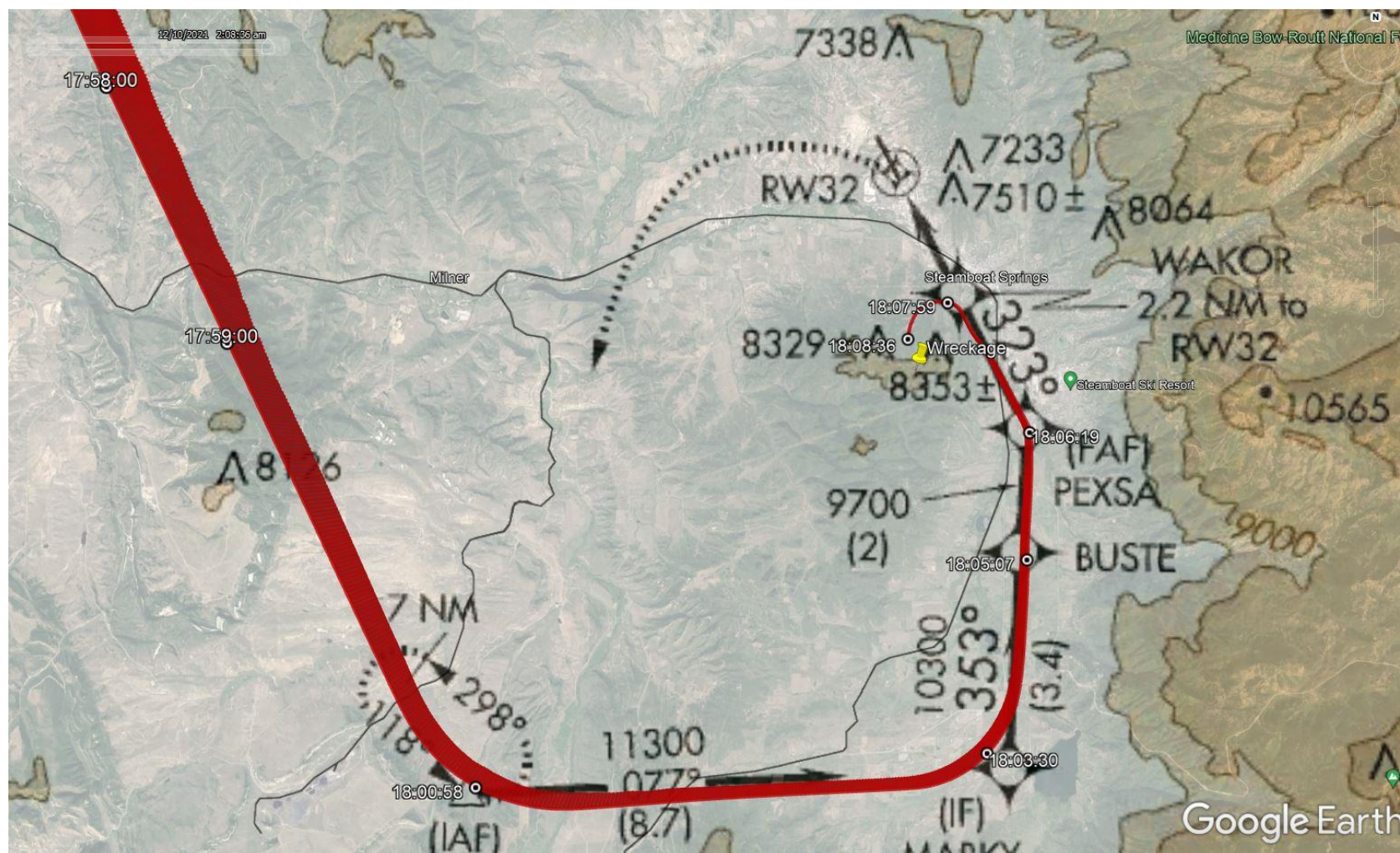


Figure 4. A Google Earth plot showing the accident aircraft's ground track in the vicinity of the KSBS terminal area. An FAA published approach plate for the RNAV (GPS)-E approach has been overlaid with a 50% opacity. A yellow pin has been added indicating the position of the wreckage.

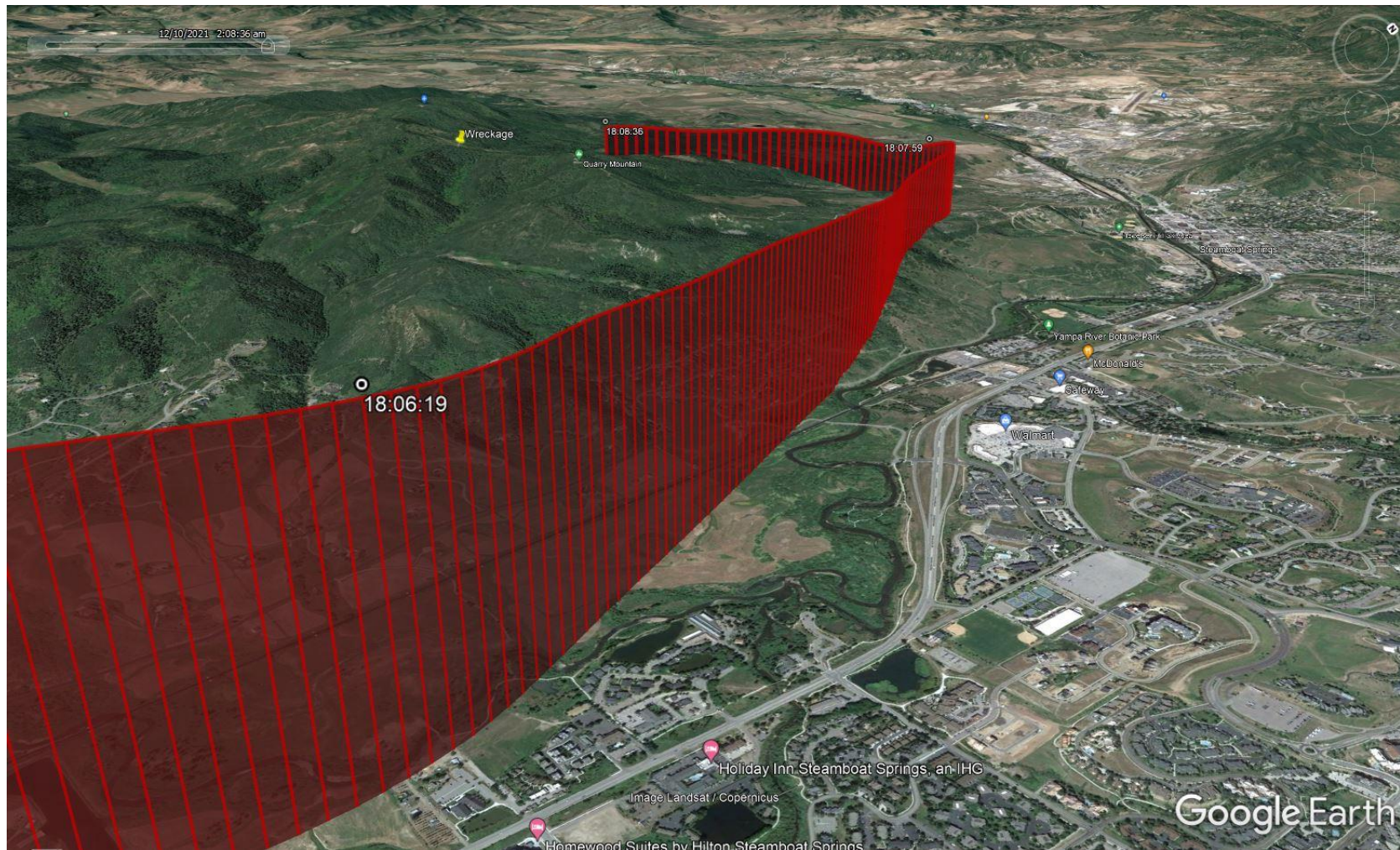


Figure 5. A Google Earth plot showing the accident aircraft's approach to KSBS. The wreckage location is indicated with a yellow pin.

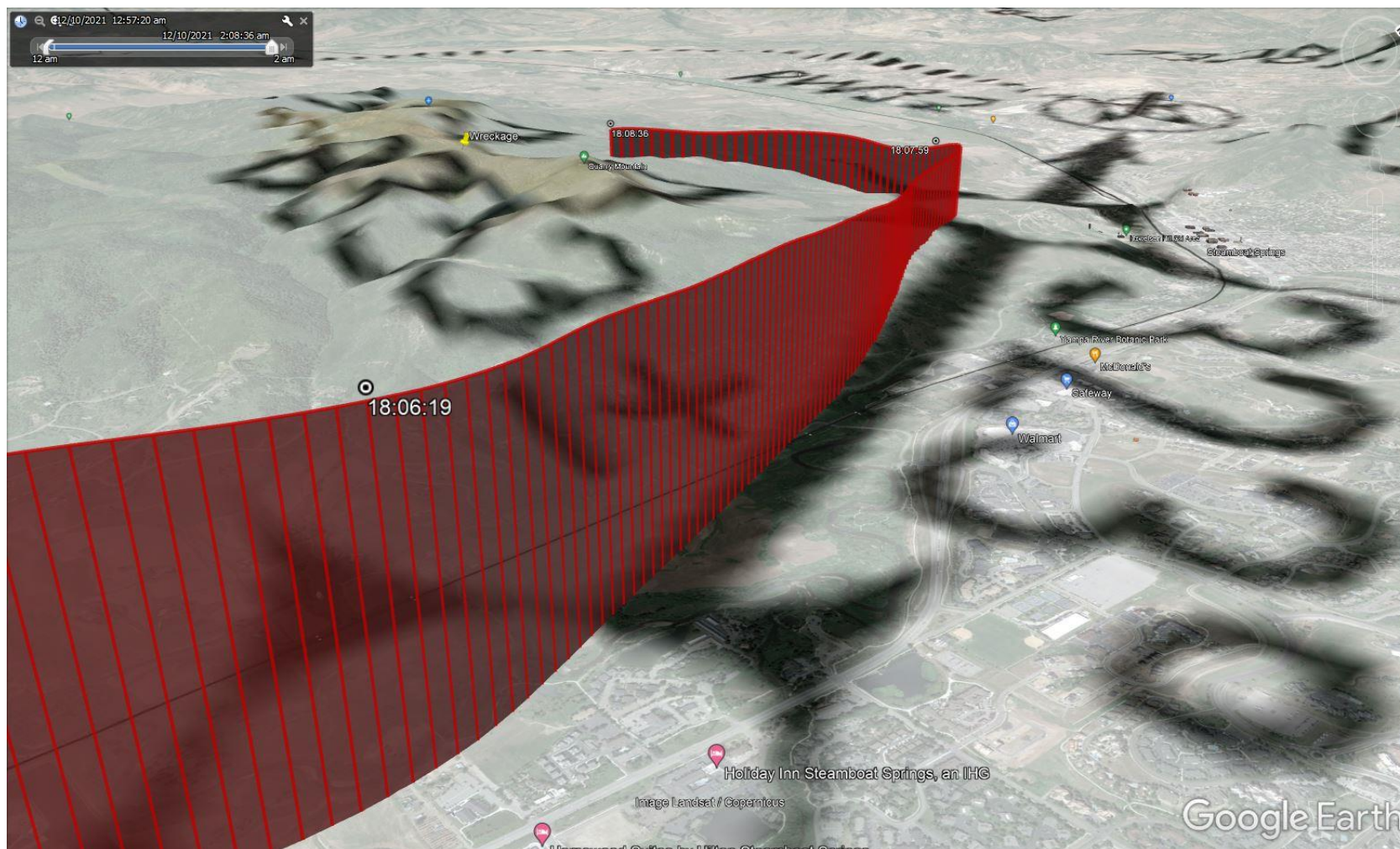


Figure 6. A Google Earth plot showing the accident aircraft's approach to KSBS. The wreckage location is indicated with a yellow pin. An FAA published approach plate for the RNAV (GPS)-E approach has been overlaid with a 50% opacity.



Figure 7. A Google Earth plot showing a view of the aircraft's ground track centered around Quarry Mountain. The wreckage location is indicated with a yellow pin. An FAA approach plate for the RNAV (GPS)-E approach has been overlaid with a 50% opacity.

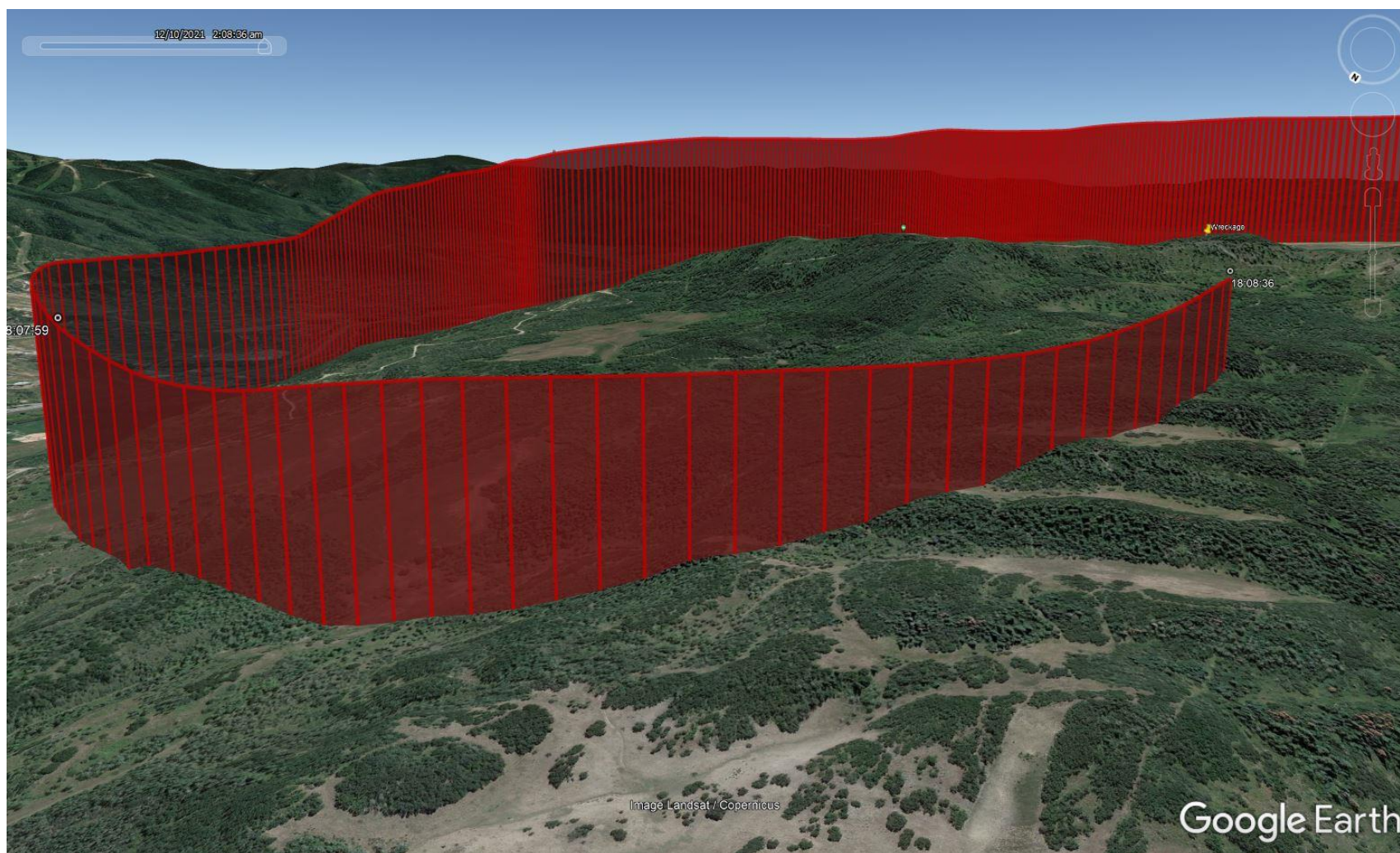


Figure 8. A Google Earth plot showing an alternate view of the aircraft's tracklog in the vicinity of Quarry Mountain, west of Steamboat Springs, CO. The view of this image is oriented to the south-east (toward Quarry Mountain from the west side of the approach course to KSBS).

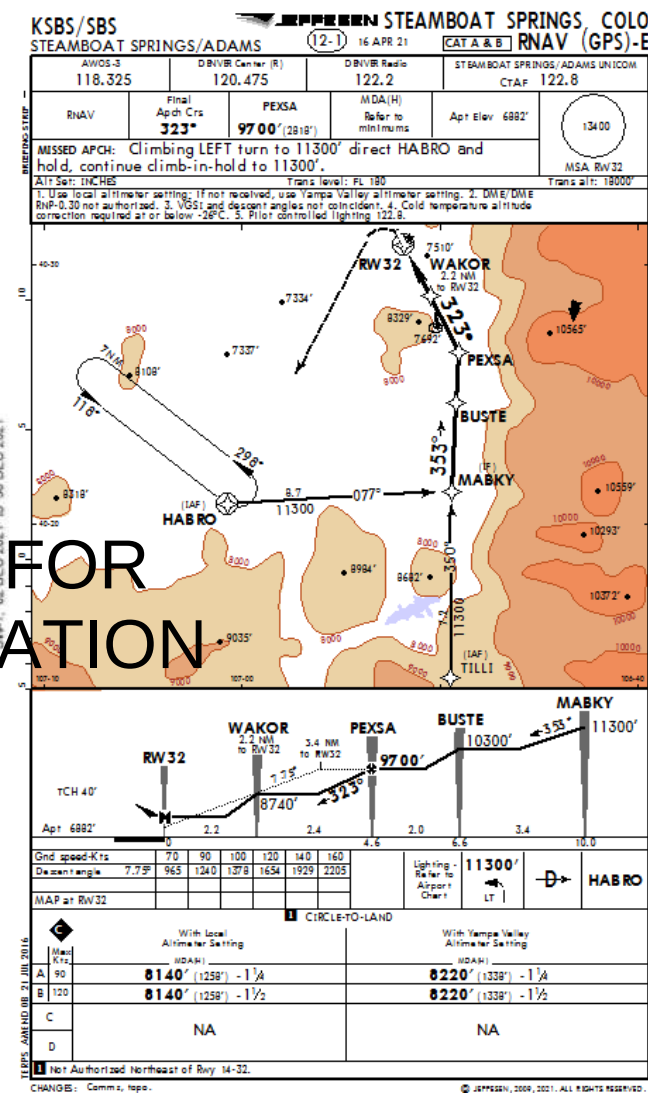
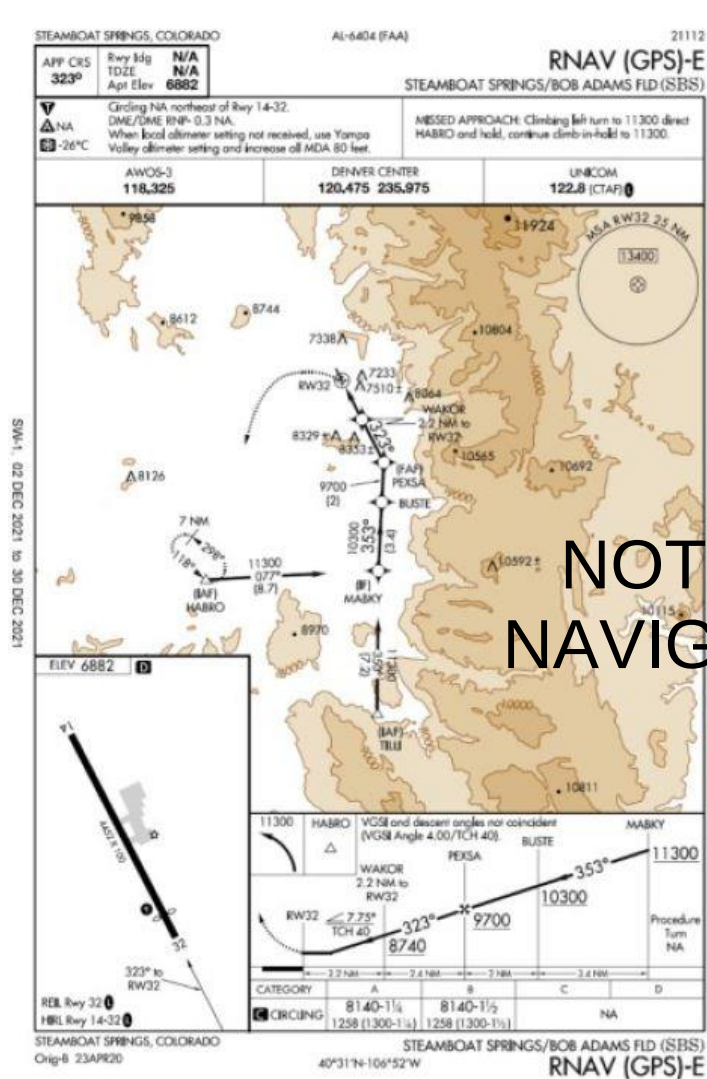


Figure 9. The FAA published approach plate for the RNAV (GPS)-E approach at KSBS (left) and the Jeppesen published approach plate for the same approach. Both approach plates depicted here were the versions current at the time of the accident. NOT TO BE USED FOR NAVIGATION.

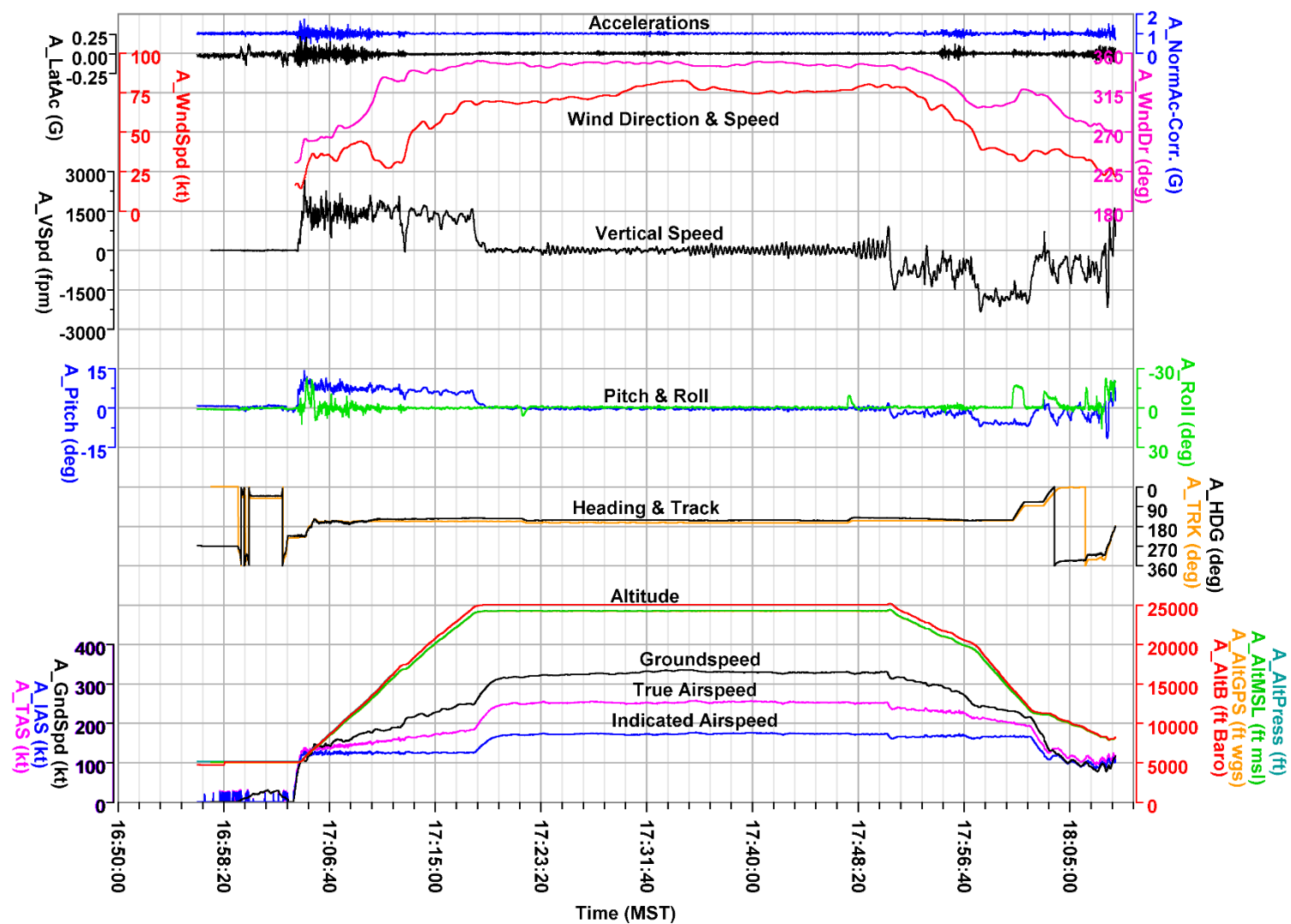


Figure 10. A plot of relevant GTN-750 parameters for the entire accident flight.

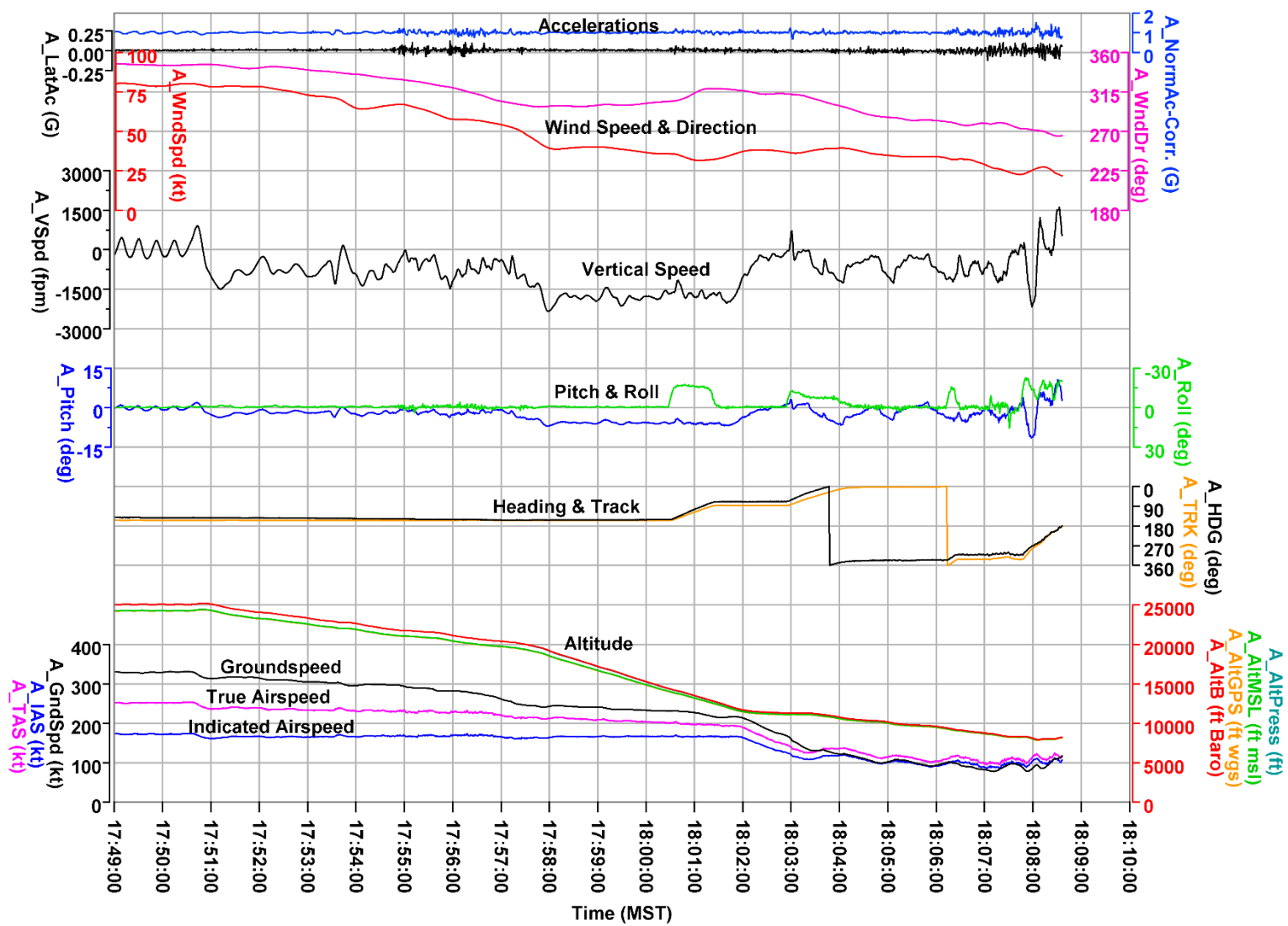


Figure 11. A plot of relevant GTN-750 parameters for the terminal portion of the accident flight.

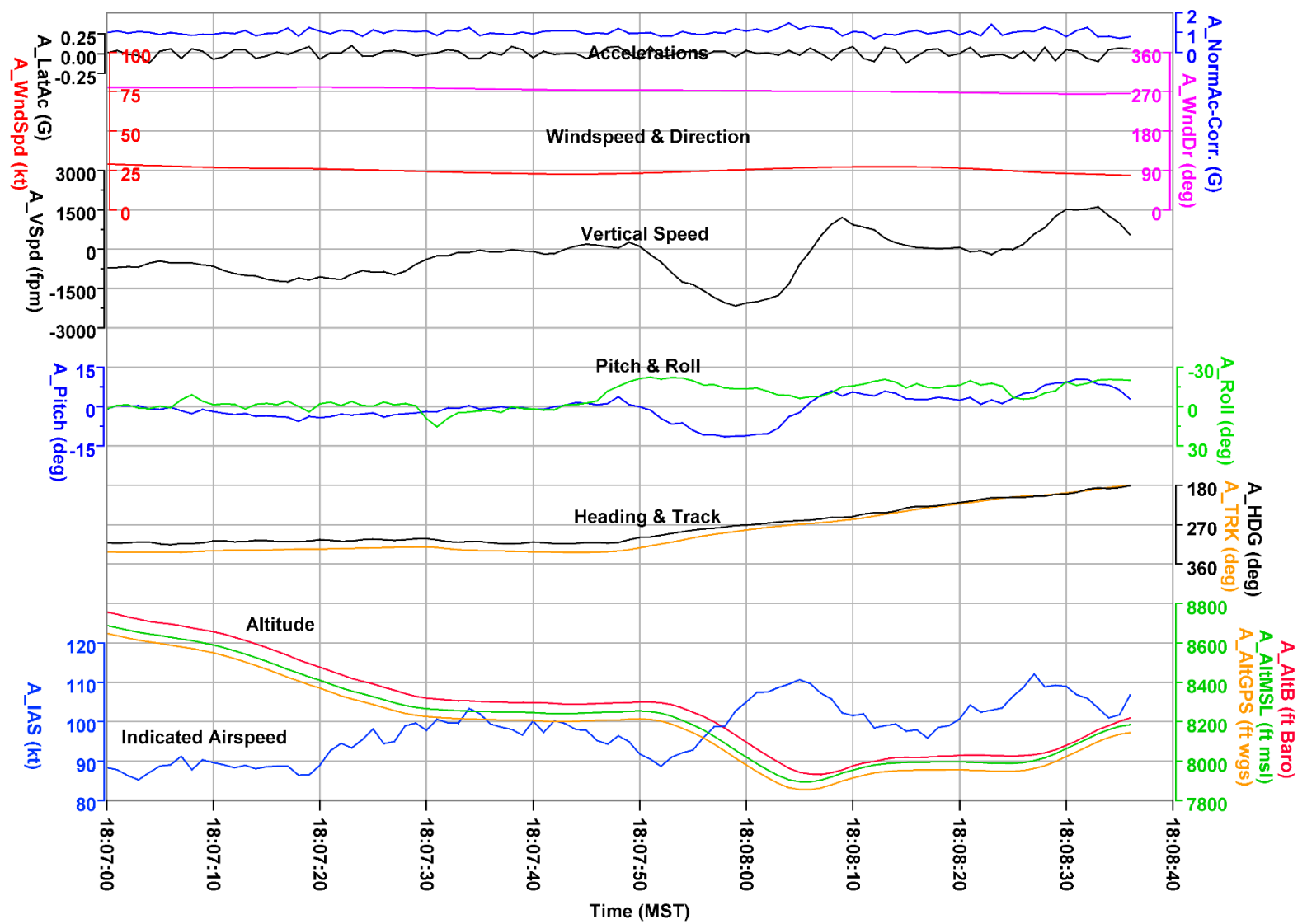


Figure 12. A plot of relevant GTN-750 parameters for the final portion of the accident flight.

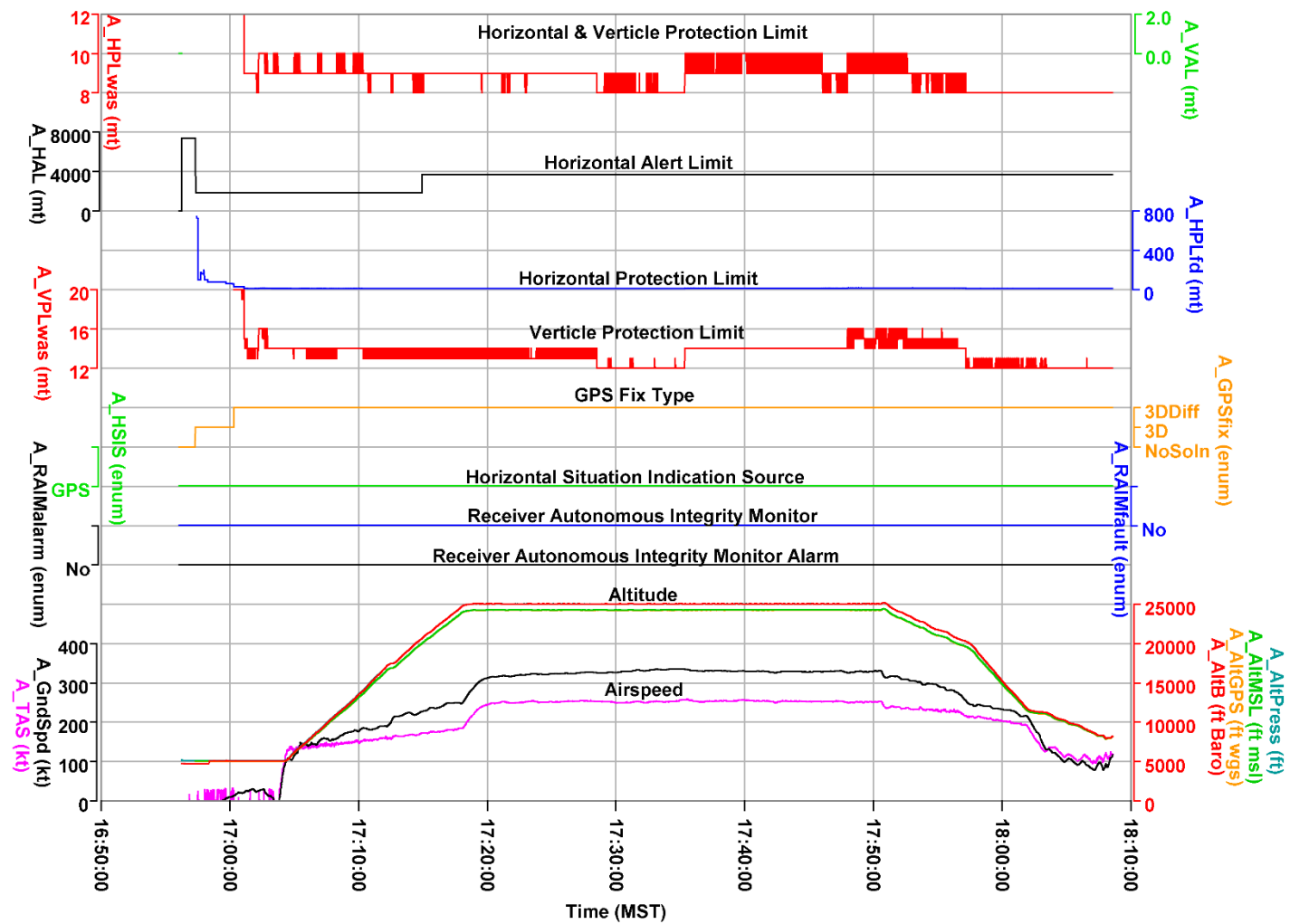


Figure 13. A plot of GPS quality related data from GTN-750 Unit A.

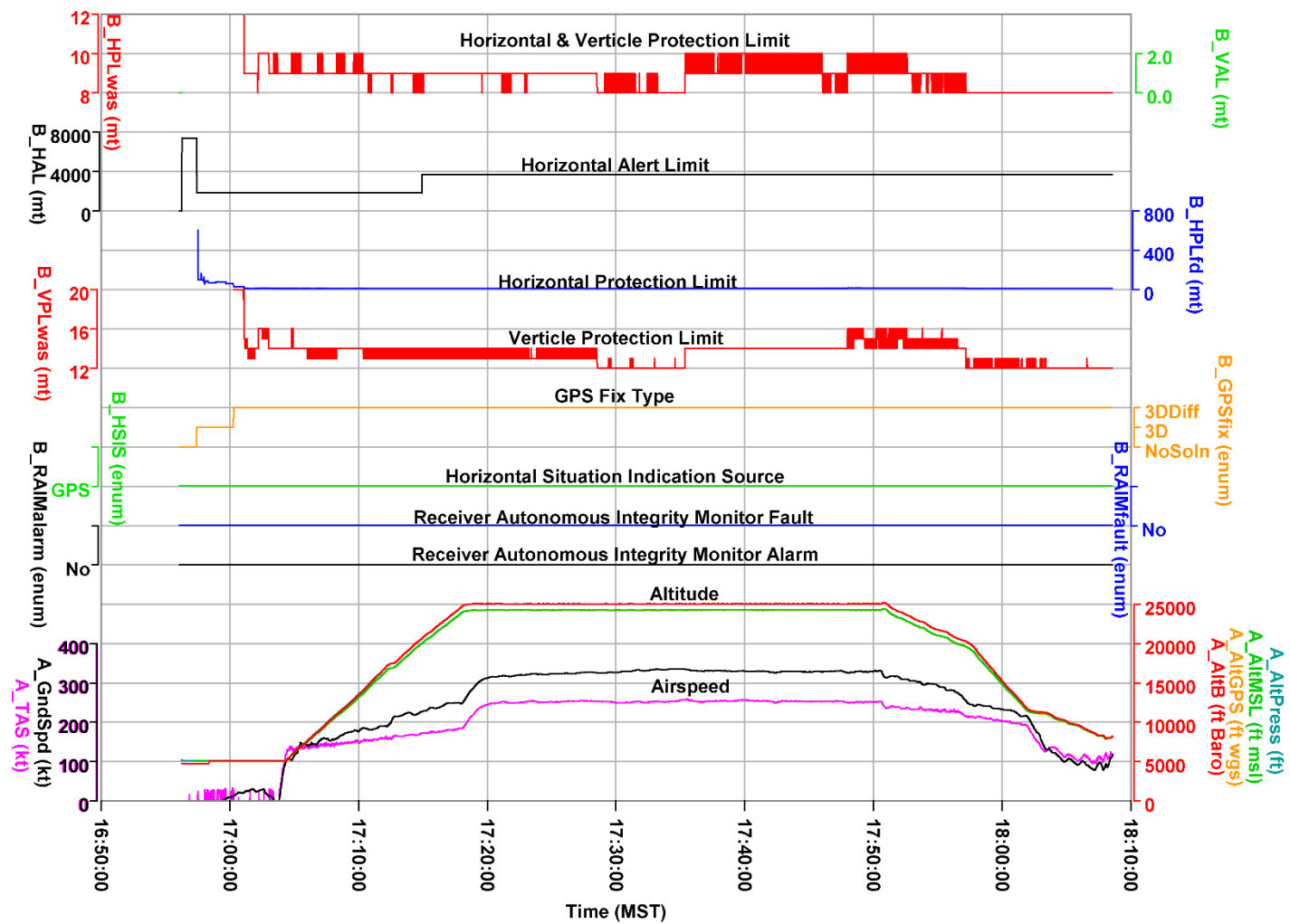


Figure 14. A plot of GPS quality related data from GTN-750 Unit B.

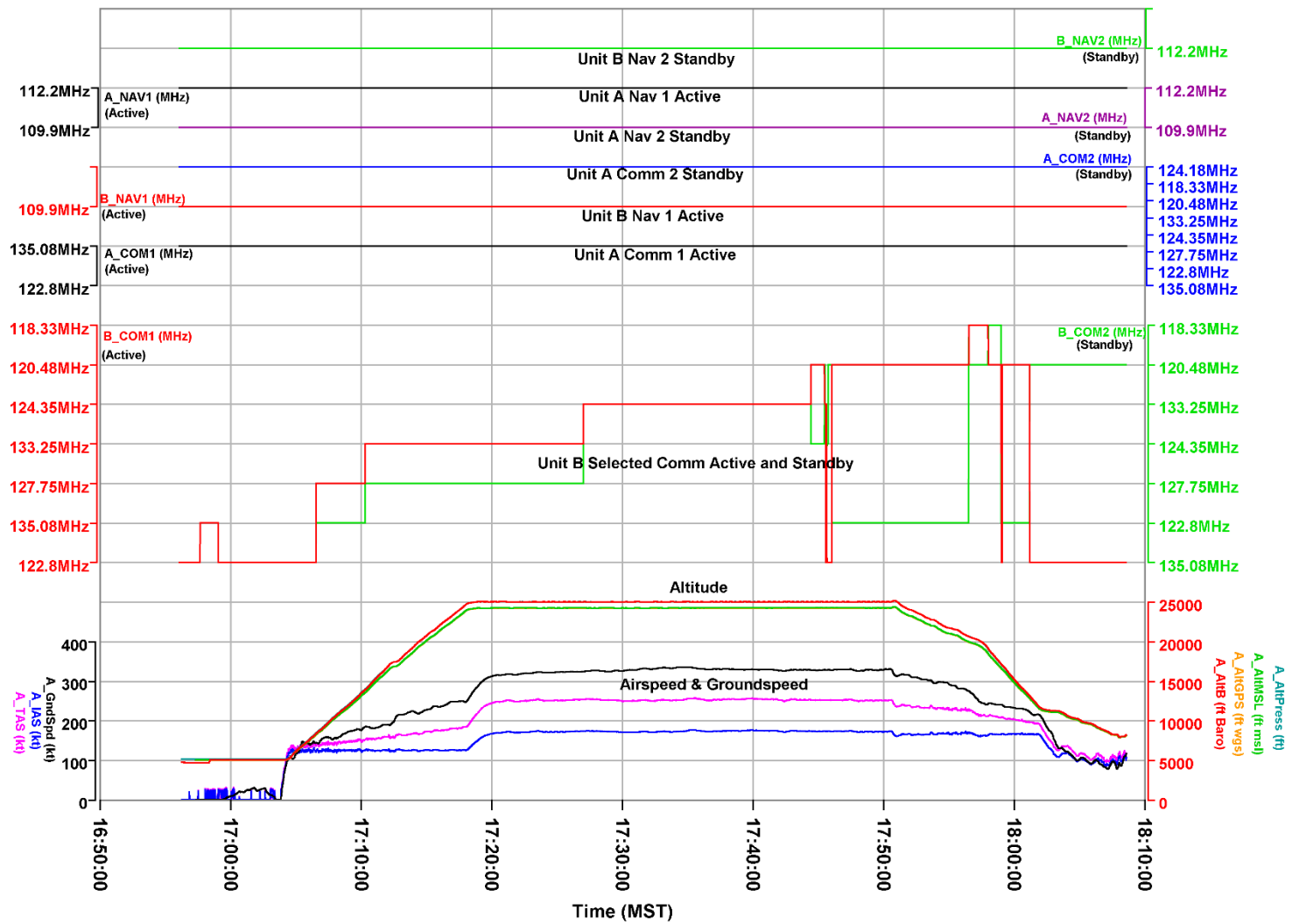


Figure 15. A plot of communication and navigation frequency recorded data from both Unit A and Unit B.

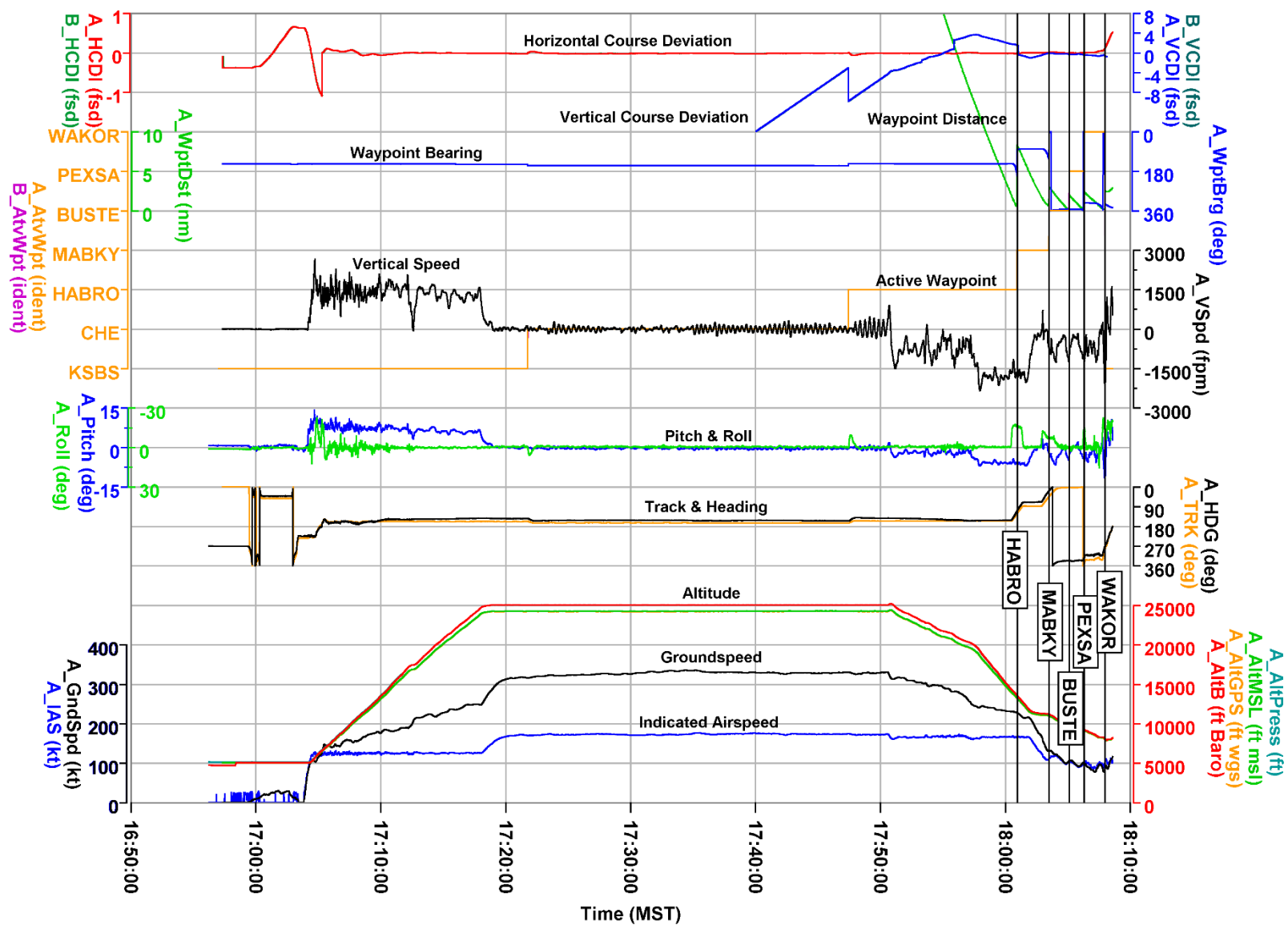


Figure 16. Parameters related to IFR navigation recorded by the GTN-750 for the entire flight.

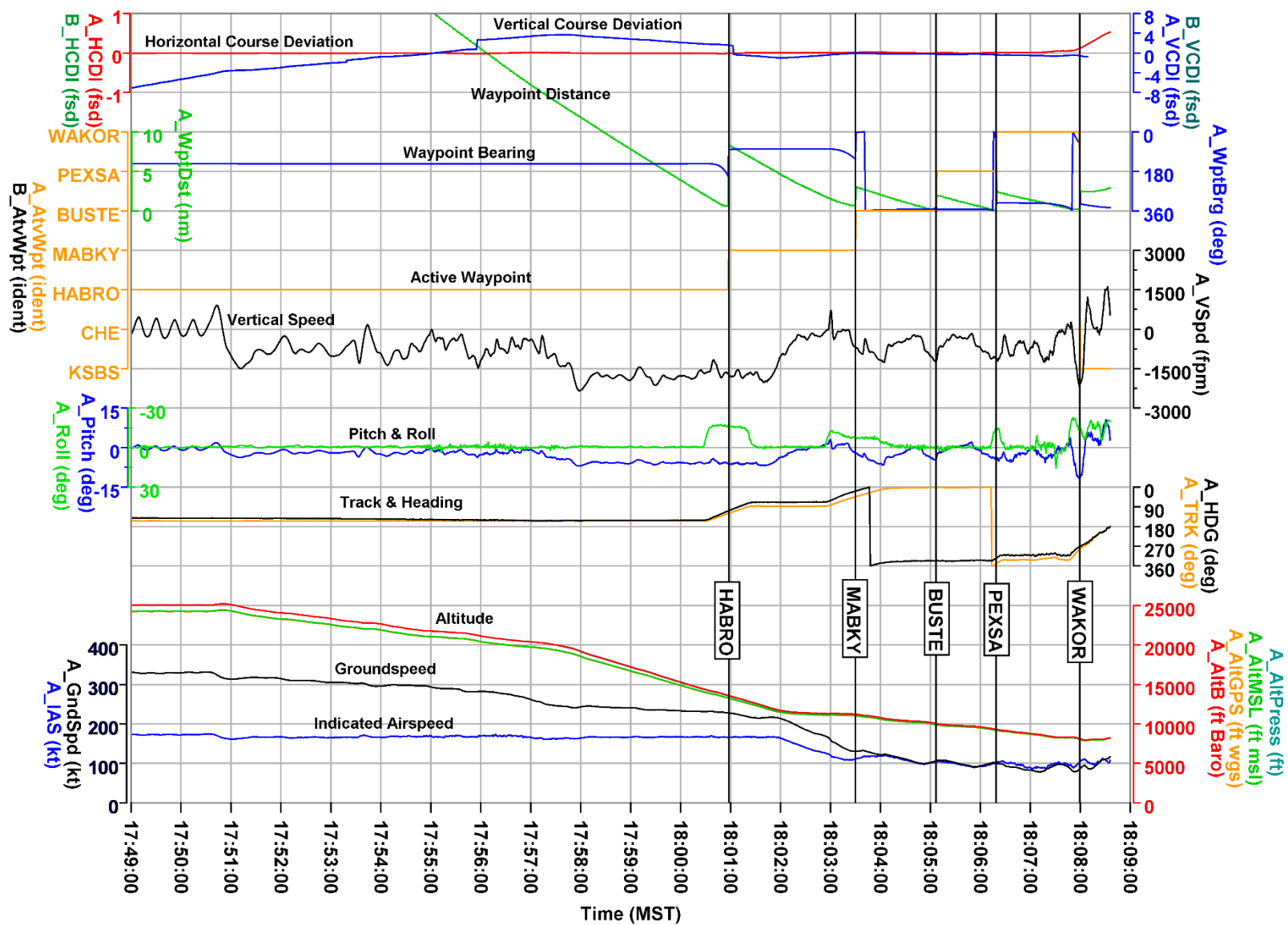


Figure 17. Parameters related to IFR navigation recorded by the GTN-750 for the descent phase and terminal area of the flight.

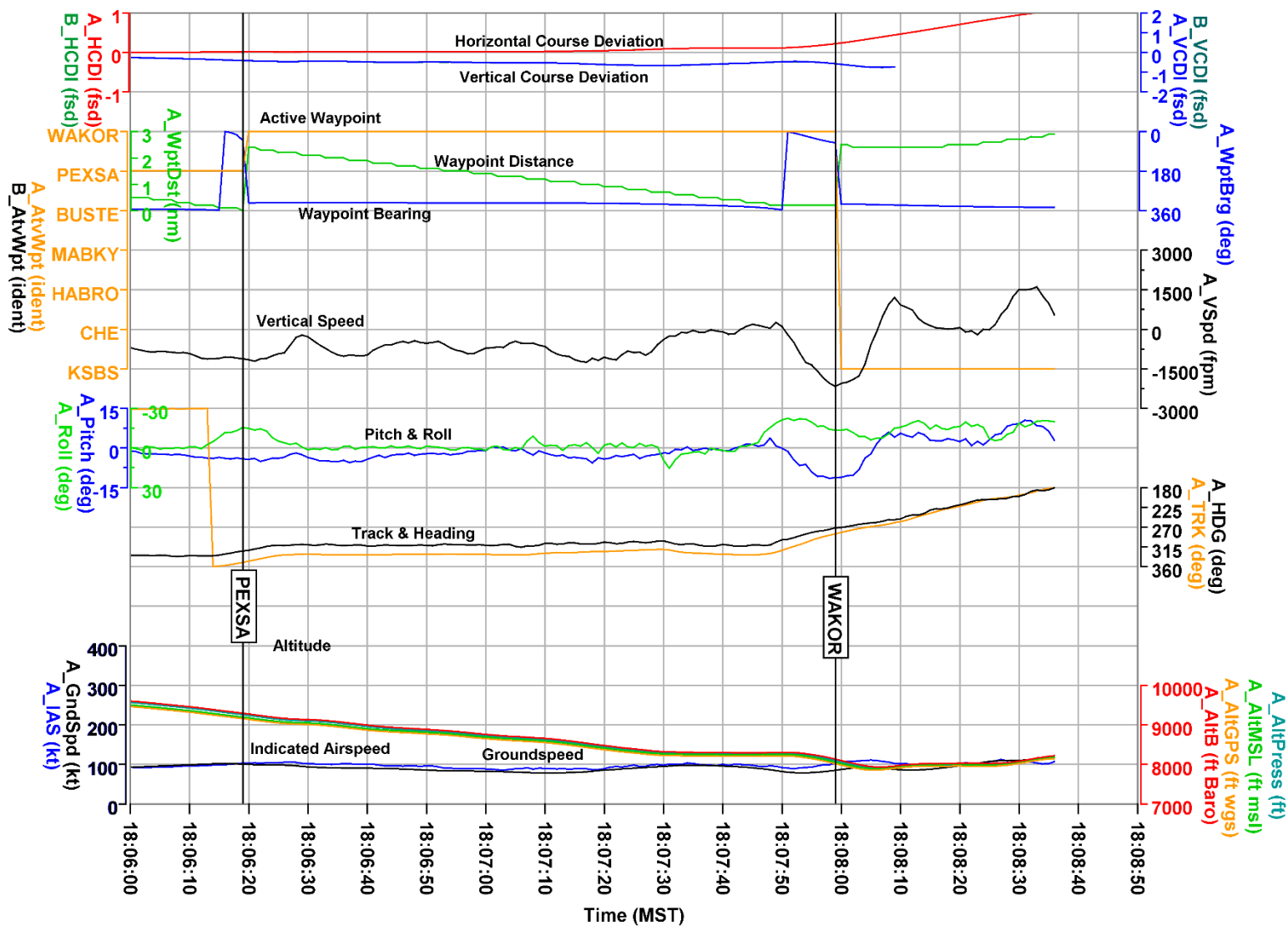


Figure 18. Parameters related to IFR navigation recorded by the GTN-750 for the final portion of the flight.

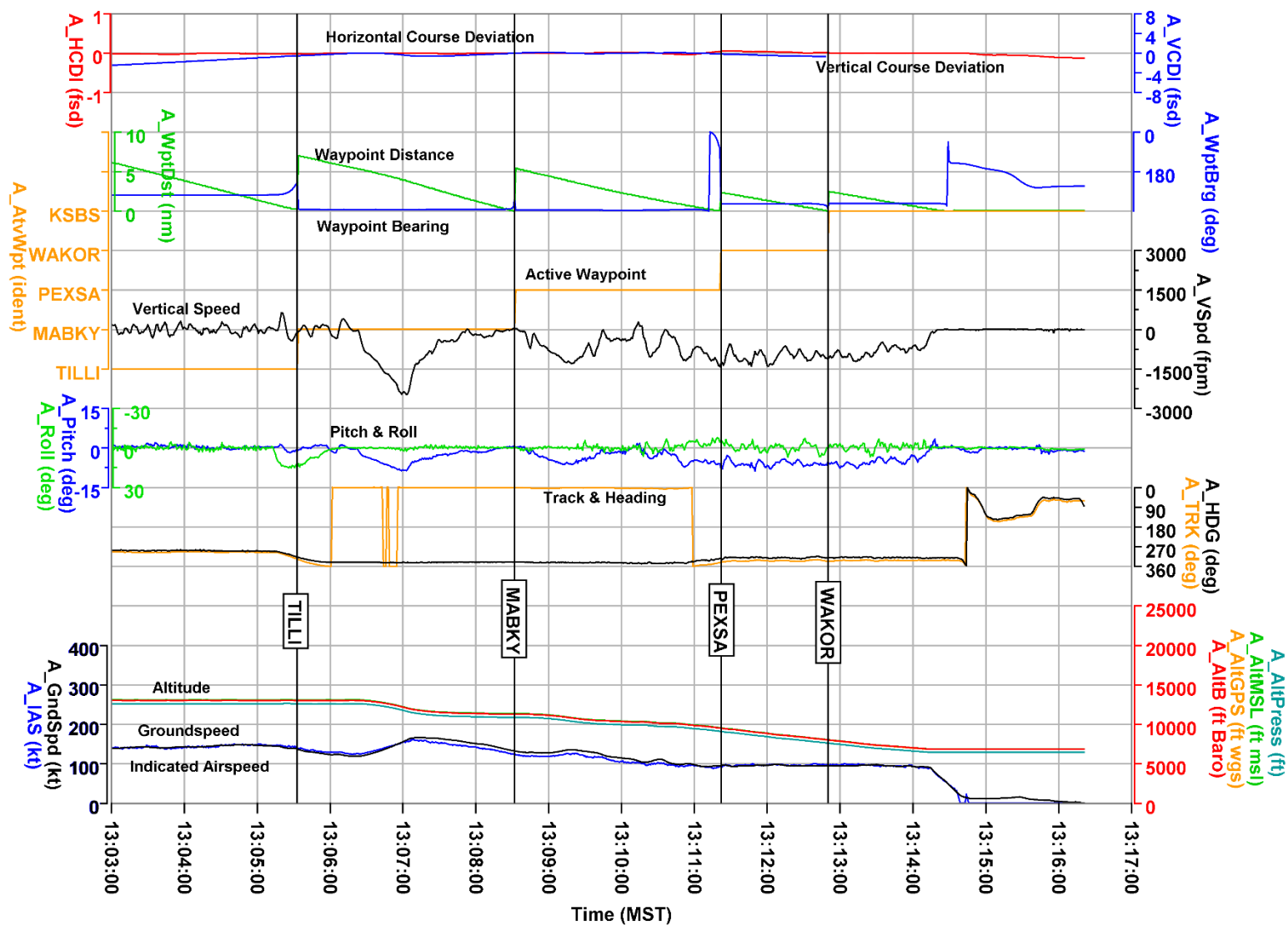


Figure 19. Parameters related to IFR navigation recorded by the GTN-750 for a previous approach to KSBS on November 11, 2021.

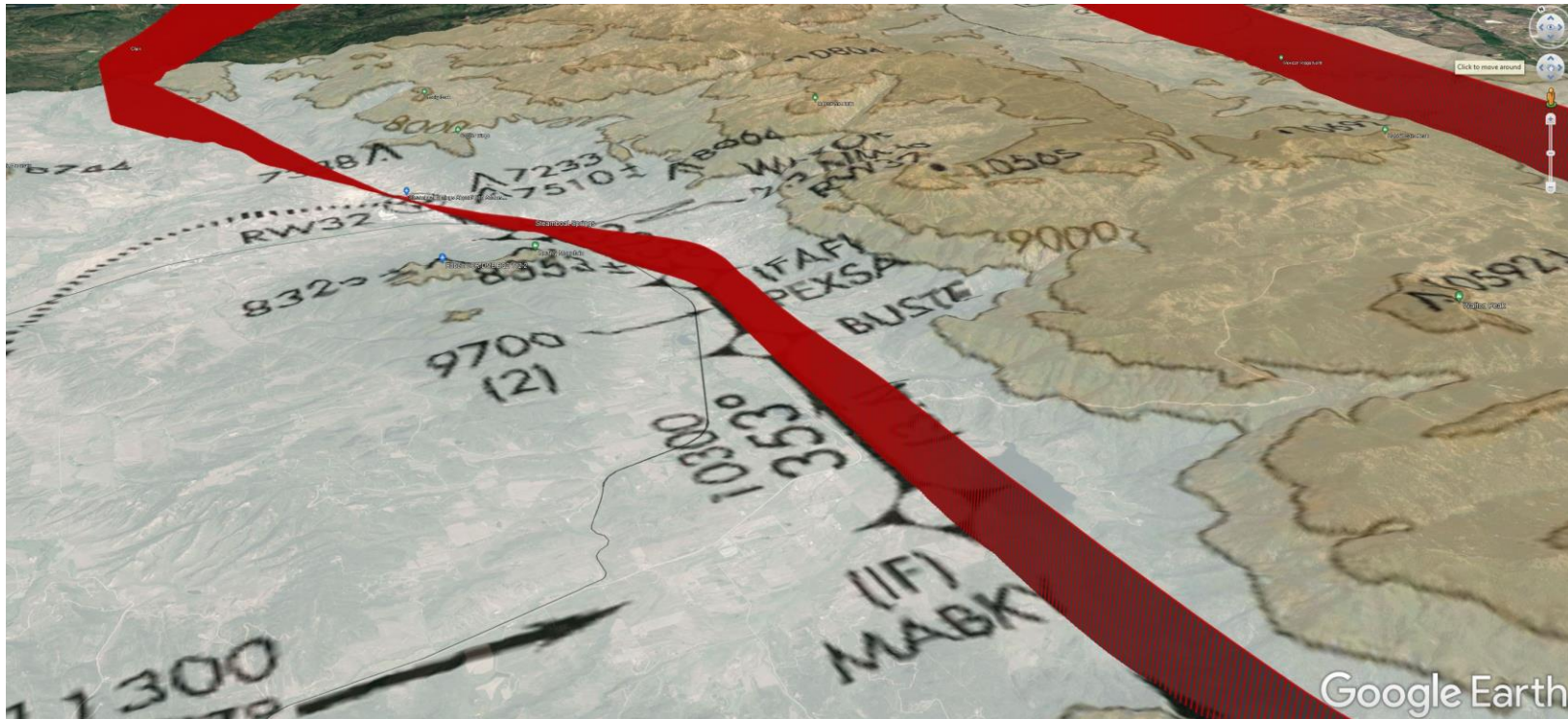


Figure 20. The aircraft's groundtrack recorded by the GTN-750 for a previous approach to KSBS on November 11, 2021. An FAA approach plate for RNAV (GPS)-E has been overlaid on the plot.

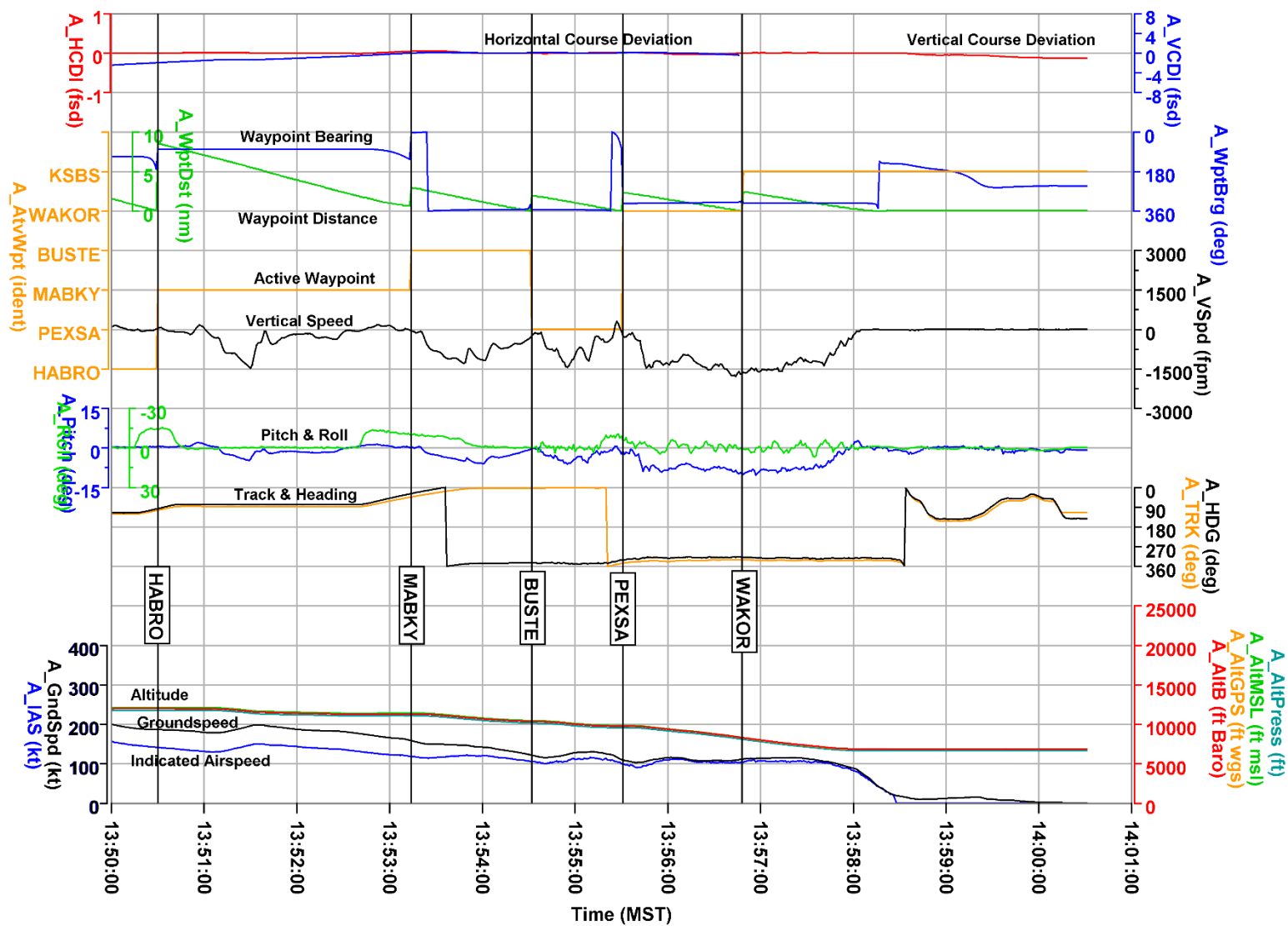


Figure 21. Parameters related to IFR navigation recorded by the GTN-750 for a previous approach to KSBS on December 4, 2021.

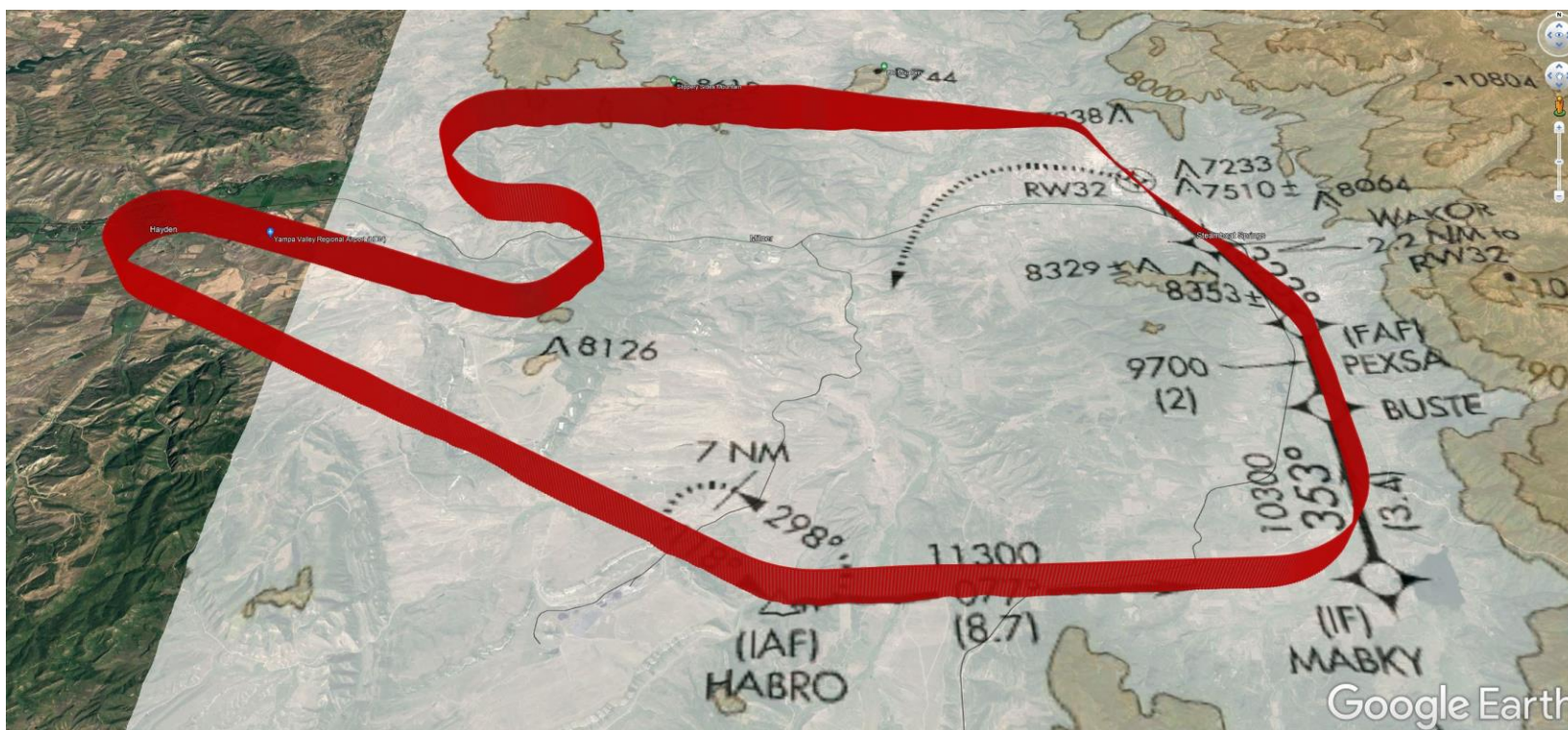


Figure 22. The aircraft's groundtrack recorded by the GTN-750 for a previous approach to KSBS on December 4, 2021. An FAA approach plate for RNAV (GPS)-E has been overlaid on the plot.



Figure 23. The instrument panel of N744Z. The photo was taken from an online sales posting for the accident aircraft was undated. The sales listing advertised *"New dual Garmin 500 glass package New pilot side synthetic vision."*