CHAPTER 2

DATA COLLECTION AND PROCESSING PROCEDURE USING A GPS UNIT

2.1 Introduction

The chapter deals with some basic GPS concepts and information about the GeoExplorer II receiver that was used in this study for collecting vehicle location data. The operation of GeoExplorer is explained. The steps in data collection are discussed including the phases for preparation, data collection in the field, and post processing to obtain the route map.

2.1.1 GPS concepts

NAVSTAR is a satellite-based positioning system operated by the U.S. Department of Defense (DoD), consisting of three segments: the space segment, the control segment and the receiver. The space segment consists of 24 satellites that broadcast a signal providing information on their location. They orbit the earth every twelve hours at an altitude of about 12,600 miles (20,200 km). Each satellite contains several high-precision atomic clocks and constantly transmits radio signals using its own unique code.

The control segment consists of ground locations, which monitor the movement of the satellites and transmits data to each satellite to ensure that they are broadcasting accurate information on their orbital path to earth. The user segment is a signal receiver, which receives the signal and uses information contained in the signal to calculate latitude, longitude, and altitude.

The data collection method makes validity checking of travel runs possible by overlaying GPS runs on the GIS base map. The GPS system used for this study was a Trimble GeoExplorer II mapping system consisting of a GeoExplorer II GPS receiver, antenna, Pathfinder Office software and accessories.

2.2 System components

The standard Trimble GeoExplorer II mapping system that was used for data collection included the following components:

- A GeoExplorer II receiver
- Receiver case
- AA battery pack
- Pathfinder software with key
- Set of cables and power cords

2.2.1 GeoExplorer receiver

The GeoExplorer II receiver (Figure 2.1) is a high performance six-channel hand-held receiver. It can be used as a battery- powered unit or can be connected to any other source of power using the cable provided. This makes it ideal for portable field use. The receiver can be used for navigation and to store position and attribute information for point, line or area features.

Figure 2.1: Trimble GeoExplorer II Receiver

2.2.1.1 Power to receiver

Power is supplied to the receiver from either 4 AA batteries or an external power kit. The external power kit allows the user to power the receiver from a rechargeable 12V camcorder battery or from a vehicle. It includes the following:

- Battery eliminator
- Vehicle power adapter with fuses
- Power splitter cable
- Rechargeable 12V camcorder
- Battery charger

2.2.1.2 GeoExplorer II menu structure

The functions in the GeoExplorer receiver are structured as a hierarchical menu. The menu has seven submenus as shown in Table 2.1.

2.2.1.3 Memory Specifications

The GeoExplorer II receiver has only a limited amount of memory available. The number of hours the receiver can collect data, however, depends on the type of data collected. To ensure that the receiver does not stop collecting data, data collected should be downloaded to a PC and the files from the receiver should be cleared constantly. This also ensures that a backup of the data is available even if the data is not processed immediately.

Whenever a file is open, the amount of free memory available can be checked on the File Status screen. The free memory available for any data recording is equal to the total memory minus 64 KB and the memory for any existing files. The total amount of time the receiver can work continuously varies with the file type.

Table 2.1: Descriptions of Menu in GPS receiver

Option	Description
Data Capture	The items under Data Capture allow the user to open a rover or base file and record data. It allows the user to review files, delete files, review and delete data dictionary
Position	Position displays the current position: latitude, longitude and altitude. The user can check whether positions are currently being computed or if the position displayed is old.
GPS Status	The items under GPS status allow the user to check which satellites are being tracked, where the satellites are and what their signal strengths are. The user also can see the accuracy of the positions being calculated
Navigation	The items under Navigation allow the user to store waypoints, select which points the user wants to navigate to and from, choose which format of the navigation screen required and view the screen during navigation.
Date and Time	The Date and Time option displays the current date and time.
Configuration	The items under Configuration allow the user to set the parameters that control data collection, display and data transfer.
Data Transfer	The Data Transfer option lets the user transfer files between the GeoExplorer II receiver and the PC

2.3 Preparation for data collection

Before taking the GeoExplorer to the field to start data collection, there are some steps to be followed in the office. These are explained in the following sections.

2.3.1 Planning

The best time to collect GPS data, based on where the satellites will be, needs to be determined. Now that there is 24-hour/day satellite coverage, the chance that there are too few satellites to collect data is very slim. Still such planning will avoid frustration in the field and assist in achieving good accuracy.

2.3.2 Creating and transferring a Data Dictionary

The feature and attribute information are obtained using a Data Dictionary. The Data Dictionary editor can be found in the Pathfinder Office software. After the Data Dictionary is created it has to be transferred to the receiver. The Data Dictionary need not be created if only position data is collected. The advantage of using a Data Dictionary is explained using an example.

When bus trajectory data is collected, it may also be necessary to obtain information on the dwell time, number of people boarding or alighting the bus at each stop. In such cases, a predefined Data Dictionary can be stored in the receiver, which can be activated when the bus reaches a stop. After entering the data, the user can go back to collecting position data by pressing the resume button. Only one Data Dictionary can be stored on the GeoExplorer at a time.

2.3.3 Checking the critical parameters

The important step to follow before using the receiver is to check the critical parameters. The configuration parameters on the GeoExplorer receiver must be set correctly before the data is recorded. If the parameters are not set correctly, the receiver may not compute positions or it might record data that cannot be differentially corrected. It is good practice to check these parameters before each use.

A description of the parameters which are critical for recording accurate GPS data, is given below:

- Feature Logging Rate, Points

This parameter allows the user to determine how often positions are stored when recording point features. The default setting is to record the GPS position at one-second intervals.

- Feature Logging Rate, Line/Area

This allows the user to determine how often positions are stored when recording line or area features. The default setting is to record the GPS position at five-second interval.

- Feature Logging Rate, Min Position

This feature allows the user to set the minimum number of positions required for a point feature. This rate is to be set in conjunction with point logging rate. When the data is collected the feature can be saved before the number of position have been collected. A warning message appears in this case indicating that the data recording is not complete.

- Not in Feature Rate

This lets the user determine how often the positions are stored when not recording features. The default setting is to record all the GPS positions that GeoExplorer calculates.

- Position Mode

This is very important to determine the type of data required. Pos Mode let the user choose a position fix mode. Or in other words the user can choose to collect two-dimensional positions (latitude, longitude), or three-dimensional positions (latitude, longitude and altitude). The option chosen affects the number of satellites needed to calculate a position. Two-dimensional require a minimum of three satellites and three-dimensional positions require at least four satellites to calculate a position.

- 2D Altitude

2D Alt allows the user set an altitude value to be used when the GeoExplorer receiver is collecting two-dimensional positions only.

• Elevation Mask

This feature allows the user to specify the minimum elevation above the horizon that a satellite must reach before the GeoExplorer receiver uses it for position calculation. The default and recommended value is 15 degrees for a rover file.

• SNR Mask

This allows the user to specify a minimum strength that a satellite must have before the GeoExplorer receiver uses it to calculate positions.

• PDOP Mask

PDOP Mask allows you to set a maximum PDOP (Position Dilution of Precision) value. PDOP is an indication of the accuracy of the GPS positions calculated by the GeoExplorer receiver on the field. If the value is less than or equal to 4 the position are considered highly accurate. When the value is in the range 5 to 8 the accuracy is acceptable. The default value is six, which means when the PDOP goes above this value the receiver stops recording the positions.

• PDOP Switch

This allows the user to set a PDOP value that the causes the GeoExplorer to switch between 2D and 3D mode when the position mode id set to Auto 2D/3D. The default value is again 6.

2.3.4 Checking the non critical parameters

The following section describes the noncritical parameters that affect display and data collection. The configuration parameters must be set accurately in the receiver before recording accurate data. These parameters are called noncritical because they are important but not critical for collecting accurate GPS data. The non-critical parameters are listed below with a brief description.

• Antenna Height

This is the height of the antenna above the features being surveyed.

• Log DOPS

Log DOPs lets the user choose whether or not DOP measurements are to be measured in the rover file. The DOP measurements can be useful for troubleshooting data sets if any problems are encountered.

• Velocity

This lets the user choose whether or not he wants velocity measurements recorded in the file.

• File Prefix

File Prefix allows the user to specify a single letter to identify the rover file. When the prefix is changed all the subsequent rover files will start with that character.

• Reference Position

Reference Pos allows the user to enter the known position of the base station. The reference position can be obtained from map or a previously conducted survey. The coordinates of the Reference position should be the same as the coordinate system selected in the GeoExplorer.

• Sat Health

Sat Health gives permission to the user to enable and disable satellites and override health messages. The default is to enable all satellites and to follow the intent of all health messages.

2.3.5 Assembling the equipment in the office

The following equipments are to be taken to the field to start the data recording:

- GeoExplorer receiver
- Antenna
- Cable to connect the receiver to the power line in the car or 4 AA batteries

2.4 Field operations – Data collection

All the critical and non-critical parameters are set as required. The antenna needs a clear view of the sky to receive satellite signals. People, buildings, heavy tree cover, large vehicles, or powerful transmitters block signals. The signals could go through leaves, plastic, glass, rain although this may weaken the signal.

2.4.1 Connections

The external antennas are connected to the GeoExplorer through an antenna jack provided in the upper corner on the back of the receiver. The internal antenna is not preferred as the readings were taken from inside a vehicle. Also with the external antenna the amount of multipath encountered is reduced. The power cod connects the GeoExplorer to the power line in the vehicle. A battery could be used as an alternative but this has time limitations.

2.4.2 Getting a clear view of the sky

The antenna needs a clear view of the sky to receive satellite signals. Signals can be received from any directions, but if the antenna is covered the GeoExplorer can lose the satellites and stop computing positions. Another problem can occur when using the receiver around obstructions. The antenna not only receives the direct signals but also reflected signals. This resulted in less accurate positions.

2.4.3 Recording files

The GPS data that is collected are stored continuously in the files. If a data dictionary is not loaded, then data can be collected as positions in a file but attributes and features cannot be collected. The data collected for creating route maps was done without using data dictionaries. The stops were recorded as point features. Each stop was collected as single feature stored in a separate file. The Not In Feature Rate is set to All in this case.

2.5 Data post processing

Once the data file has been collected in the field, the positions need to be differentially corrected before the points can be plotted to obtain the map. The Pathfinder Office software used to perform this operation.

2.5.1 Transferring the data files to PC

The data files have to be transferred from the GeoExplorer II receiver to the PC using the Pathfinder Office software. The transfer feature in the receiver and the software are used for this purpose. The file is transferred to the Pathfinder Software with a suffix of .ssf, for e.g., r032305.ssf. Figure 2.2 shows the Transfer window from the Pathfinder software.

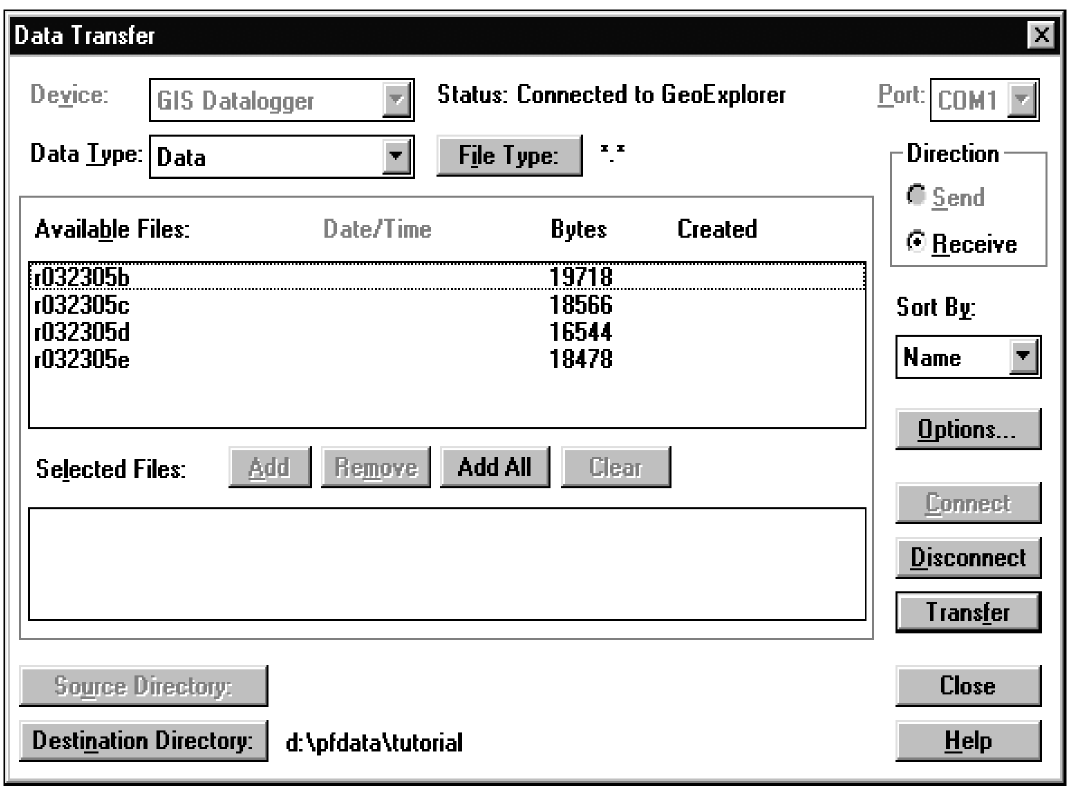


Figure 2.2: Data Transfer Window from Pathfinder Office Software.

The files need to be differentially corrected before they can be used. The differential corrections need to be applied to all the data files collected. For this purpose a base file is required. The Pathfinder Office software allows the user to obtain the base file using an internet search and then use the same for differential correction. The differential correction window from the Pathfinder Office software is shown in Figure 2.3.

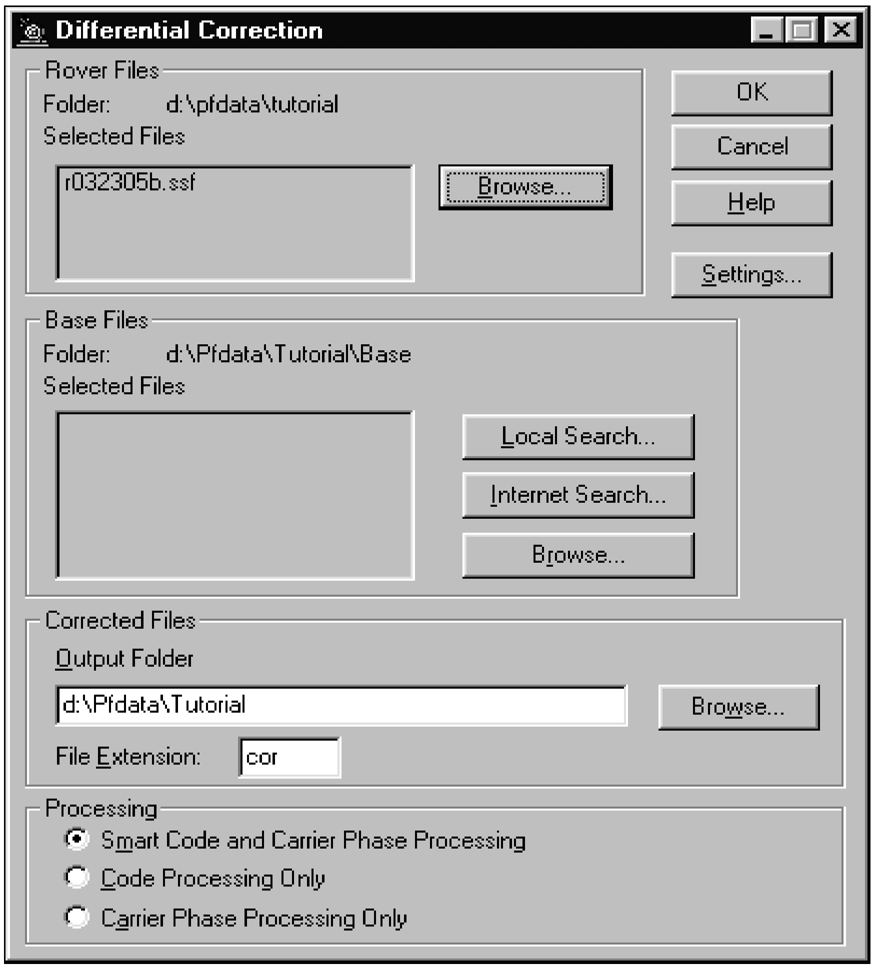


Figure 2.3: Differential Correction Menu from Pathfinder Office Software.

After differential correction, a plot of the points can be seen using the software. The file can be exported into many formats. The differentially corrected file can be viewed as a text file using the Export function of the Pathfinder Office software. The text file so obtained can be used to plot the bus route trajectories. The file Export menu from the Pathfinder software is shown in Figure 2.4.

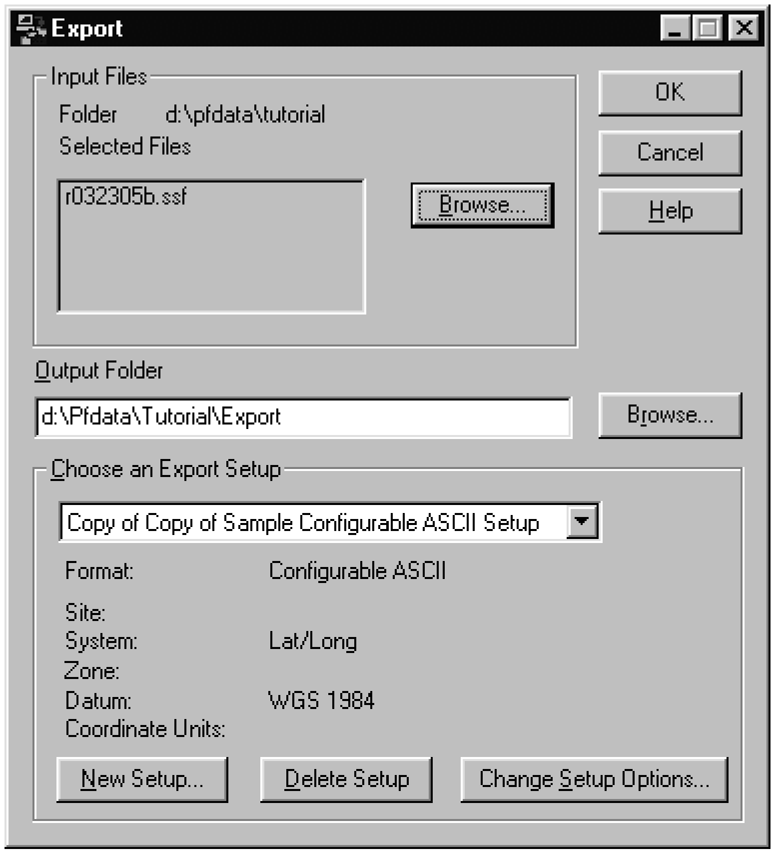
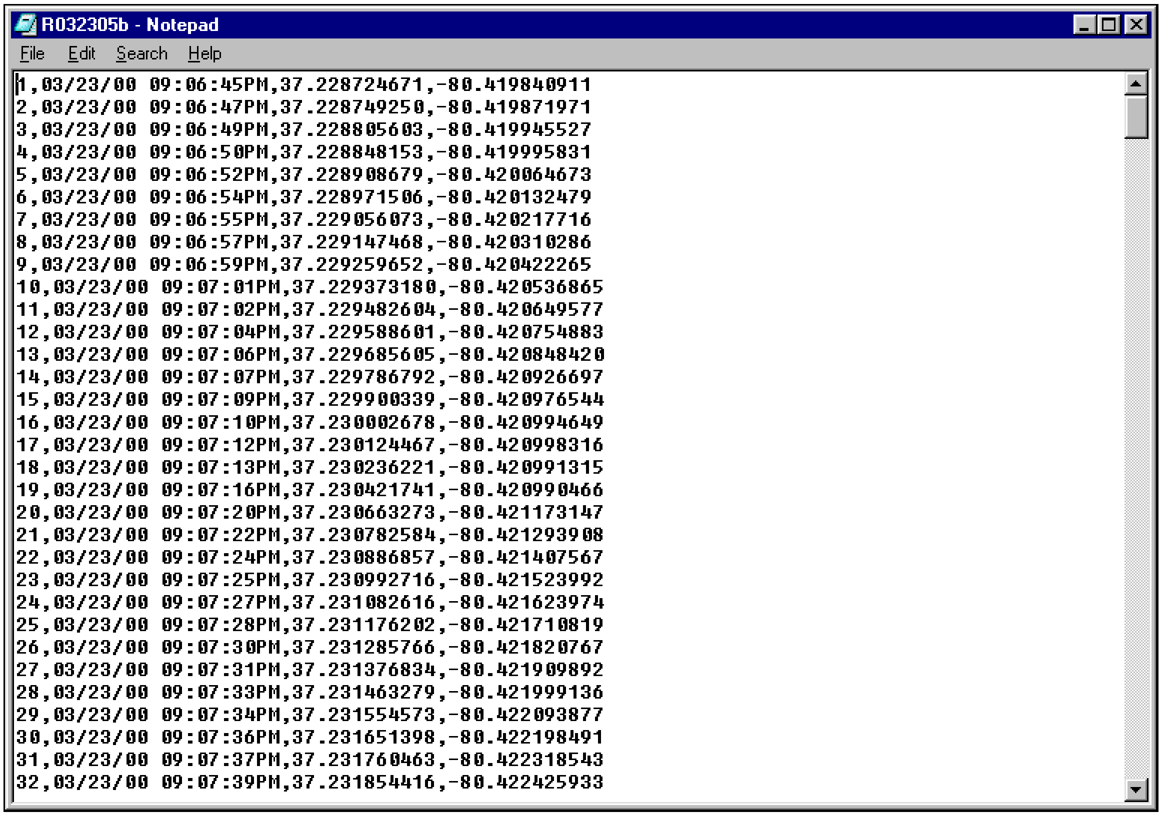


Figure 2.4: Export Menu from Pathfinder Office Software

Once the file is exported, the format that is requested is written to export directory of the folder and can be viewed. The fields that are required can be chosen from the export menu. The Feature ID, Time, Latitude, Longitude were the fields that were necessary to plot the map. In the text file, these fields are separated by a comma. A sample text file obtained after the operation is shown in Figure 2.5.



R032305b - Notepad

File Edit Search Help

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1,03/23/00 09:06:45PM,37.228724671,-80.419840911
2,03/23/00 09:06:47PM,37.228749250,-80.419871971
3,03/23/00 09:06:49PM,37.228805603,-80.419945527
4,03/23/00 09:06:50PM,37.228848153,-80.419995831
5,03/23/00 09:06:52PM,37.228908679,-80.420064673
6,03/23/00 09:06:54PM,37.228971506,-80.420132479
7,03/23/00 09:06:55PM,37.229056073,-80.420217716
8,03/23/00 09:06:57PM,37.229147468,-80.420310286
9,03/23/00 09:06:59PM,37.229259652,-80.420422265
10,03/23/00 09:07:01PM,37.229373180,-80.420536865
11,03/23/00 09:07:02PM,37.229482604,-80.420649577
12,03/23/00 09:07:04PM,37.229588601,-80.420754883
13,03/23/00 09:07:06PM,37.229685605,-80.420848420
14,03/23/00 09:07:07PM,37.229786792,-80.420926697
15,03/23/00 09:07:09PM,37.229900339,-80.420976544
16,03/23/00 09:07:10PM,37.230002678,-80.420994649
17,03/23/00 09:07:12PM,37.230124467,-80.420998316
18,03/23/00 09:07:13PM,37.230236221,-80.420991315
19,03/23/00 09:07:16PM,37.230421741,-80.420990466
20,03/23/00 09:07:20PM,37.230663273,-80.421173147
21,03/23/00 09:07:22PM,37.230782584,-80.421293908
22,03/23/00 09:07:24PM,37.230886857,-80.421407567
23,03/23/00 09:07:25PM,37.230992716,-80.421523992
24,03/23/00 09:07:27PM,37.231082616,-80.421623974
25,03/23/00 09:07:28PM,37.231176202,-80.421710819
26,03/23/00 09:07:30PM,37.231285766,-80.421820767
27,03/23/00 09:07:31PM,37.231376834,-80.421909892
28,03/23/00 09:07:33PM,37.231463279,-80.421999136
29,03/23/00 09:07:34PM,37.231554573,-80.422093877
30,03/23/00 09:07:36PM,37.231651398,-80.422198491
31,03/23/00 09:07:37PM,37.231760463,-80.422318543
32,03/23/00 09:07:39PM,37.231854416,-80.422425933
```

Figure 2.5: Sample output text file.

2.6 Conversion to coordinate system

The latitude and longitude values have to be converted to a coordinate system to measure distances in any desired units. Corpscon software was used to do this conversion. The Corpscon software can convert from latitude, longitude to any coordinate system. The data were converted into State Plane Coordinate system. Each state in the United States has a plane coordinate system, which is based on one or more of either the Lambert conic conformal projection or traverse Mercator projection. The Lambert projection is used in states having a large east-west dimension; the traverse Mercator projection is employed for states having longer north-south dimension. The Corpscon software uses the Lambert projection for Virginia and converts the latitude and longitude of every data point in a file to the State plane coordinate system in meters.

The input file to be converted by the software can be a text file. The GPS data points in the files obtained after exporting were then converted using the software. The Corpscon software window is shown in Figure 2.6.

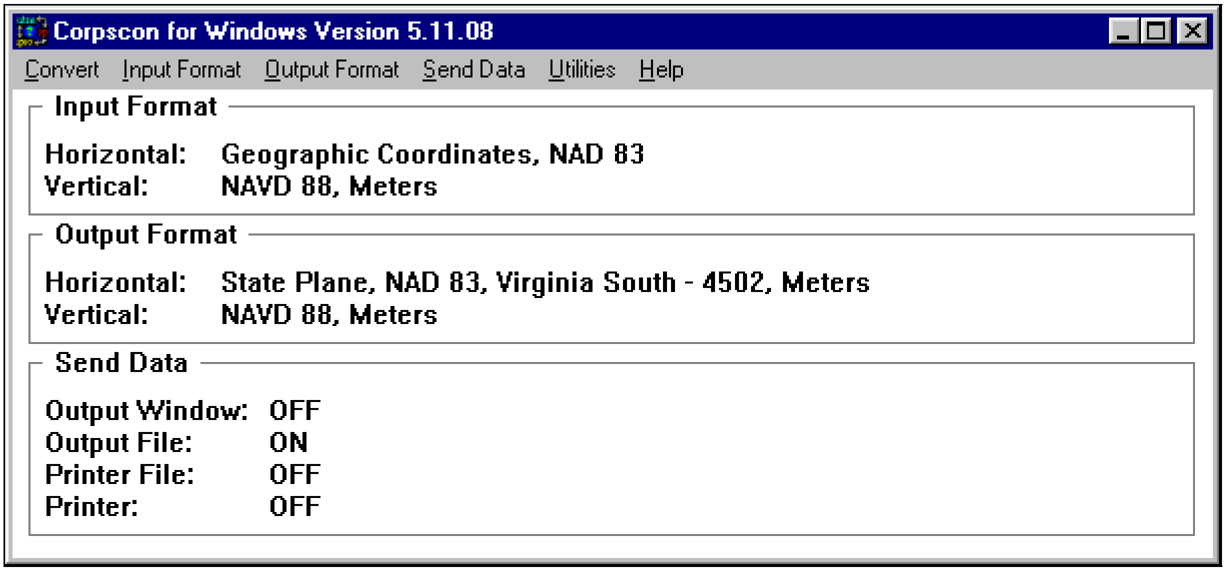
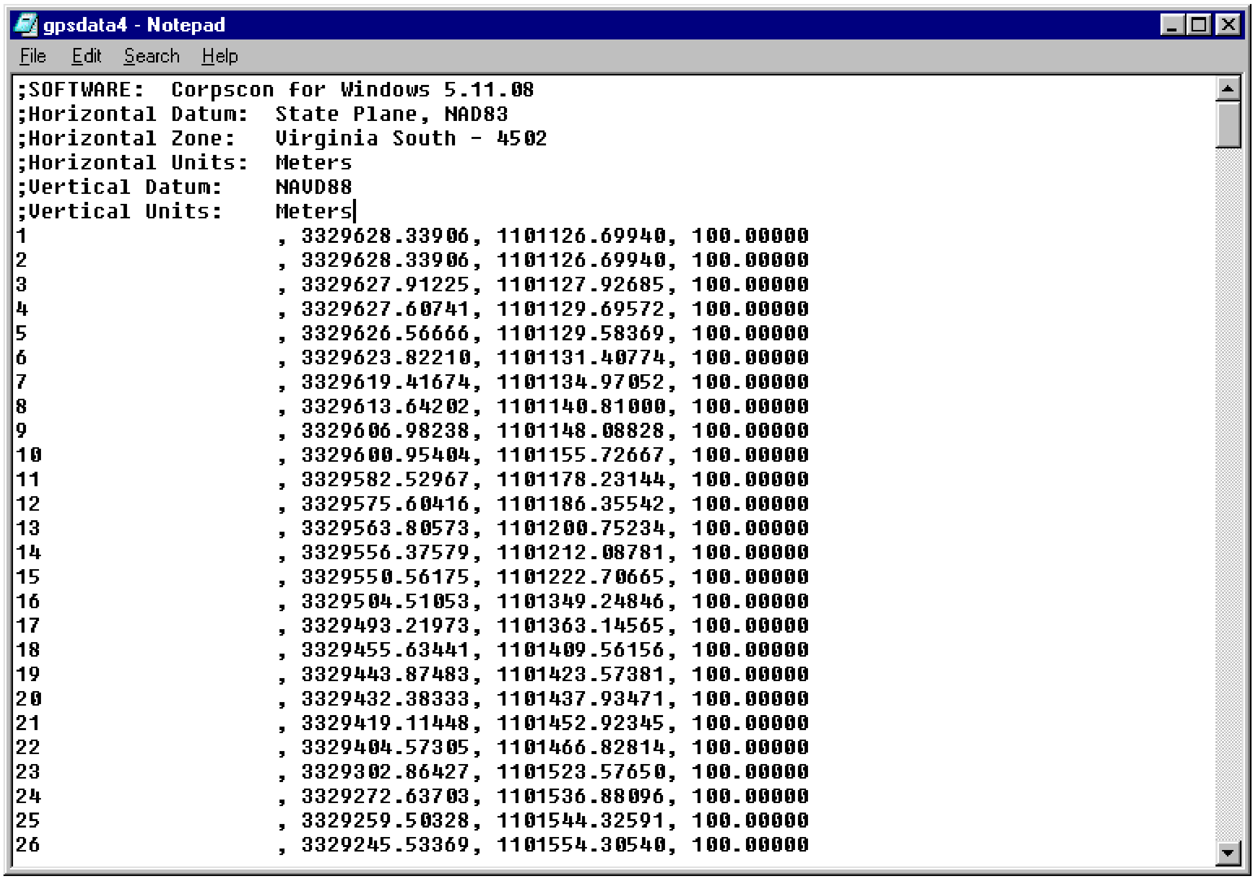


Figure 2.6: Corpscon Software window

The output file, which is also in text format, is shown in Figure 2.7. The file contains the point ID, X coordinate, Y coordinate and altitude fields separated by a comma. A default altitude value is required to do the calculation.


gpsdata4 - Notepad

File Edit Search Help

```
;SOFTWARE:  Corpscon for Windows 5.11.08
;Horizontal Datum:  State Plane, NAD83
;Horizontal Zone:   Virginia South - 4502
;Horizontal Units:  Meters
;Vertical Datum:    NAVD88
;Vertical Units:    Meters
1                   , 3329628.33906, 1101126.69940, 100.00000
2                   , 3329628.33906, 1101126.69940, 100.00000
3                   , 3329627.91225, 1101127.92685, 100.00000
4                   , 3329627.60741, 1101129.69572, 100.00000
5                   , 3329626.56666, 1101129.58369, 100.00000
6                   , 3329623.82210, 1101131.40774, 100.00000
7                   , 3329619.41674, 1101134.97052, 100.00000
8                   , 3329613.64202, 1101140.81000, 100.00000
9                   , 3329606.98238, 1101148.08828, 100.00000
10                  , 3329600.95404, 1101155.72667, 100.00000
11                  , 3329582.52967, 1101178.23144, 100.00000
12                  , 3329575.60416, 1101186.35542, 100.00000
13                  , 3329563.80573, 1101200.75234, 100.00000
14                  , 3329556.37579, 1101212.08781, 100.00000
15                  , 3329550.56175, 1101222.70665, 100.00000
16                  , 3329504.51053, 1101349.24846, 100.00000
17                  , 3329493.21973, 1101363.14565, 100.00000
18                  , 3329455.63441, 1101409.56156, 100.00000
19                  , 3329443.87483, 1101423.57381, 100.00000
20                  , 3329432.38333, 1101437.93471, 100.00000
21                  , 3329419.11448, 1101452.92345, 100.00000
22                  , 3329404.57305, 1101466.82814, 100.00000
23                  , 3329302.86427, 1101523.57650, 100.00000
24                  , 3329272.63703, 1101536.88096, 100.00000
25                  , 3329259.50328, 1101544.32591, 100.00000
26                  , 3329245.53369, 1101554.30540, 100.00000
```

Figure 2.7: Text file with coordinates for GPS data points

The coordinates of points can be used to calculate the distance between the two points. The coordinates of GPS data points, shown in Figure 2.7 are plotted in Figure 2.8. The plot represents the data collected along Tom's Creek A bus route. The route map is then digitized into desired intervals of distance using the procedure described in the next chapter.

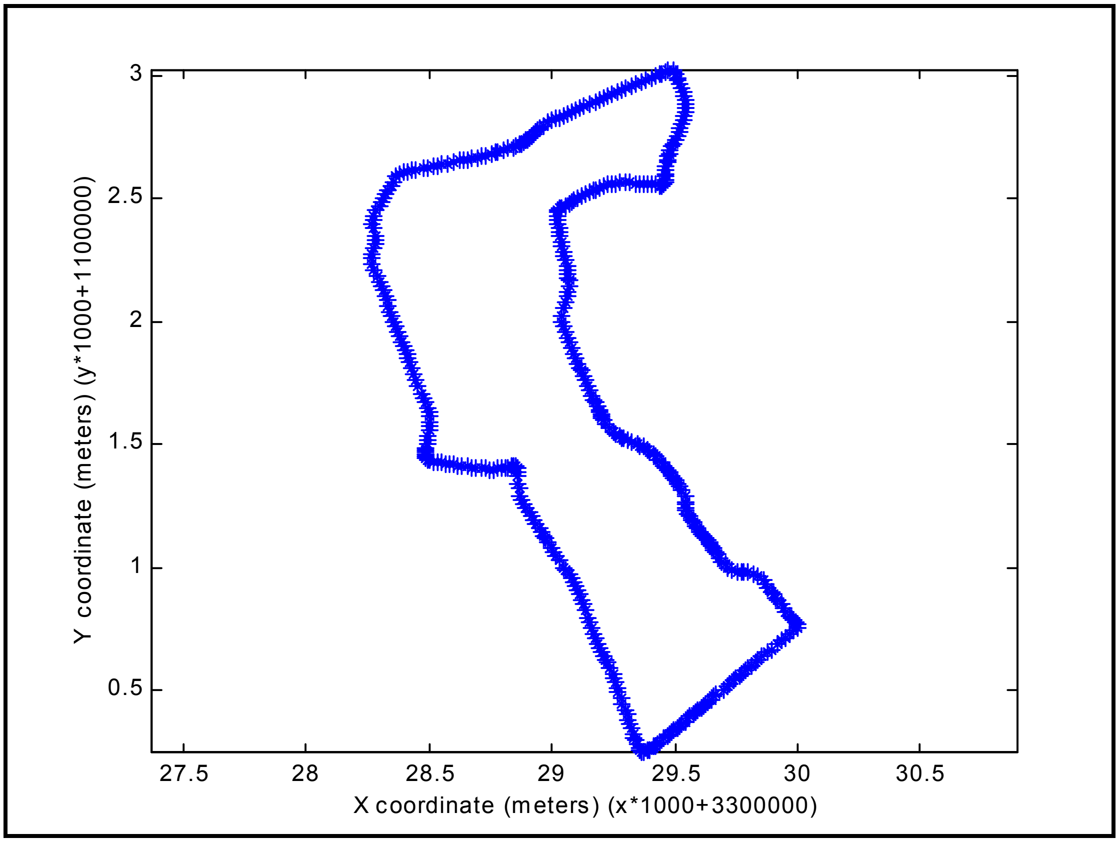


Figure 2.8: Plot of coordinates of GPS data points