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

November 8, 2011

17 - GPS Factual Report

by Bill Tuccio

A. EVENT

Location:	Cordele, Georgia
Date:	September 24, 2011
Aircraft:	Cessna 120
Registration:	N3101N
Operator:	Private
NTSB Number:	ERA11LA503

B. GROUP - No Group

C. SUMMARY

On September 24, 2011, about 1940 eastern daylight time, a Cessna 120, N3101N, was substantially damaged when it impacted trees and terrain near Crisp County-Cordele Airport (CKF), Cordele, Georgia. The student pilot was fatally injured. Visual meteorological conditions prevailed, and no flight plan was filed for the local personal flight, which was conducted under the provisions of Title 14 Code of Federal Regulations Part 91.

D. DETAILS OF INVESTIGATION

On October 26, 2011, the NTSB Vehicle Recorder Laboratory received the following device(s):

GPS Manufacturer/Model:	Lowrance AIRMAP 2000c
Serial Number:	101969147

Lowrance AIRMAP 2000c Description

The Lowrance AIRMAP 2000c is a WASS[1]-capable, battery operated hand-portable 12-channel mapping GPS unit equipped with a 320 x 240 pixel color LCD display, soft key controls, and support for custom maps. The unit has the capability of performing E-6B[2] calculations. It contains a slot for a multi-media card (MMC) or Secure Digital (SD) FLASH[3] memory card. This card may be used to transfer and store custom map, waypoint[4], route[5], and trail[6] data to and from a desktop PC to the GPS unit. A serial interface using NMEA 0183[7] communication protocols is mounted in the back of the GPS unit, but the internal operating software does not support the download of saved data via this serial port.

The Lowrance AIRMAP 2000c can store up to 100 routes composed of up to 100 waypoints each. The unit can also store trail data composed of up to 10,000 latitude-longitude points per trail. Up to 100 individual trails may be named and saved by the user. Once the limit has been reached for recording continuously updated trail data trail, older latitude/longitude points are overwritten with new data on a first-in, first-out basis. The AIRMAP 2000c may be programmed to update trail data in one of three ways: automatically, by time, or by distance traveled. The default 'automatic' mode only updates trail data when the GPS unit senses that position has changed by at least 0.1 miles, or that direction has changed by 2° or more. Updating by time may be set to record a new latitude / longitude point every 1 to 9,999 seconds. Updating by distance may be set to record a new latitude/longitude point whenever the distance traveled from the last update exceed anywhere from 0.01 miles to 9.99 miles. All recorded data is stored internally in non-volatile memory[8], and may be copied to a MMC or SD card inserted in a card slot in the battery compartment. The data is stored in a Lowrance proprietary *.usr file format. This card may be read using a standard desktop PC running the Microsoft Windows operating system.

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[1] Wide Area Augmentation System. WAAS is based on a network of approximately 25 ground reference stations that covers a very large service area. Signals from GPS satellites are received by wide area ground reference stations (WRSs). Each of these precisely surveyed reference stations receive GPS signals and determine if any errors exist. Each WRS in the network relays the data to the wide area master station (WMS) where correction information is computed. The WMS calculates correction algorithms and assesses the integrity of the system. A correction message is prepared and uplinked to a geosynchronous satellite via a ground uplink system (GUS). The message is then broadcast from the satellite on the same frequency as GPS (L1, 1575.42MHz) to receivers on board aircraft (or hand-held receivers) which are within the broadcast coverage area of the WAAS. WAAS-capable receivers are capable of basic GPS accuracy to approximately 7 meters vertically and horizontally.

[2] E-6B is refers to mechanical and electronic tools assisting common flight related computations.

[3] FLASH Memory is a form of re-writeable, non-volatile memory that can retain data without external power - provided that the chip is not heated beyond the data retention temperature limit as stated in the datasheet

[4] Geographical point specified by a set of latitude and longitude data along with descriptive information.

[5] An ordered list of waypoints.

[6] Linked list of latitude and longitude data representing the position of the aircraft as a function of time.

[7] NMEA, National Marine Electronics Association. NMEA Standard 0183 is an ASCII-based serial communication protocol.

[8] Non-volatile memory is semiconductor memory that does not require external power for data retention.

GPS Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed that the unit had sustained minor damage (figures 1 and 2). An internal inspection was performed and revealed slight corrosion around the AA batteries (figure 3). External power was applied to the accident unit and recorded waypoint, route, and tracklog data was successfully transferred to the unit's SD card as a *.usr file. Figures 4 and 5 depict screens from the power application.

Figure 1. Front of device.

Figure 2. Back of device.

Figure 3. Battery case and corrosion.

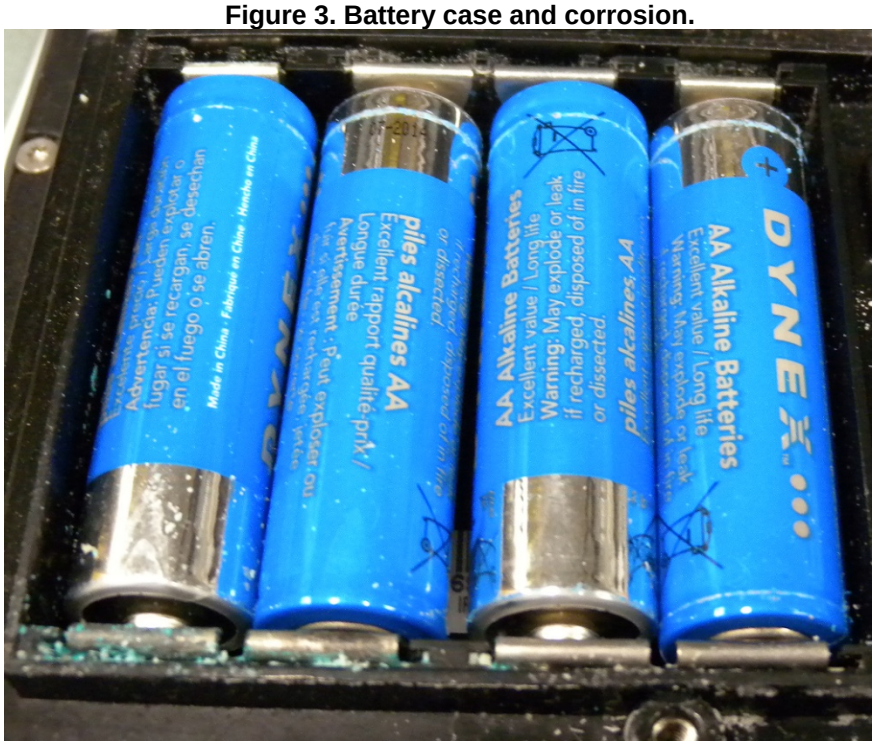


Figure 4. Startup screen during power application.

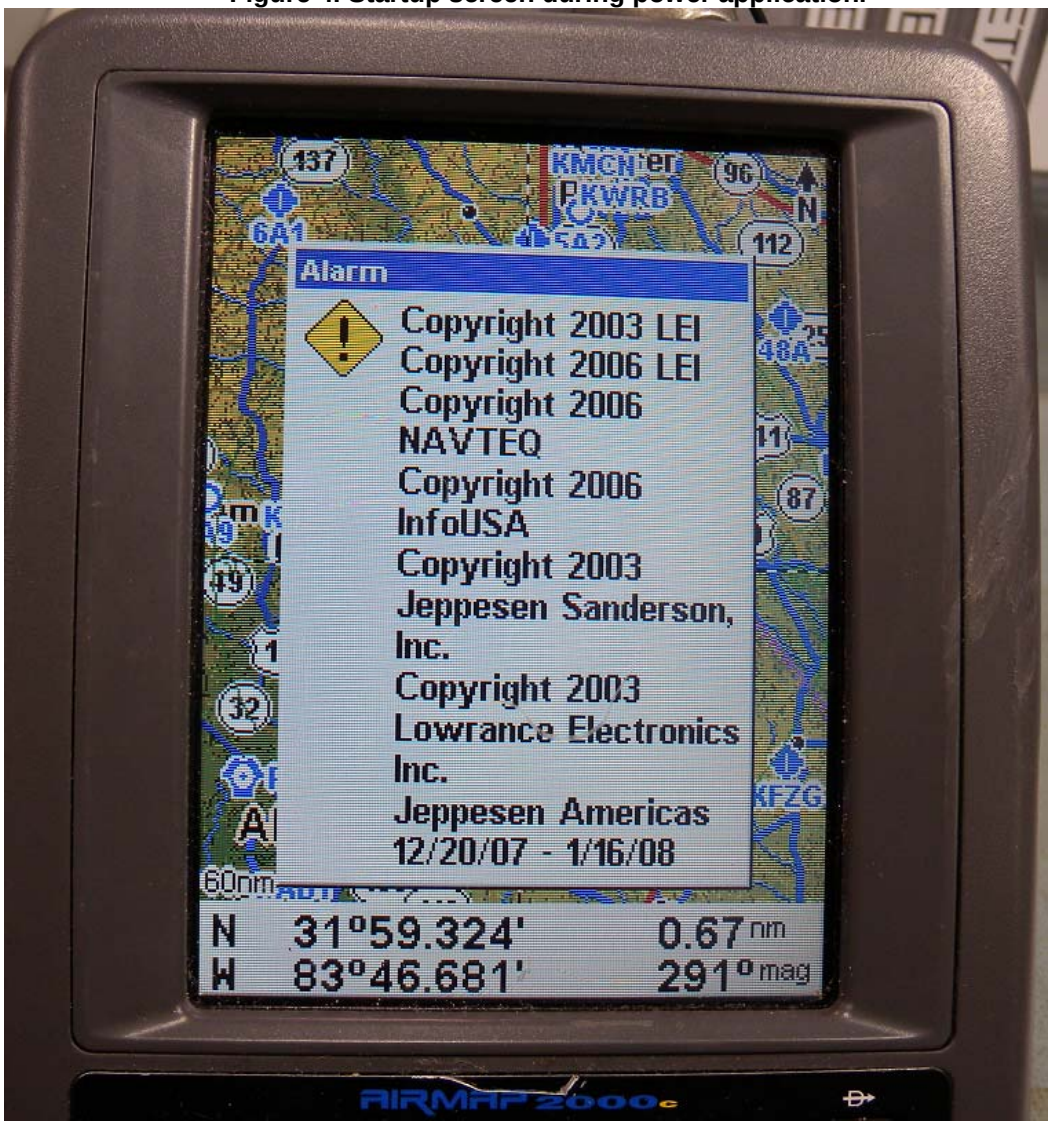
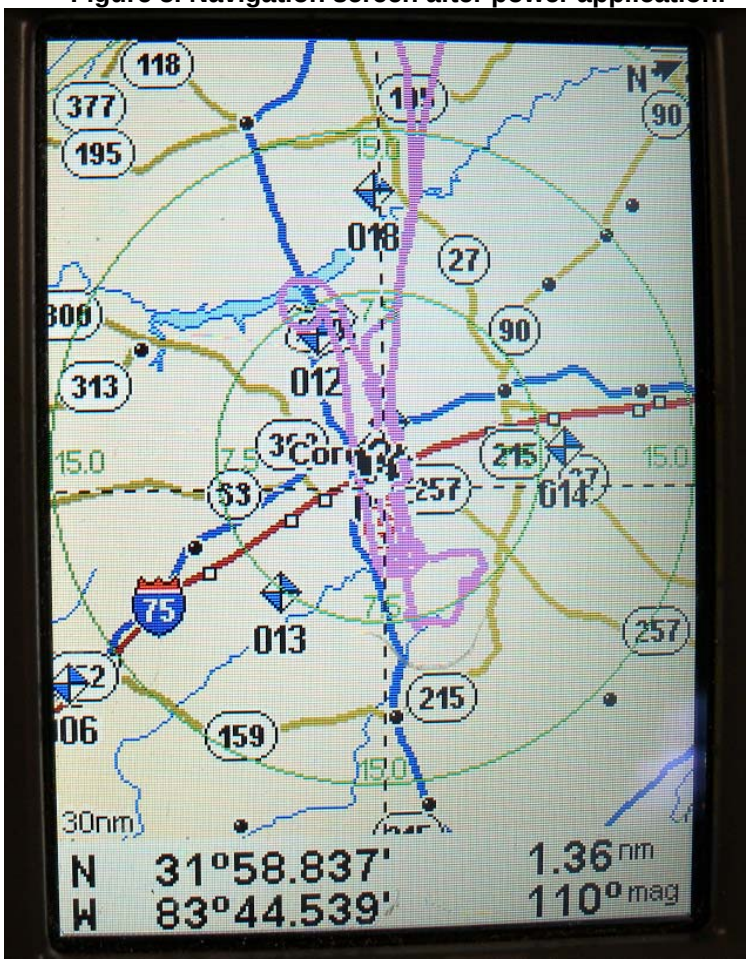


Figure 5. Navigation screen after power application.



GPS Data Description

The data extracted included 1,203 trail data points consisting only of latitude and longitude data, recorded in chronological order. The trail data contained no date/time stamp making groundspeed calculation impossible. GPS altitude was similarly not recorded. Since the trail update mode was set to 'automatic' while recording this trail data, no assumptions can be made concerning the relative timing of the recorded lat/lon points.

The manner in which the Lowrance unit writes trail data points to internal memory is such that a power interruption may cause loss of data. The last points recorded by the unit compared to the Investigator in Charge (IIC) reported accident location suggest data loss occurred.

GPS Parameters Provided

Table 1 describes data parameters provided by the GPS device. Latitude and Longitude are recorded by the device. Data point number was added during data extraction and represents the ordinal position of the recorded trail point.

Table 1: GPS Data Parameters

Parameter Name	Parameter Description
Latitude	Recorded Latitude (degrees)
Longitude	Recorded Longitude (degrees)
Point ID	Ordinal position of position in file (integer)

OVERLAYS AND TABULAR DATA

Figure 6 is a graphical overlay generated using Google Earth. The overlay includes IIC supplied locations of the first tree strike and the main wreckage. The ordinal position of the points depicted start with Point #1149 tracing a path over the CKF airport. Point #1193 is west of the airport followed by Point #1194 east of the airport leading to the final recorded point #1203.

Figure 7 is similar to Figure 6 and zooms out to show the last 100 points recorded by the device. Points #1103 through #1203 show the aircraft flying over the CFK airport and then on a path aligned with runway 10. This overlay also shows the IIC supplied points of first tree strike and main wreckage. The last point, #1203, is east of the IIC reported location of the wreckage.

Figure 8 is a graphical overlay generated using Google Earth from the accident device and shows the path traced by all 1,203 recorded points. Selected points are captioned to show the ordinal sequencing of points. The path shows a variety of circling maneuvers and a path to the Jimmy Carter Regional Airport (ACJ) runway 5, and back to the CKF airport.

Tabular data used to generate figures 6 through 8 are included as Attachment 1. This attachment is provided in electronic comma-delimited (.CSV) format.

Figure 6. Select points around IIC reported accident location.

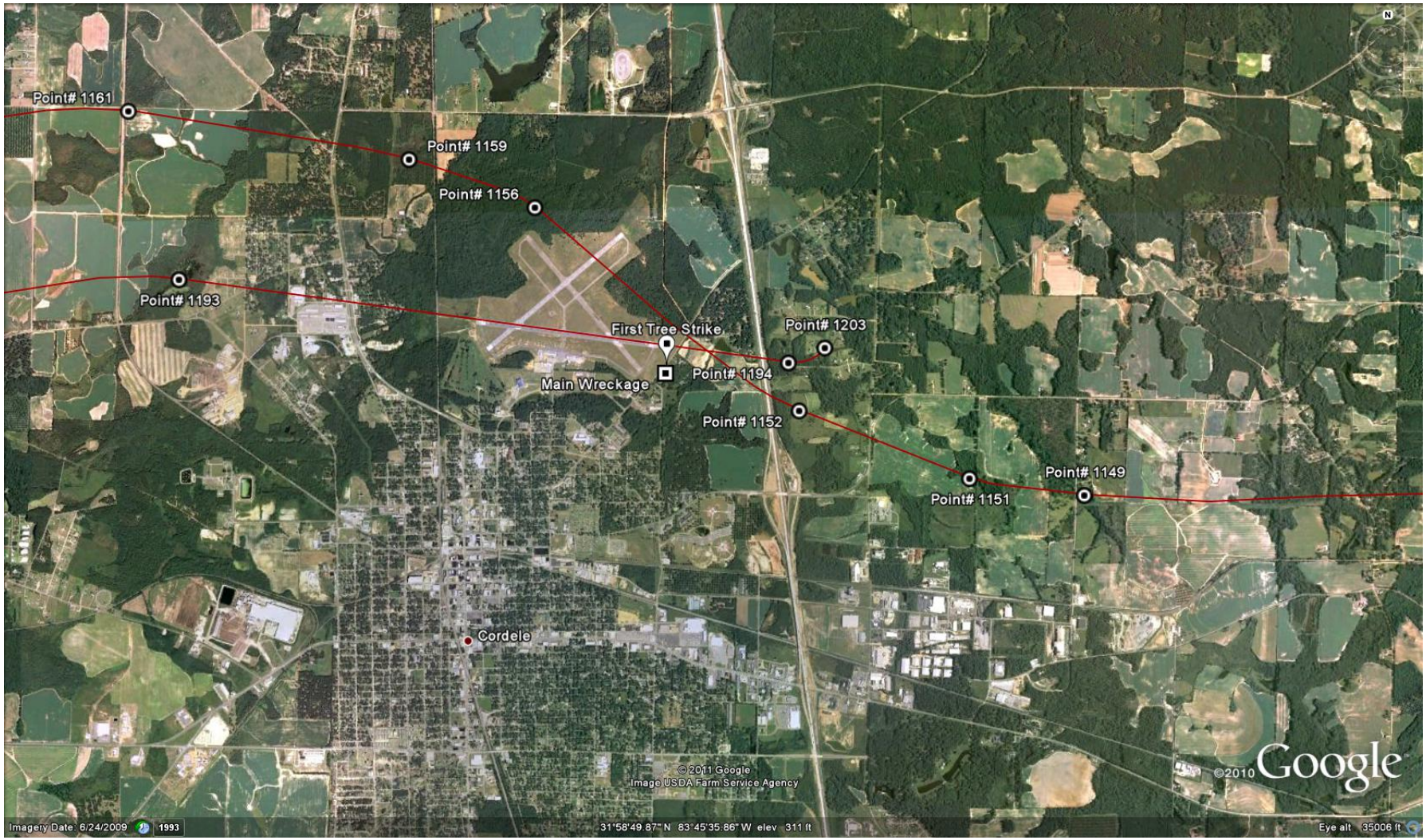


Figure 7. Last 100 recorded points.

Figure 8. All recorded points.