

NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

December 16, 2020

Multiple Electronic Devices

Specialist's Factual Report
by Sean Payne

1. EVENT

Location: Sioux Falls, SD
Date: June 7, 2020
Aircraft: Mitsubishi MU-2B
Registration: N44MX
Operator: McNeely Charter Service, Inc.
NTSB Number: CEN20LA215

On June 7, 2020, about 0425 central daylight time (CDT), a Mitsubishi MU-2B airplane, N44MX, was destroyed when it was involved in an accident near Sioux Falls, South Dakota. The pilot was fatally injured. The airplane was operated as a Title 14 *Code of Federal Regulations* (CFR) Part 135 cargo flight.

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: **1za022680**
Device 2: **Garmin Aera 660**
Device 2 Serial Number: **4nn006389**
Device 3: **Garmin Connexx FlightStream 510**
Device 3 Serial Number: **402002878**
Device 4: **Avidyne EX-500**
Device 4 Serial Number: **b1702**

2.1. Garmin Aera 660 Device Description

Garmin Aera 660 is a battery-powered portable multi-function display and GPS receiver with sunlight readable a 5-inch diagonal touchscreen operation display. The unit includes a built-in Jeppesen database and can receive XM satellite radio for flight information including NEXTRAD radar, lightning, METARs, TAFs, and TFRs. The unit can also perform and store weight and balance calculations. A built-in AOPA Airport Directory and Safe Taxi Airport Diagrams are included for selected fields. The unit stores date, route-

of-flight, and flight-time information for up to 50 flights. The unit has 23 different map ranges available, from 200 feet to 800 nm. A flight record is triggered when groundspeed exceeds 30 knots and altitude exceeds 250 feet and ends when groundspeed drops below 30 knots for 10 minutes or more. A detailed track log – including latitude, longitude, date, time, and GPS altitude information– is stored within the unit whenever the receiver has a lock on the GPS navigation signal. Position is updated within the track log as a function of time or distance moved, depending on how the unit has been configured. Once the current track log memory becomes full, new information either overwrites the oldest information or recording stops, depending on how the unit is configured. The current track log can be saved to long-term memory and 15 saved track logs can be maintained in addition to the current track log. Track log storage may be activated or de-activated at user discretion. All recorded data is stored in non-volatile memory.¹ The unit contains hardware and software permitting the download of recorded waypoint, route, and track log information to a PC via a built-in USB port. An internal button-battery is used to back-up power to the internal memory and real-time clock during those periods when main power is removed.

2.1.1. Garmin Aera 660 Data Recovery

The device was badly damaged as shown in figure 1. The device would have required a “chip-off” and subsequent binary conversion of data in order to create a track log. Garmin Aera devices that require chip off and binary conversion typically do not recover the final moments of an accident flight, and typically do not include the aircraft’s ground track up until the wreckage location. This is attributed to a volatile memory loss schema that occurs when the unit is shut down improperly, in this case an impact with terrain. In addition to the known history of data loss, the GPS data from the Garmin GTN 750 discussed in section 2.1. contains better quality data set than the Garmin Aera 660 could have produced. For that reason, the Garmin Aera 660 data was determined to be redundant and was not recovered.



Figure 1. The Garmin Area 660 from the accident airplane.

¹ Non-volatile memory (NVM) – Semi-conductor memory that does not need power applied to retain data.

2.1.2. Garmin Aera 660 Data Description

No data was extracted from the device.

2.2. Garmin FlightStream 510 Device Description

The FlightStream 510 is an electronic device in the form factor of a SD memory card that contains Wi-Fi and Bluetooth connectivity capability. When installed in a Garmin navigator like the GTN 750 it gives the capability to stream data to and from the unit (GTN) to a connected iPad or Android tablet device running compatible software. The FlightStream 510 SD card records no data, but the connected tablet device could contain the data streamed from the GTN.

2.2.1. Garmin FlightStream 510 Data Recovery

The device in good condition as shown in figure 2. The device was connected to a PC via a USB write blocker and read normally. A review of the data showed no stored flight data, only chart information, as expected.



Figure 2. The Garmin FlightStream 510 from the accident airplane.

2.2.2. Garmin Connex FlightStream 510 Data Description

The device contained no flight data.

2.3. Avidyne EX-500 Device Description

The Avidyne EX-500 is a 5.4 inch multifunction display (MFD) that is able to display radar, datalink weather, traffic and terrain information. The MFD allows the pilot to display this information in a series of selectable electronic layers. It can provide XM weather datalink information. It includes a terrain and water basemap with obstacles over 200 feet above ground level (agl). The unit can be configured to interface with a stormscope as well as Honeywell/Bendix/King Enhanced Ground Proximity Warning System (EGPWS) information. The unit can interface with an optional Jeppesen Chart package. The device contains a removable Compact Flash (CF) card which contains configuration files and logs of weather data packets received. The device does not record whether these data was displayed to the pilot, nor does the unit store flight or engine data of any kind.

2.3.1. Avidyne EX-500 Data Recovery

The device had severe impact damage as shown in figure 3. The unit was cut open and the CF card was removed. The CF card was read normally using a PC, the contents of

the card were copied and examined. The contents were determined to be non-pertinent to the accident investigation.



Figure 3. The Avidyne EX-500 from the accident airplane.

2.3.2. Avidyne EX-500 Data Description

The data were determined to be non-pertinent to the accident investigation.

2.4. 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 certified for primary domestic, oceanic, and remote navigation including en route, terminal, and non-precision approaches, and approaches with vertical guidance, such as LPV and LNA/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.

2.4.1. Garmin GTN 750 Data Recovery

Upon arrival at the Vehicle Recorder Division, an exterior examination revealed the unit had sustained significant damage. The device is pictured in figure 4. The unit 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.

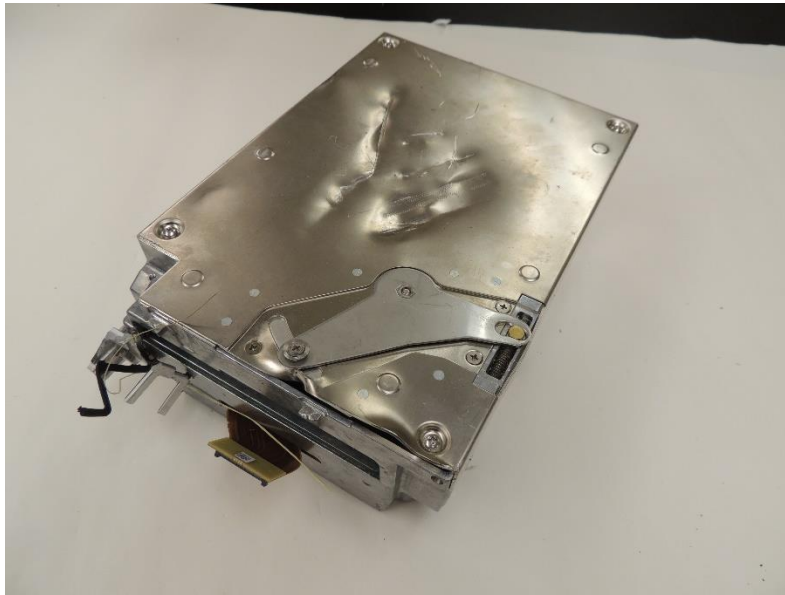


Figure 4. The Garmin GTN-750 from the accident airplane.

2.4.2. Garmin GTN 750 Data Description

The data extracted included a number of log sessions (approximately 188,613 total data points) from February 13, 2020, through June 7, 2020. The accident flight recording was found, it started at 4:09:30 CDT and ended at 4:26:09 CDT on June 7, 2020.

Attachment 1 to this report is all recorded flight data from the GTN-750 from February 13, 2020, through June 7, 2020. Note: All times in this report are presented in CDT, all times in the attachment are presented in UTC.

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 were removed.

Table 1. Garmin GTN-750 Parameters

Parameter Abbreviation	Description
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	Verical Speed (feet per minute)
HDG	Heading (degrees)
TRK	Track (degrees)
FQtyC	Fuel Quantity
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
VCDI	Vertical Course Deviation Indicator
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 CDT. All data in this report is presented in CDT.

Figure 5 is a Google Earth plot showing the accident aircraft's ground track and recorded altitude data in the vicinity of the accident location. Some times of note are when the recording began at 4:10:33 CDT, when the aircraft began taxiing around 4:14:30 CDT, when the aircraft reached the run-up apron around 4:23:30, when the aircraft began takeoff roll around 4:25:30 CDT, and the final data point at 4:26:09 CDT.

Figure 6 is a Google Earth plot showing the accident aircraft's ground track in the vicinity of the run-up apron and the beginning of the aircraft's takeoff roll on the accident flight. The purpose of this plot is to show the timeframe of the accident aircraft in the vicinity of the run-up apron and the time of its departure on takeoff roll.

Figure 7 is a Google Earth plot showing the accident aircraft's ground track and recorded altitude data in relation to the runway's centerline. The figure is from the perspective of the runway's threshold.

Figure 8 is a Google Earth plot showing the accident aircraft's ground track and recorded altitude data in relation to the runway's centerline. There is a noticeably right ground track that begins about 1500 feet from the departure runway's threshold. This figure is from the perspective near the region 1500 feet from the departure runway's threshold. The Google Earth imagery shows markings for the airport's land based arresting gear, which was not rigged at the time of the accident.

Figure 9 is a Google Earth plot showing a top down view of the aircraft's ground track centered around an area approximately 1500 feet from the departure runway's threshold. Yellow rings representing the GTN750's Horizontal Protection Limit (HPL) have been added to represent the potential variance in the aircraft's groundtrack. The radius of this circle, which is centered on the GPS position solution, is guaranteed to contain the true position of the receiver to within the specifications of the Receiver Autonomous Integrity Mentoring (RAIM) scheme.

The plot in figure 10 is of the entire accident flight recording. It shows the aircraft began taxiing around 4:15 CDT. Around 4:24 CDT, the aircraft came to a stop for approximately 1 minute. Around 4:25:30, the aircraft began a takeoff roll. The data describes a climb, with a peak value of around 2000 feet per minute (fpm), followed immediately by a steep descent with a peak value of around -3000 fpm near the time of impact at 4:26:09 CDT. While the aircraft was airborne, data show the aircraft in a right turn, its heading changing from roughly 150 degrees to 179 degrees at the time of impact.

It is important to note that the values for calculated wind speed and calculated wind direction are derived from the GTN750's other recorded values. Due to the dynamic changing of the aircraft's position data, and various other factors, the calculated wind speed and heading may not be accurate.

Figure 11 is a plot of the accident flight with an expanded time frame between 4:23 CDT and impact at 4:26:09 CDT.

Figure 12 is a plot of the accident aircraft's previous flight, with an expanded time scale between roughly 9:14 PM CDT and 9:19 PM CDT on June 6 showing the aircraft's departure.

Figure 13 is a plot of the accident aircraft's previous flight during its arrival phase to Joe Foss Field Airport (FSD), Sioux Falls, South Dakota. On the arrival phase of the flight, the GTN-750 recorded a negative peak vertical speed value of about -4000 fpm as the aircraft began a descent out of approximately 4000 feet.

Figure 14 is a plot of the accident aircraft's previous flight during its approach phase to FSD. The plotted time interval is between 1:35 CDT and 1:43 CDT on June 7. The plot highlights the aircraft's descent profile out of 5000 feet on approach to the terminal area of FSD. The time between the last recorded data point on the previous flight and the accident flight was 2 hours 17 minutes and 16 seconds.

Figure 15 is a plot constructed of all departure profile data of the accident aircraft recorded on the GTN-750. The plot's time alignment is based on the change in vertical speed which is estimated to have occurred near the time of liftoff of each flight. Three critical elements are plotted here, vertical speed (Vspd) in feet per minute, True Airspeed in knots, and pressure altitude (AltPress) in feet (normalized to local field elevation). V_{mc} (minimum controllable velocity for the Mitsubishi MU-2) is annotated. Two flights appear anomalous in respect to departure profile. One flight was the accident flight on June 7th and the second flight was recorded on May 11, 2020. The May 11 flight was between Georgetown-Scott County Regional Airport, Georgetown, Kentucky (27K) and West Memphis Municipal Airport, West Memphis, Arkansas (AWM).

Figure 16 is a plot constructed of the two anomalous departure profiles described above. Vertical speed, true airspeed and normalized pressure altitude are described, as well as the MU-2's V_{mc} at flaps 20. The plot is annotated to show the accident flight and flight on May 11.

Figure 17 is a plot of relevant GTN-750 showing the aircraft's departure profile on a flight conducted on May 11, 2020 between 11:58:59 UTC and 13:29:47 UTC. Times on this plot are given in UTC.

Attachment 1 are data from the Garmin GTN-750 from the accident aircraft which includes all recorded data.

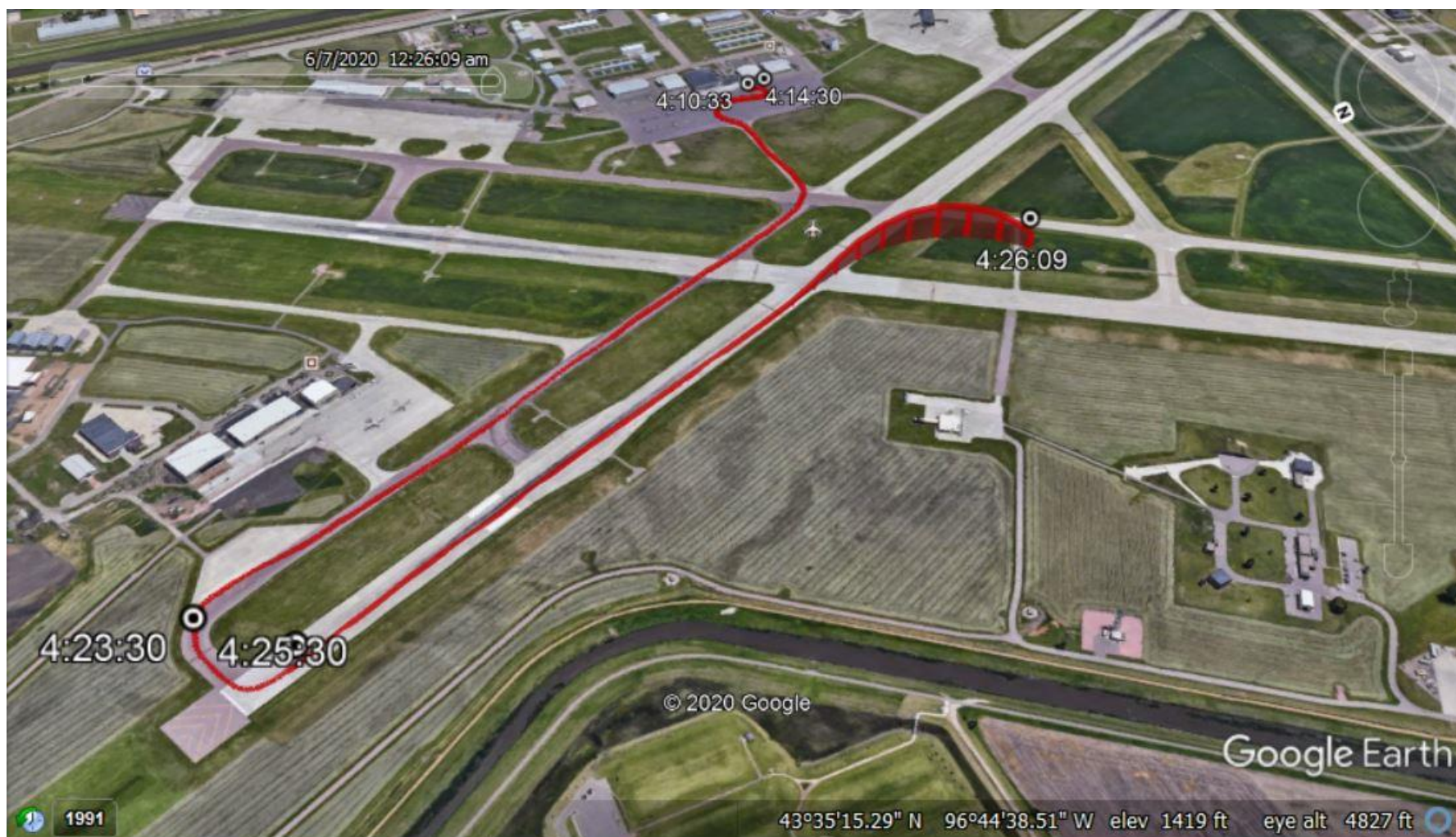


Figure 5. A Google Earth plot showing the accident aircraft's ground track and recorded altitude data in the vicinity of the accident location.



Figure 6. A Google Earth plot showing the accident aircraft's ground track in the vicinity of the run-up apron and subsequent departure.



Figure 7. A Google Earth plot showing the accident aircraft's ground track and recorded altitude data in relation to the runway's centerline.



Figure 8. A Google Earth plot showing the accident aircraft's ground track and recorded altitude data in relation to the runway's centerline. There is a noticeably right ground track that begins about 1500 feet from the departure runway's threshold.

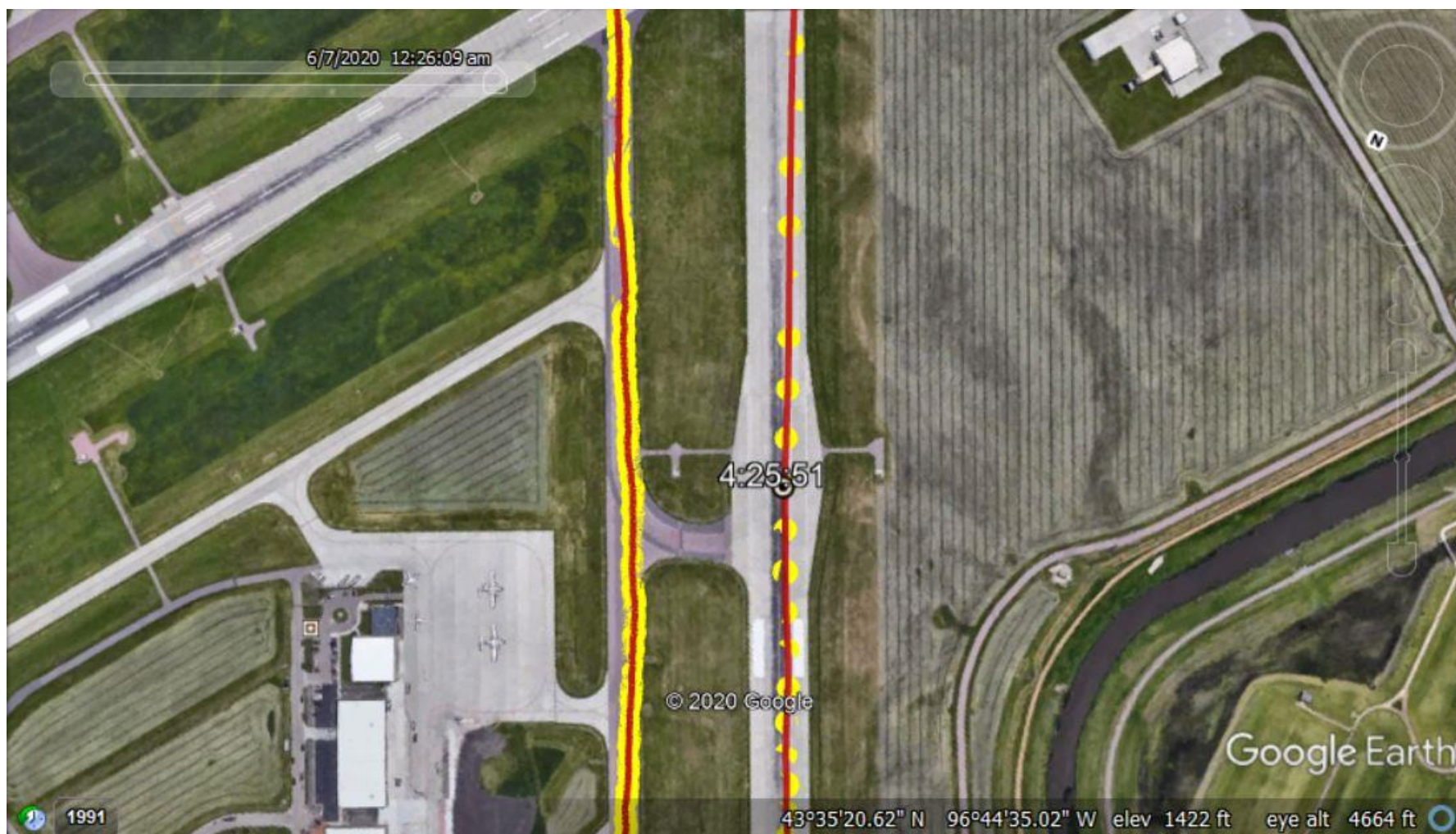


Figure 9. A Google Earth plot showing a top down view of the aircraft's ground track centered around an area approximately 1500 feet from the departure runway's threshold. Yellow rings representing the GTN750's Horizontal Protection Limit (HPL) have been added to represent the potential variance in the aircraft's groundtrack.

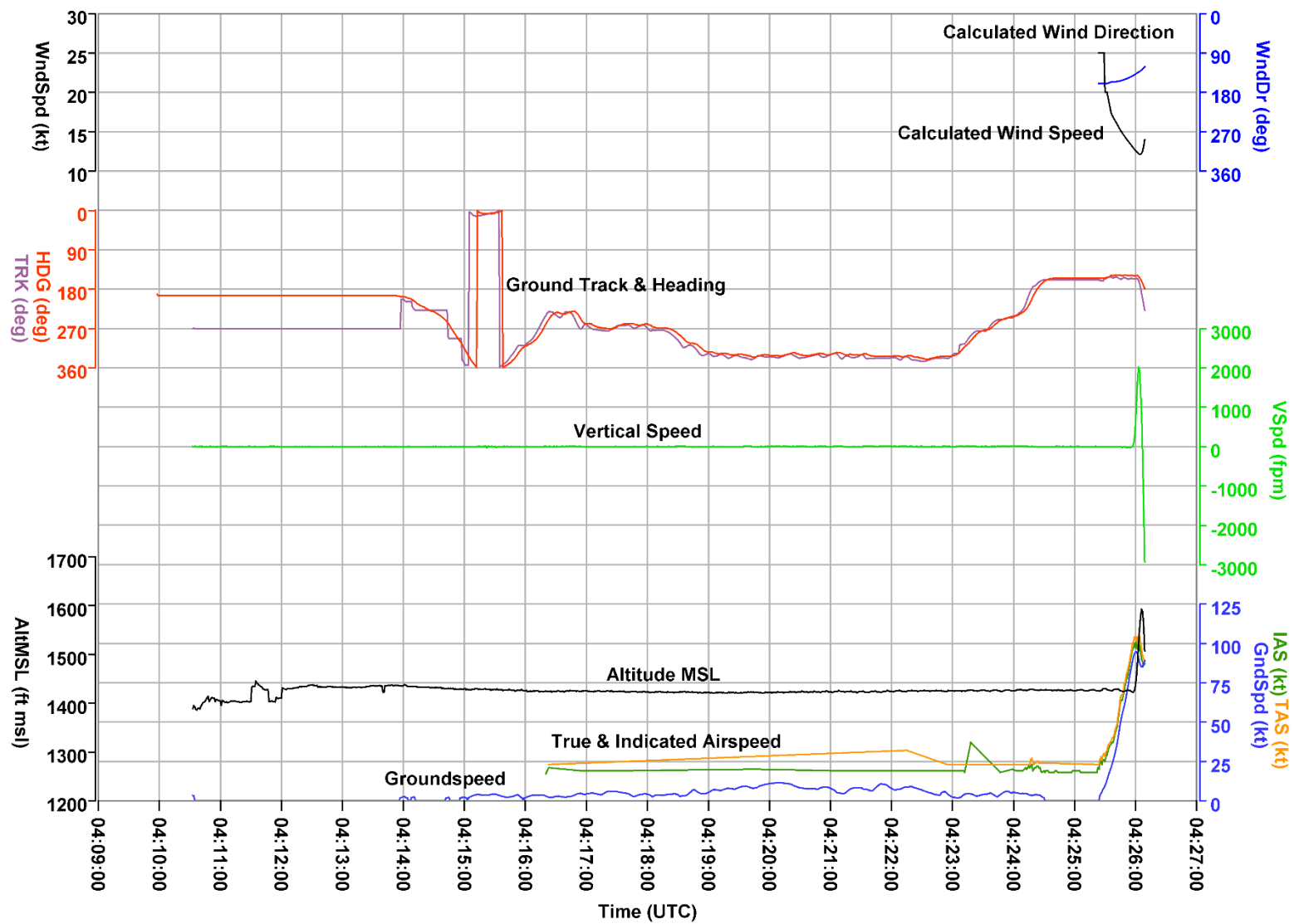


Figure 10. A plot of relevant GTN-750 parameters for the entire accident flight.

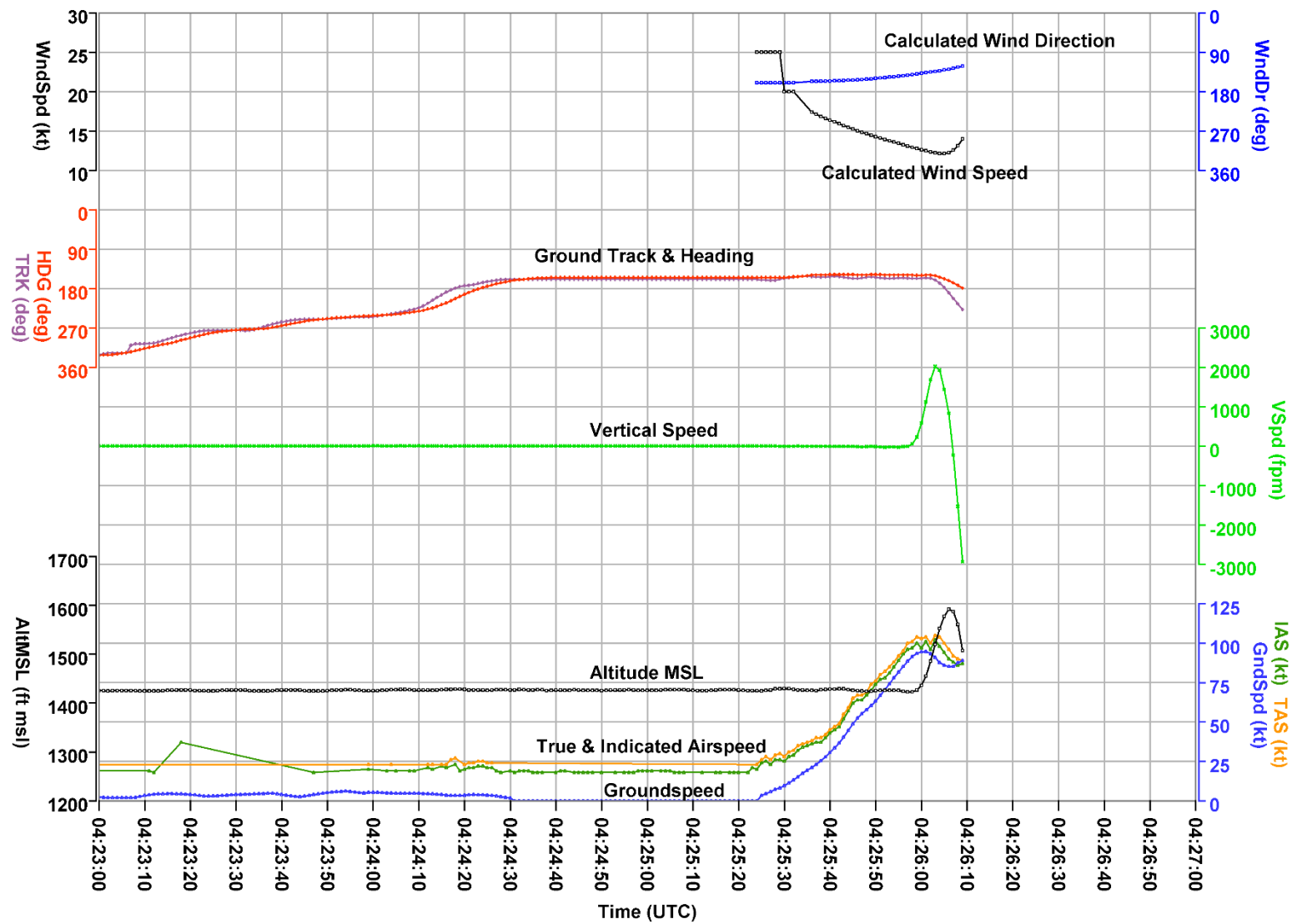


Figure 11. A plot of relevant GTN-750 parameters for the time period between 4:23 and the last data point at 4:26:09 CDT.

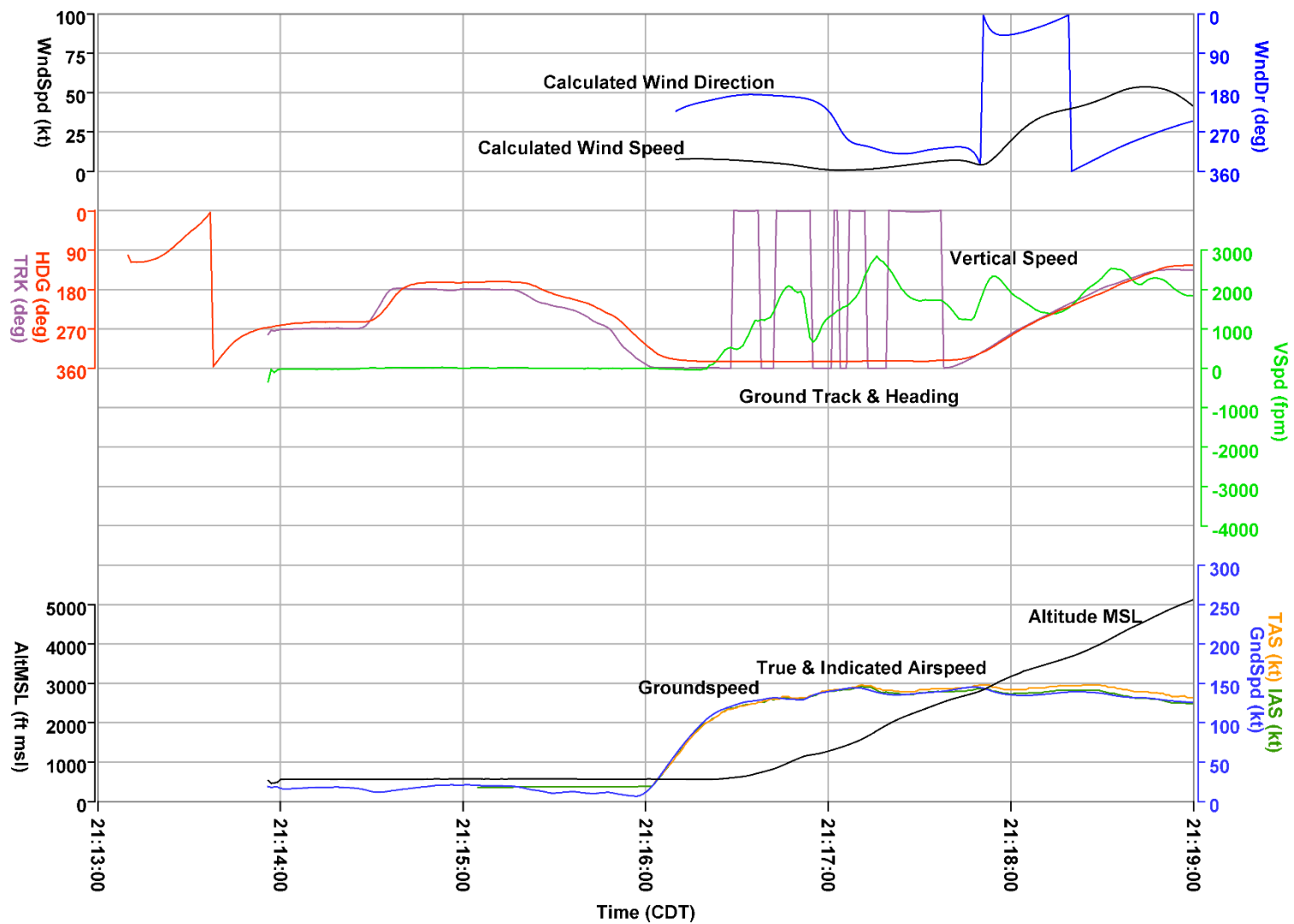


Figure 12. A plot of relevant GTN-750 parameters for the departure of the accident aircraft on the flight previous to the accident.

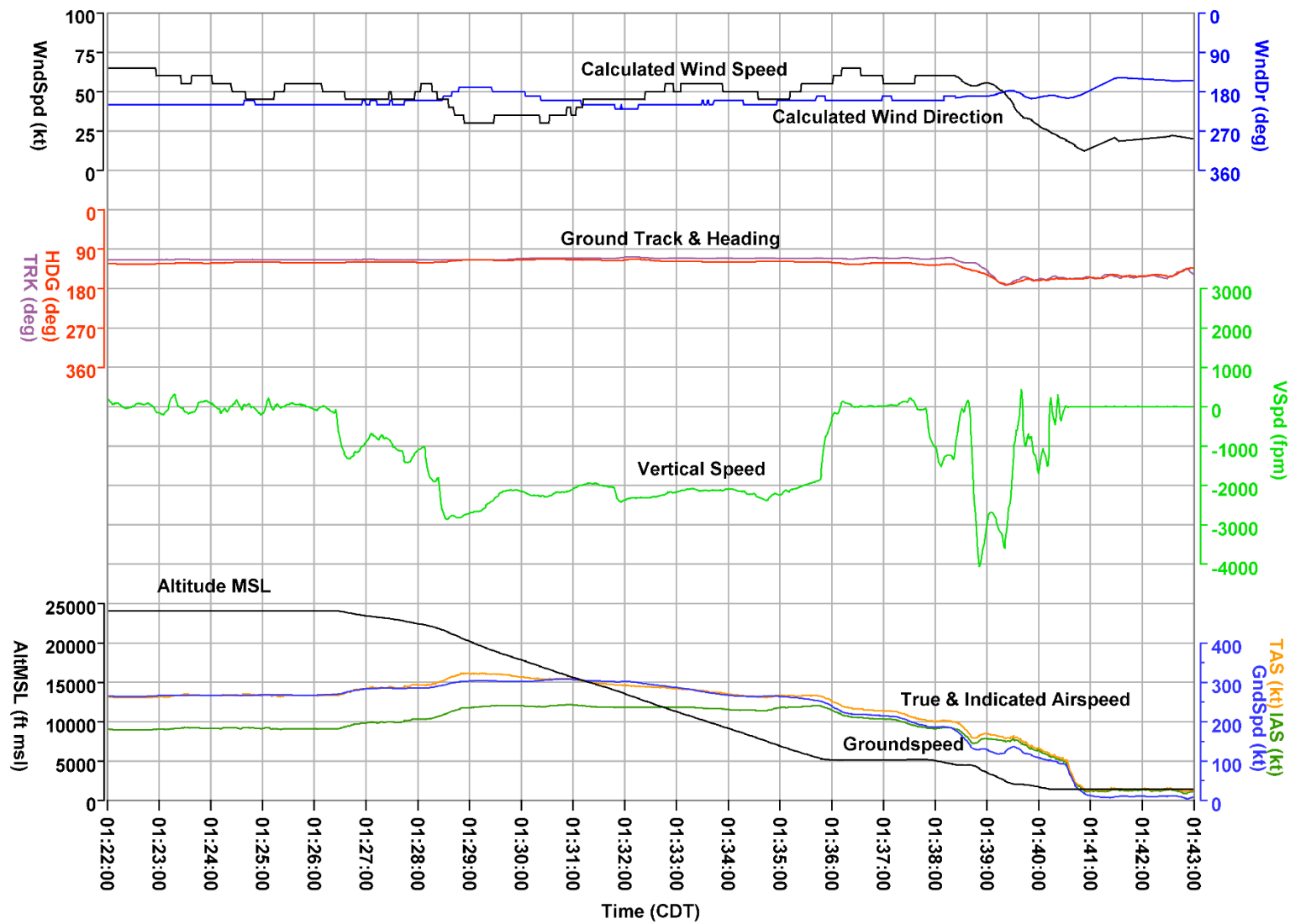


Figure 13. A plot of relevant GTN-750 parameters for the accident aircraft's arrival phase to FSD on the flight previous to the accident.

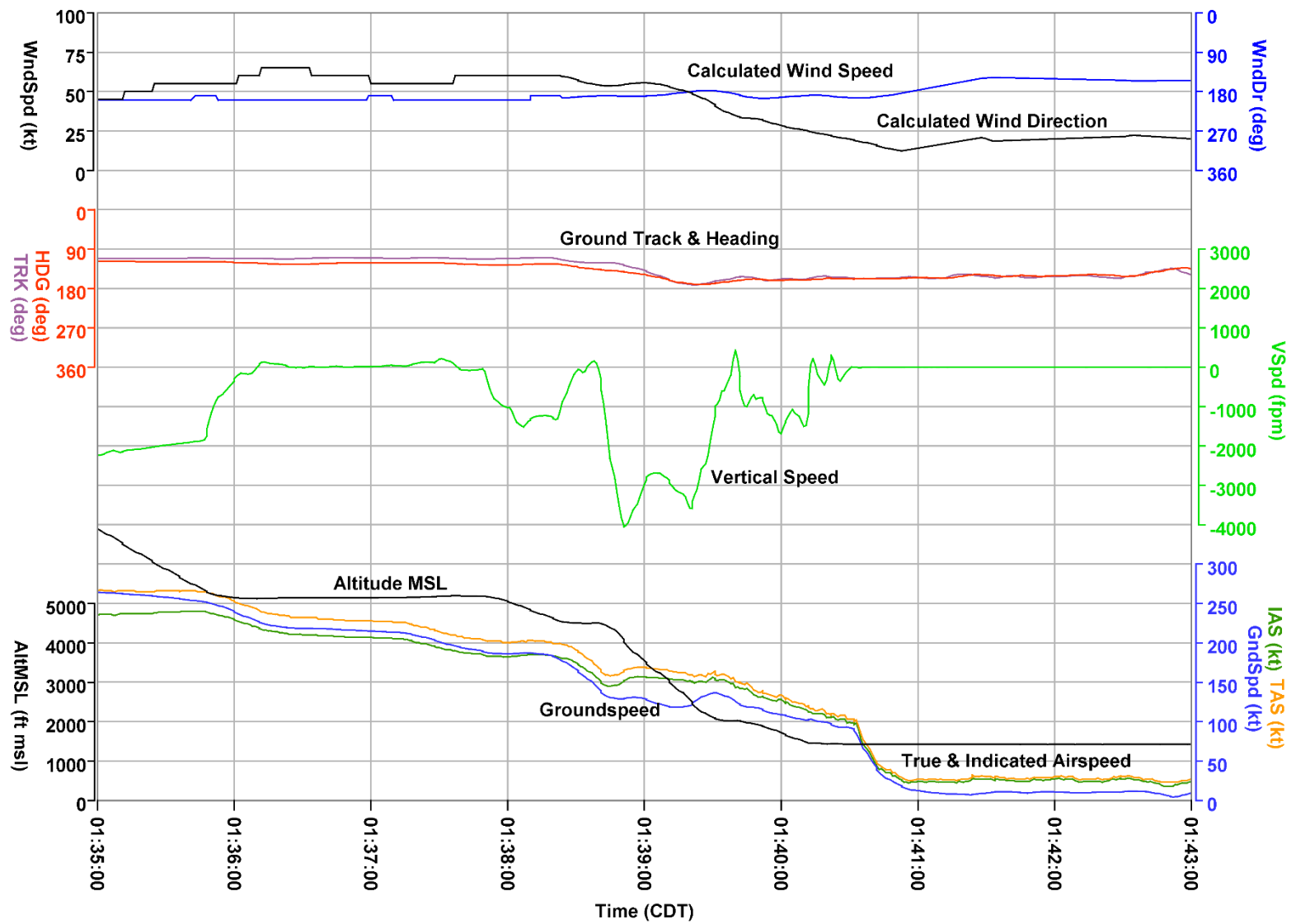


Figure 14. A plot of relevant GTN-750 parameters for the accident aircraft's approach phase to FSD on the flight previous to the accident.

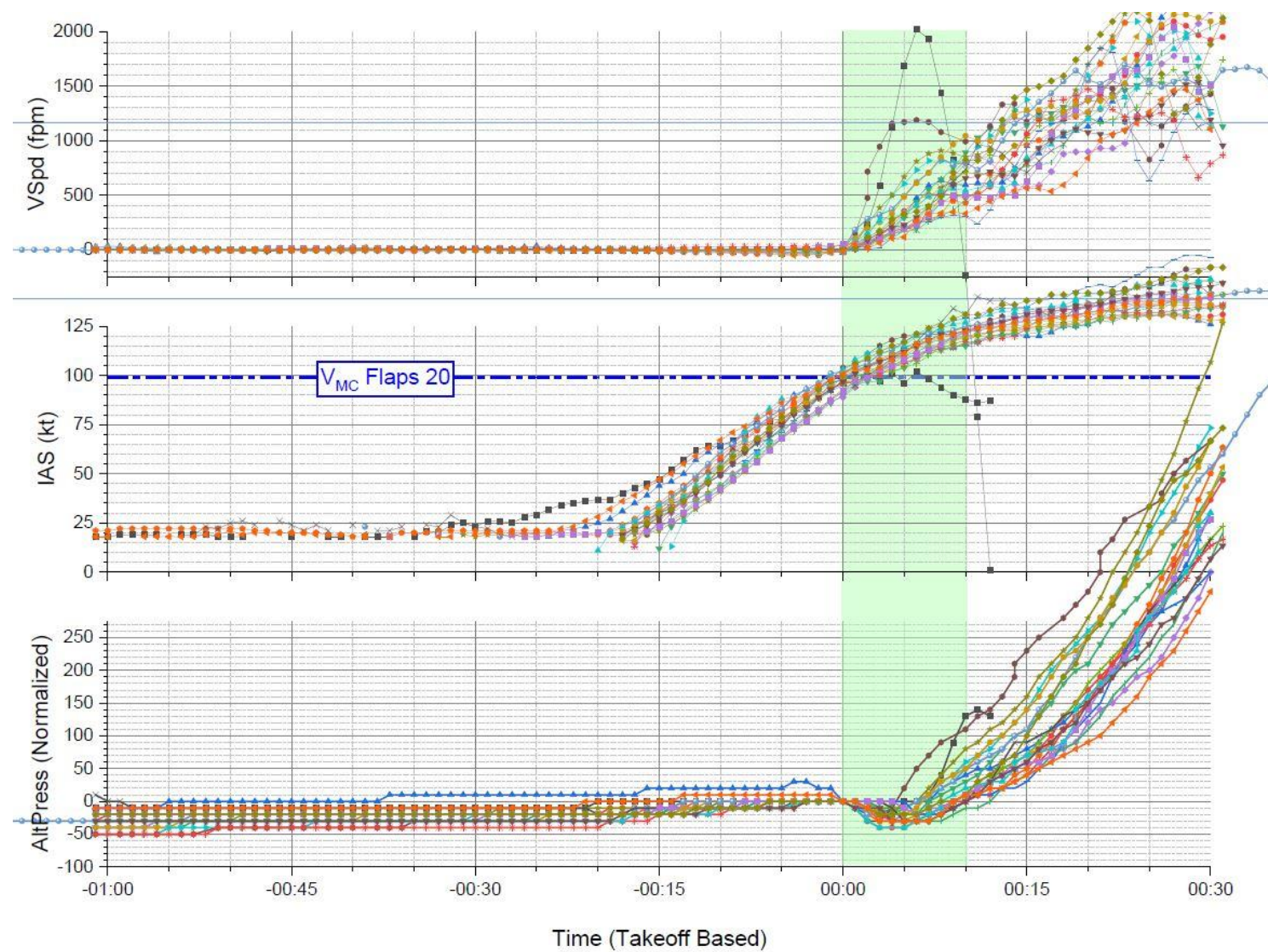


Figure 15. A plot constructed of all departure profile data of the accident aircraft recorded on the GTN-750 for the accident aircraft. The accident flight data is represented by the black square data points and black line.

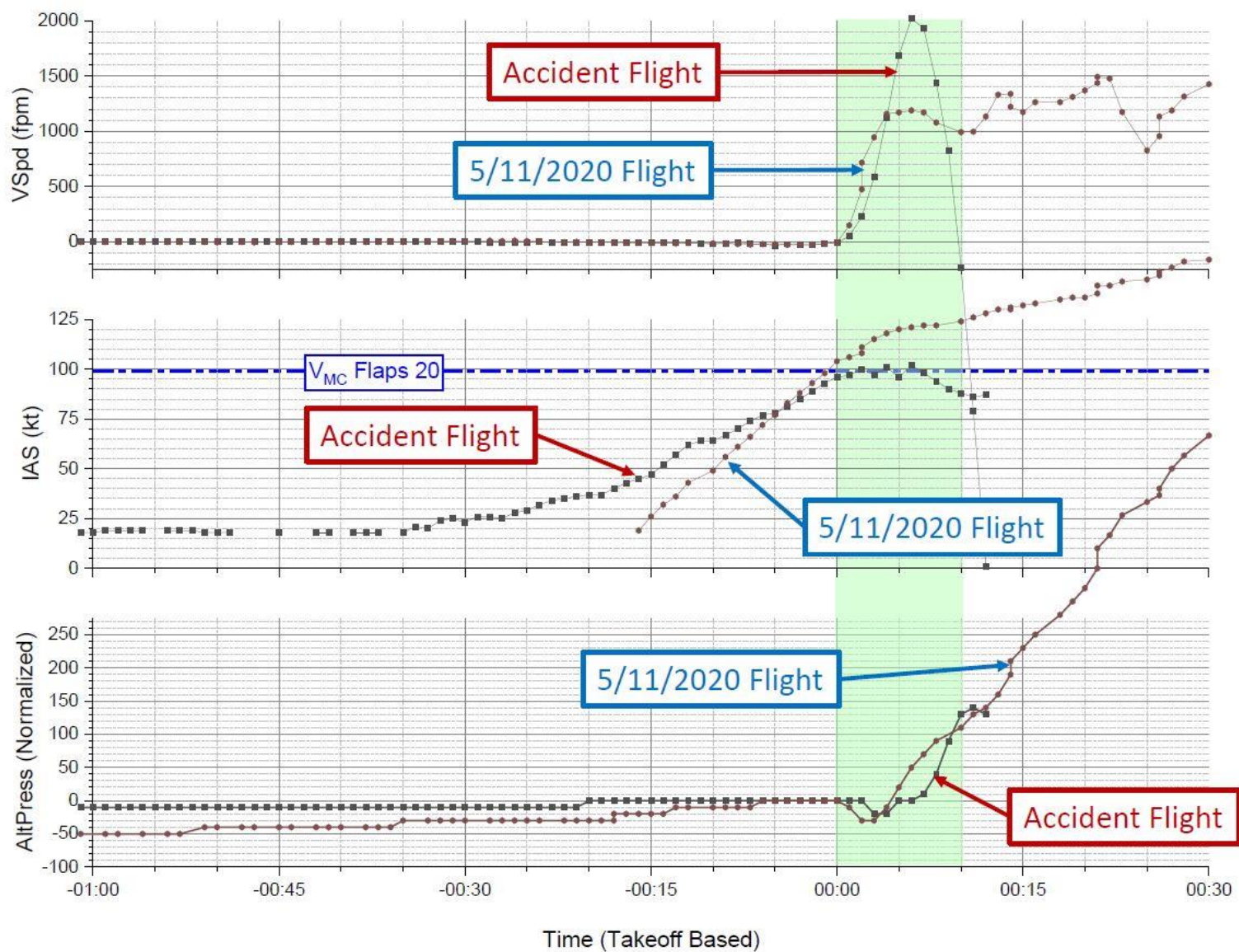


Figure 16. A plot of departure profile data for the accident flight and a flight that occurred on May 11, 2020.

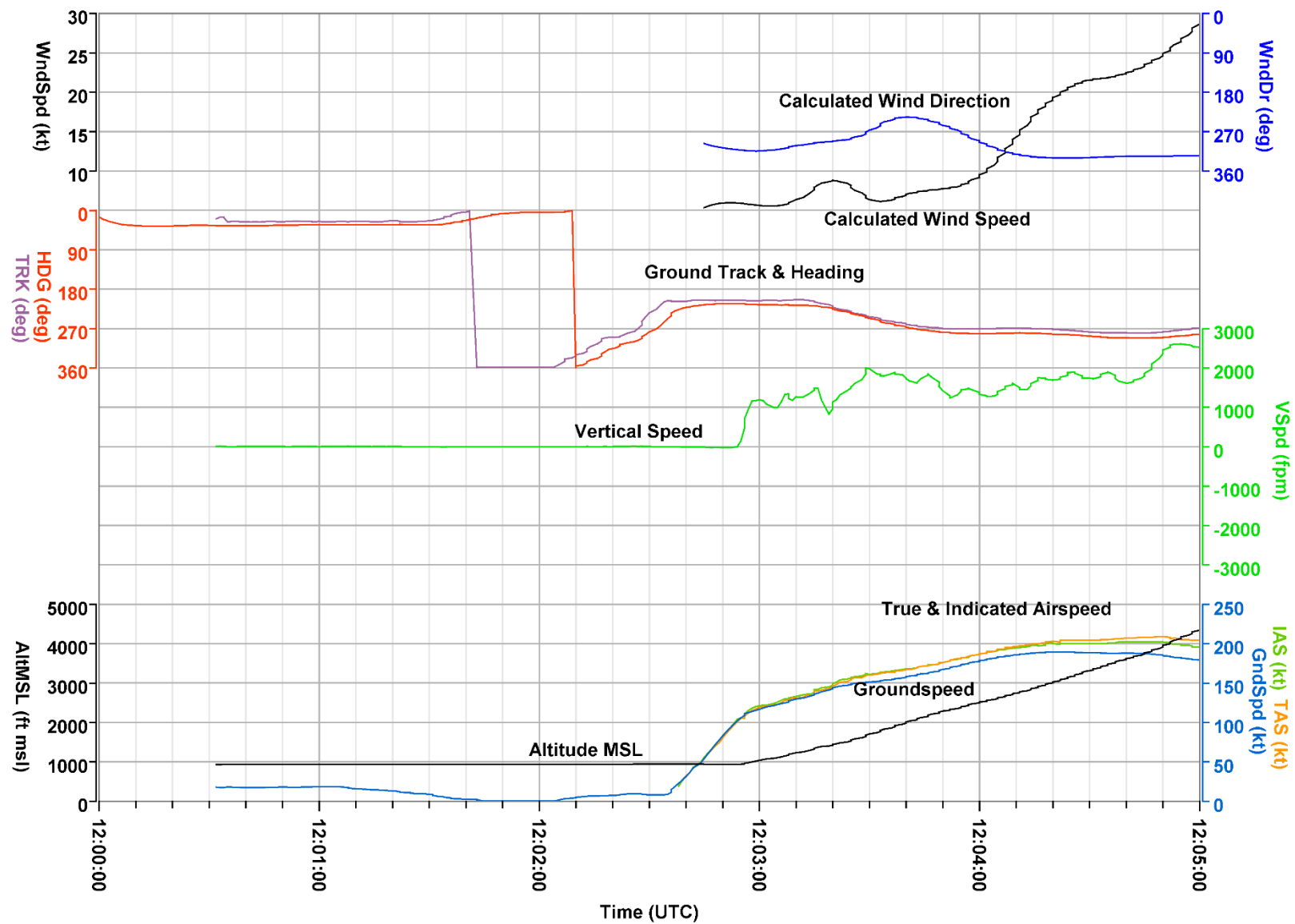


Figure 17. A plot of relevant GTN-750 parameters for the departure of the accident aircraft on a flight conducted on May 11, 2020.