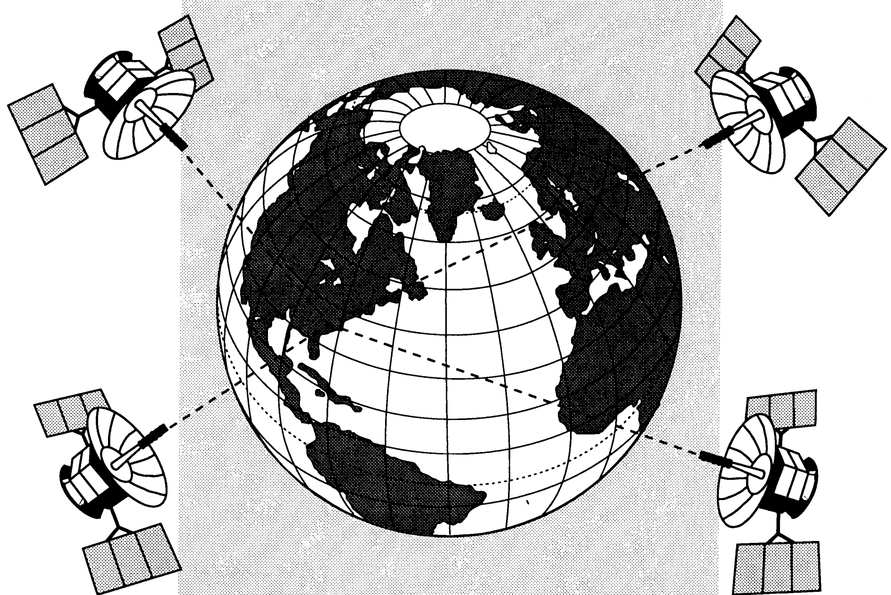
FINAL REPORT

USE OF GLOBAL POSITIONING SYSTEM FOR CAPTURE OF ENVIRONMENTAL DATA



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16. Abstract

The purpose of this study was to determine the feasibility of using the Global Positioning System (GPS), composed of 24 NAVSTAR satellites emitting individually coded radio signals with accurate timing and ephemeris information, to capture environmental field data. The accuracy of data collected in diverse environments and the practicality of transferring the data into a geographic information system (GIS) or computer aided design system (CADD) were tested. Three different data sets were collected: point, line, and area data. A Trimble GeoExplorer mapping grade GPS was used as the rover for data collection tests. Trimble base stations in North Carolina were used as the source of postprocessing data. Data collection was accurate and conversion of the data into GIS or CADD formats was practical. GPS technology is a highly feasible way to capture environmental location data.

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ENVIRONMENTAL RESEARCH ADVISORY COMMITTEE

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BACKGROUND

The Virginia Department of Transportation's Environmental Division needs location data for bridges, wetlands, cultural resources, contaminated sites, endangered species habitats, and much else. The Environmental Division needs an efficient, accurate way to collect this location data in a digital format for data transfer, manipulation and analysis by computer systems like CADD (computer aided design) or GIS (geographic information systems).

The Department of Defense's Global Positioning System (GPS) can now be used to acquire location data. The GPS is composed of 24 NAVSTAR satellites orbiting the earth twice a day at an altitude of 20,200 km. Each satellite emits individually coded radio signals including very accurate timing and ephemeris information. GPS receivers, which can now be purchased by the general public, receive and interpret these signals, thus determining the receiver location. A GPS receiver calculates its position by using the known location of each of the satellites it is receiving signals from and the time it takes for the signal to travel from each of the satellites to the receiver. This information determines the distance from each satellite to the receiver. Signals from four different satellites are required to calculate the position of the GPS receiver by solving for unknowns: latitude, longitude, altitude, and time. This position calculation process is known as trilateration (Figure 1) (Lange, 1992; Trimble, 1994).

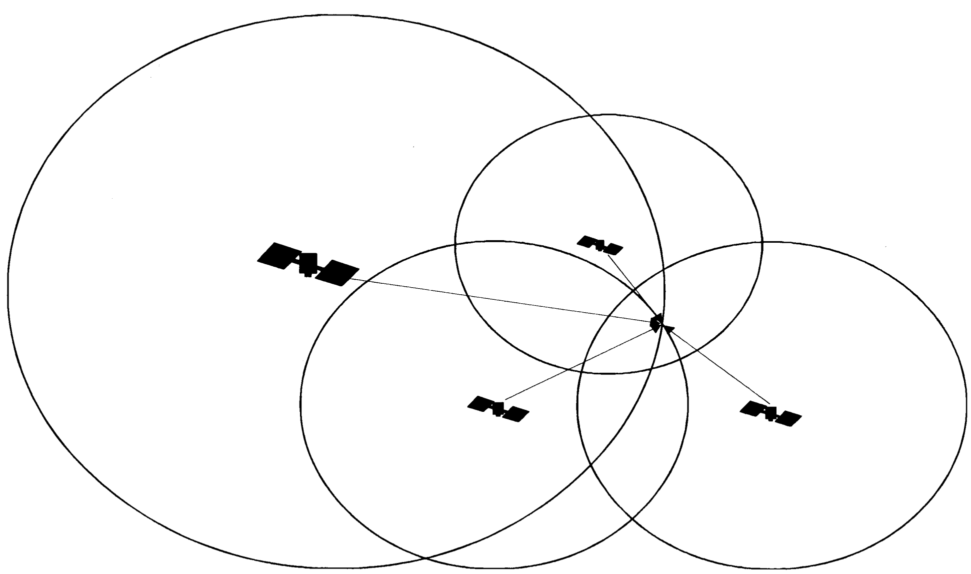

Figure 1. Trilateration.

Currently, data are collected differently in various environments, and accuracy may vary greatly. Since the Environmental Division and other state agencies sometimes share their databases, data collection needs to be consistent to ensure comparability and compatibility between and within data sets. Boundaries and actual locations change frequently, so there needs to be a way to combine new data with existing data without having to recollect the entire data set. Also, because individuals with a wide variety of backgrounds will be responsible for data collection, the method of collection needs to be as simple as possible. GPS data collection addresses these problems.

Several sources of error can affect the position information calculated by a GPS receiver. The major sources include satellite timing errors, signal delays due to atmospheric perturbance, ghosting or multipath errors, and selective availability. Selective availability (S/A) means that the Department of Defense can degrade the timing and ephemeris information sent out by the satellites to prevent potentially hostile users from receiving extremely accurate real time data. Satellite timing errors result in a miscalculation of the distance from a particular satellite by altering the time needed for the signal to travel from satellite to receiver. Atmospheric conditions can also result in distance miscalculation by slowing the signal after it leaves the satellite. Multipath errors are caused by the receiver picking up a signal that has been deflected off another object, causing a delay in the travel time, and again resulting in a miscalculation of the distance between satellite and receiver.

Most position calculation errors caused by these factors, including errors associated with S/A, can be diminished by a process known as differential correction. Differential correction involves having a reference receiver collect data at a location where the exact coordinates are known (survey monument) at the same time the roving receiver is collecting data. The combined error for a specific time is then determined by comparing the base receiver's calculated position with its known location value. The data collected from the roving receiver are then recalculated taking into account the time-specific error factor. Differential correction is often referred to as "postprocessing." With postprocessing, data can typically be collected to an accuracy of several meters with a mapping grade GPS receiver (Trimble, 1994). More expensive, higher-grade receivers capable of calculating more accurate positions are available, but the data collection process can then become more time-consuming and extremely temperamental. The higher-end receivers are probably not practical for most of VDOT's environmental field data collection.

GPS has been used to capture data for geographic information systems for several years. VDOT has participated in studies using GPS to develop a road track base for a GIS (Rockwell International Corporation, 1989; Space Development Services, Inc., 1991; Ohio State University, 1991). GPS has also been used to record specific feature locations. Survey-grade GPS is now commonly used for sub-centimeter accuracy survey projects. Mapping grade receivers are being used to collect environmental data for applications ranging from hazardous waste sampling locations to deep water well sitings (Barry, 1992). GPS technology is evolving rapidly, solving many of the problems originally associated with data collection. To quote the *Residency-Focused GPS/GIS Design Study*, "VDOT would be prudent not to expend any additional resources demonstrating commercial technology development, but rather to concentrate on the methods and requirements to apply technology to VDOT's specific requirements" (Space Development Services, Inc., 1991).

PURPOSE AND SCOPE

The objective of this study was to determine the feasibility of using GPS to capture environmental field location data. Subsequently, guidelines for data collection by GPS receivers will be developed to ensure that similar data sets are collected consistently throughout the state. The guidelines will apply to mapping-grade GPS receivers, not kinematic or survey-grade GPS receivers. The guidelines will not be an operations manual for any particular GPS receiver. They will give the operator a better understanding of GPS technology and some of the potential advantages and pitfalls of using this system.

METHODS

The practicality of using GPS to collect various kinds of environmental data was tested in terms of: (1) the accuracy of data collected in diverse environmental settings and (2) the ability to transfer this data into a GIS or CADD system. Three different data sets were collected to test these parameters: one set of point data, one of line data, and one of polygon or area data. Each set had different accuracy requirements and environmental constraints affecting the method of collection. Different collection methods were used for each of the three different data sets and within particular sets.

Experimental Groups

Point Data - Historic Bridge Locations

A total of 33 bridges in Albemarle County were located using GPS. Most of the bridges were relatively small, so this data was collected as point data using, in most cases, the center point or a corner of the bridge. It was also assumed that the location of the bridge with respect to the road network was more important than the true area of the bridge deck. The general surroundings of the bridges varied greatly. Some bridges had no obstructions to satellite signals and others were surrounded by heavy tree cover.

Line Data - Roadside Management Test Plots

Two roadside plots undergoing turfgrass and wildflower studies along Interstate 64 near Richmond were recorded as line data, because these features were long (100+ meters) and narrow. One plot was straight and the other semicircular. It was assumed that width was less important than length and location with respect to the road. Neither plot was under tree cover, but one plot was bordered on one side by mature forest. Most of these trees were deciduous, and would not pose a significant satellite-shadowing problem during the winter months.

Polygon (Area) Data - Wetland Delineation

Several wetland sites were chosen for data collection at the proposed Interstate 95 interchange north of the current Atlee Elmont interchange at Route 656 and I-95. Because the area calculations associated with these features are as important as the locations, and because they are irregularly shaped, they were excellent trials for polygon data collection. The wetland boundaries were previously delineated by VDOT personnel and that delineation was accepted by the U.S. Army Corps of Engineers. Most of the site was obstructed by a heavy tree canopy. The canopy in some cases was greater than 15 meters in height. The majority of the site, however, was covered by immature trees with a canopy height approximately seven to 10 meters above the ground, accompanied by thicker ground cover and shrubs four to five meters high. Since the tree cover was deciduous, it would not significantly affect a satellite signal in the winter. The approximate size of the combined wetland sites was 16 hectares.

Materials Used

A Trimble GeoExplorer mapping grade GPS receiver was used as the rover for the data collection tests (Figure 2). This receiver was chosen for several reasons: (1) it is one of the least expensive GPS receivers on the market that allows the data to be postprocessed; (2) it is small enough to be used in most field collection settings; and (3) it is fairly durable, though not completely waterproof. Postprocessing data was obtained from the Trimble base stations located in Raleigh and Washington, North Carolina, because no self-sufficient base stations in Virginia currently make their data available to the general public. All of Virginia is within the suggested 500-km maximum distance from the base station in Raleigh. Most of the state except southwest Virginia is within the recommended distance from the Washington station (Trimble, 1994).

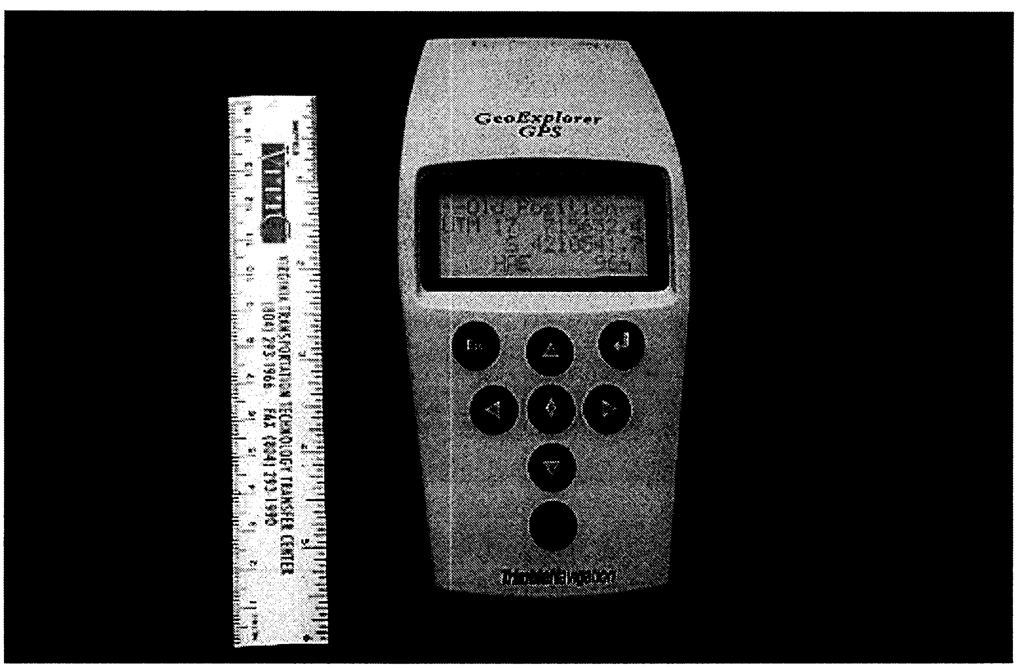

Figure 2. Mapping-grade GPS receiver.

Other materials included GEO-PC, the software package that supports the GeoExplorer receiver, and Atlas GIS and PC Arc/Info, the two geographic information system software packages used to manipulate the data downloaded from GEO-PC. A WIN 80486 DX2 PC with 16 MB of RAM and a 14,400 baud external modem was used to run the GPS software and the two GIS packages and to download files from the base and roving GPS receivers.

Procedures Used

Collection of Data

The default settings for the GPS receiver were used in all the data sets collected. The manufacturer recommends the default settings unless the user is collecting data in an abnormal setting. The more important settings and their default values are discussed below.

- Feature logging - allows the user to specify the type of data being collected and how often the signals are stored. Points were collected at 0.7 second intervals.
- Elevation mask - sets the minimum elevation above the horizon for a satellite to be used in the position calculation. The rover mask was set at 15°.
- Signal to noise ratio mask - allows the user to specify the minimum signal strength from a satellite before it is recorded. The default value was set at 4.
- Position dilution of precision mask - sets the maximum error allowance of the recorded satellite positions. The default value was set at 6.

These and other configuration settings can be adjusted; however, in most cases any adjustment in the default settings will result in less accurate data collection (Trimble, 1994).

Point Data

The bridge locations from the historic survey were registered as point data using the roving GPS receiver. The receiver was placed at the corner of each bridge deck and a roving file opened. In some cases, a single reading was taken; in others up to 200 data points were collected at a single location within one file and the values were averaged to form a distinct point.

The accuracy of the point data was assessed by collecting points at a known Geodetic Control Point High Accuracy Reference Network (HARN) Monument surveyed by the National Geodetic Survey. The monument, number VA 16 (PID: GV6210), is located in Caroline County, just off of Rt. 207. The receiver was placed on top of the monument and allowed to collect and store signals for varying lengths of time, in a manner similar to the bridge collection. This allowed for accuracy comparisons between files composed of different numbers of signals or data points.

Line Data

Two roadside management test plots were chosen along I-64 between Charlottesville and Richmond. The GPS receiver was placed at one end and physically carried the length of the plot at a normal walking speed. The accuracy of these mappings was determined by measuring the distance of each of the features in the field and comparing it with values calculated by the downloaded data in GEO-PC.

Polygon (Area) Data

The perimeter of six wetland sites was mapped by walking the flagged area and collecting data at each of the flags representing the boundary between upland and wetland. The number of points or satellite signals stored at each of the flags varied. In most cases, however, data was collected for approximately 30 seconds at each of the flags. The open file was then temporarily closed (data storage was paused) and the receiver moved to the next flag.

These area values were compared to those obtained by VDOT's Survey Division after surveying the same boundaries to test the accuracy of the GPS data. The accuracy and repeatability of area calculations using GPS was also tested by collecting a known area sample four separate times over a three-day period under various weather conditions. The corners of the polygon were used as the collection points. One hundred signals were collected and averaged for each corner of the polygon each time data was collected.

Postprocessing of Data

After the collection of data for each of the bridges, roadside management test plots, and wetland sites, the files were downloaded from the receiver to the GPS software on the PC. Each file was labeled by the date and time the file was opened. Corresponding base station files were then downloaded from one of the Trimble base stations in North Carolina. Each of the bridge files was differentially corrected and then averaged to obtain a single point. Files for the roadside management test plots were differentially corrected, but not averaged since multiple point values were not collected. The wetland files required several steps. First, all data in the wetland files were postprocessed. The points for each of the flags were then averaged to a single point using the GeoExplorer software GROUPING utility. All points in a single file were then connected, yielding a depiction of the wetland perimeter and the calculated area of the wetland.

Downloading Data into the GIS/CADD Environment

Once all the data were postprocessed, the newly created files were downloaded to a geographic information system environment. Two different GIS software packages, Atlas GIS and PC Arc/Info, were used. To download to Atlas GIS, the GPS files were saved as ASCII files. This was done with the OUTPUT utility within GEO-PC. The ASCII files were simply a series of x,y coordinate pairs in the Universal Transverse Mercator (UTM) coordinate system. These coordinate pairs could have been outputted as latitude and longitude, Virginia State Plane, or some other coordinate system. Once in ASCII format, the DOS text editor was used to attach labels that included the file name and the number of pairs making up the particular feature to each of the coordinate pairs (Figure 3). These modified ASCII files were then run through the Atlas GIS conversion program, Atlas Import/Export, resulting in the creation of Atlas geographic files with the extension .agf. Files with this extension could then be opened in Atlas GIS.

Files created with GPS were set up for export into PC Arc/Info by simply using the GIS utility in GEO-PC. This is a one-step process for creating these files because the utility allows the creation of Arc generated files (Atlas GIS files cannot be created directly from GEO-PC, hence the ASCII transition) (Figure 4).

ASCII Format from GPS Receiver (.gn3 file)	Edited ASCII Format (.bna)	
	"e", "64west",	-1770
1,283698.10,4169564.54,"Sep 19 17:12:23 1994"	283698.10	4169564.54
2,283701.29,4169584.38,"Sep 19 17:12:23 1994"	283701.29	4169584.38
3,283704.27,4169602.77,"Sep 19 17:12:23 1994"	283704.27	4169602.77
4,283707.21,4169621.06,"Sep 19 17:12:24 1994"	283707.21	4169621.06
5,283711.13,4169645.10,"Sep 19 17:12:25 1994"	283711.13	4169645.10
6,283713,93,4169662.24,"Sep 19 17:12:25 1994"	283713.93	4169662.24
7,283716.41,4169677.36,"Sep 19 17:12:26 1994"	283716.41	4169677.36
. . . .	.	.
. . . .	.	.

Figure 3. Sample file labels.

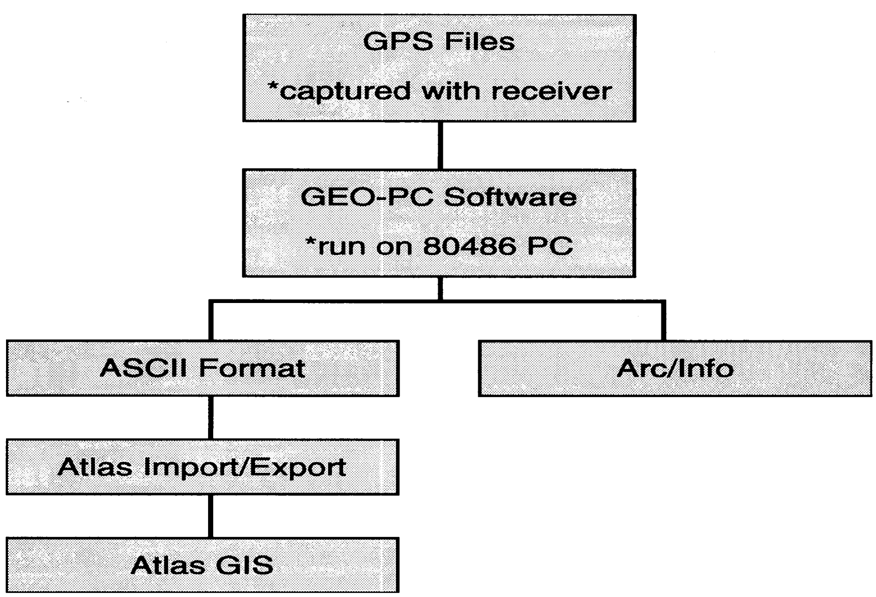

Figure 4. Downloading GPS files into Atlas GIS or Arc/Info.

Statistical Analysis of Data

Several simple statistical analyses were run for the point data collected. These tests included z tests for comparison of data differentially corrected using different base stations and a linear regression analysis to determine accuracy trends based on the number of points collected.

RESULTS

Point Data

The collection of point data representing bridge locations was successful. All 33 locations were recorded and averaged to single points representing the approximate location of the bridges. The transfer of this data to PC Arc/Info was also successful. The point files were overlaid with 1990 Topologically Integrated Geographic Encoding and Referencing (TIGER) files for Albemarle County (scale = 1:100,000) that included lines representing streams and the road network (Figure 5). Bridge locations matched well at this scale with the road locations taken from a different source. Closer examination revealed that all 33 bridges were within 10 meters of the road network as represented by the TIGER files.

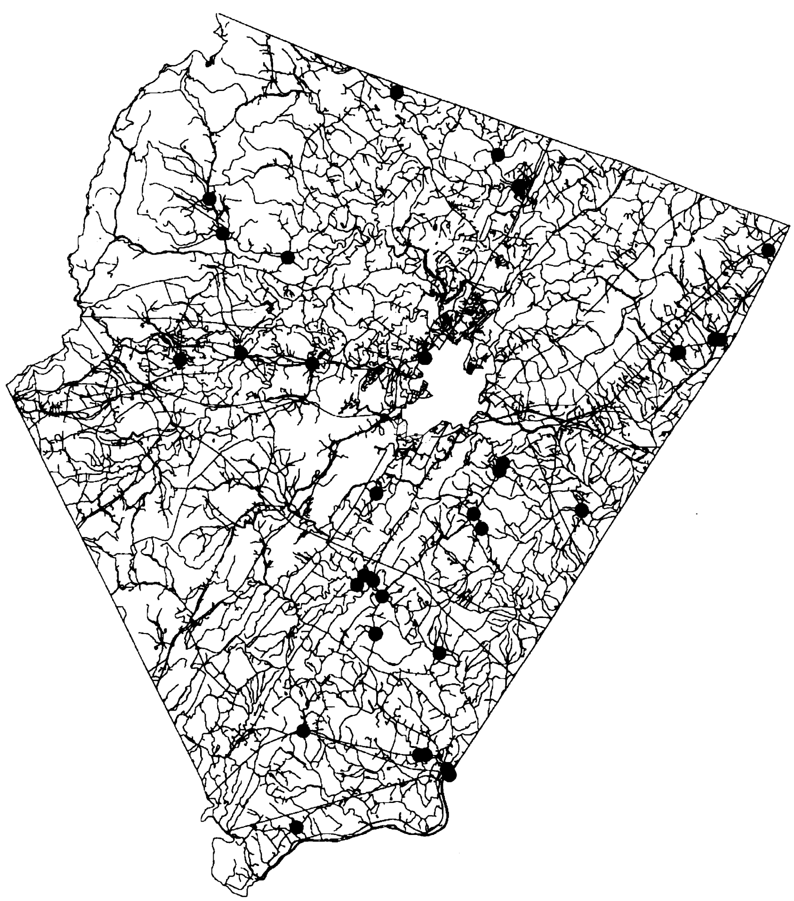

Figure 5. GPS bridge locations in Albemarle County.

The accuracy of point data taken at the HARN monument is shown in Table 1.

Table 1: Error Measurements for GPS Point Data.

Data Points Collected	x coordinate error	y coordinate error	distance from point	Base Station Location
1000	0.91	1.10	1.43	W
600	1.00	3.64	3.77	R
500	0.71	0.44	0.84	W
300	2.42	2.73	3.64	R
250	1.06	1.19	1.60	W
150	2.13	3.07	3.73	R
100	0.16	3.03	3.03	W
75	1.10	5.61	5.71	R
50[a]	0.90	3.19	3.31	W
50[b]	0.96	5.21	5.29	R
25	1.65	3.30	3.68	R
10[a]	0.73	2.71	2.81	W
10[b]	1.16	5.19	5.31	R
10[c]	0.59	2.51	2.57	R
10[d]	0.64	1.47	1.60	R
10[e]	0.07	0.58	0.58	R
10[f]	1.12	0.73	1.34	R
10[g]	1.47	1.28	1.95	R
10[h]	2.24	2.22	3.15	R
10[i]	1.47	2.21	2.65	R
10[j]	1.72	2.23	2.82	R
10[k]	2.65	2.83	3.88	R
10[l]	2.34	2.93	3.75	R
AVERAGE	1.27	2.58	2.98	
STD. DEV.	0.70	1.40	1.36	

All values are in meters. R=Raleigh; W=Washington)

Line Data

The test plots representing linear data collection were also successfully collected and downloaded into the Atlas GIS environment. Data accuracy, after postprocessing, was approximately five to nine meters different from the length values obtained by direct measurement in the field. Figures 6 and 7 show the GPS files for the test plots before and after postprocessing.

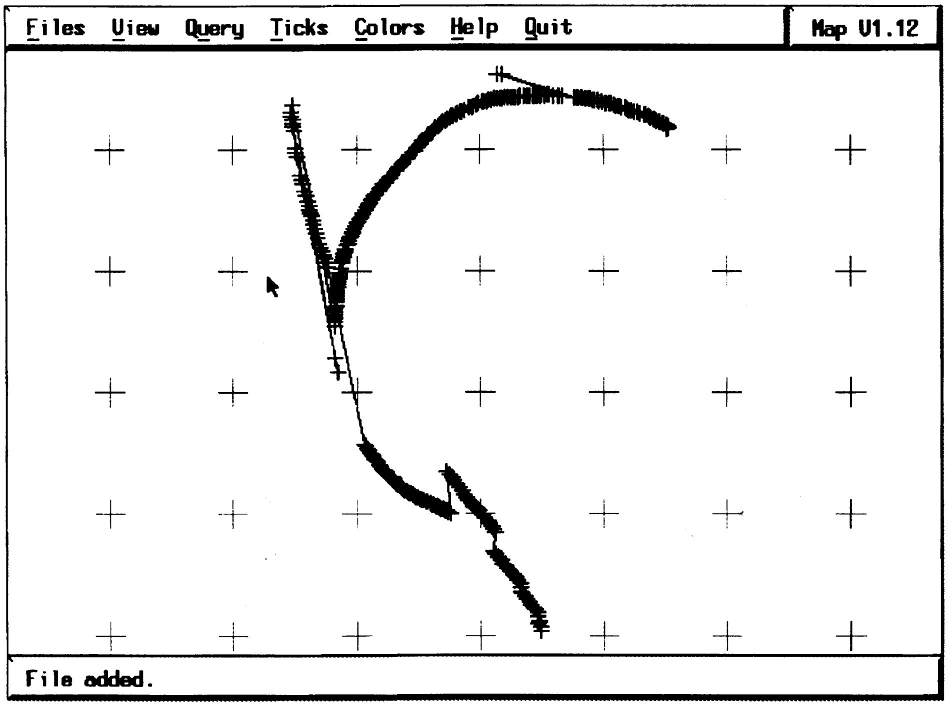

Figure 6. GPS file for linear test plot before postprocessing.

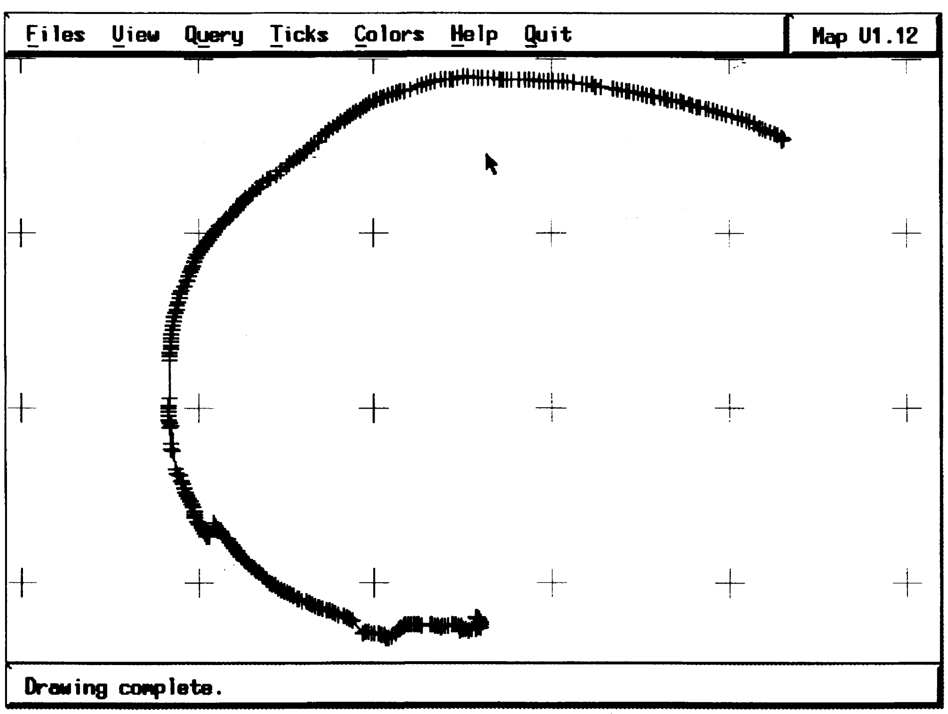

Figure 7. GPS file for linear test plot after postprocessing.

Polygon (Area) Data

The results of the wetland delineation with GPS are shown in Figure 8. Figure 9 shows the result of downloading these files into Atlas GIS. Included in this are Interstate 95 and Rt. 656. Total area values calculated by way of GPS collection were 16.15 hectares. This can be compared to 15.55 hectares obtained by VDOT's Survey Division. This equates to an error of approximately 3.8 percent.

The results of repetitive polygon delineation for a single parcel are shown in Figure 10. The resulting area calculations are shown in Table 2.

Table 2: Polygon Area Calculations.

Polygon #	Symbol	Area (hectares)	Error (hectares)	% Error
1	Δ	0.4457	0.0004	0.1
2	O	0.4744	0.0291	6.5
3	□	0.4415	0.0038	0.8
4	+	0.3967	0.0486	10.9
AVERAGE		0.4396	0.0205	4.6

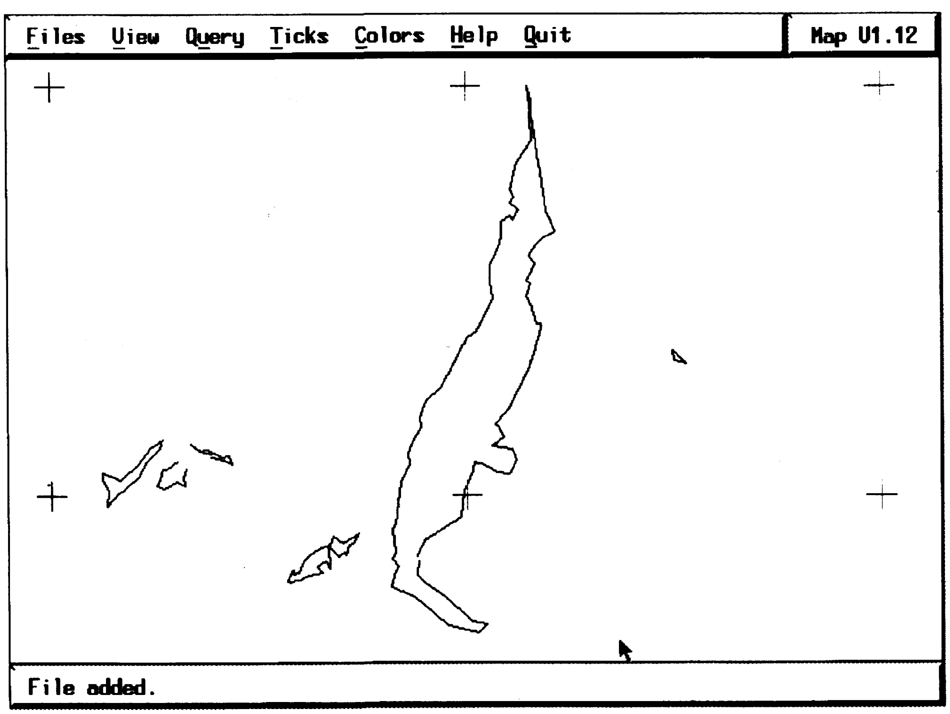

Figure 8. Wetland delineation with GPS.

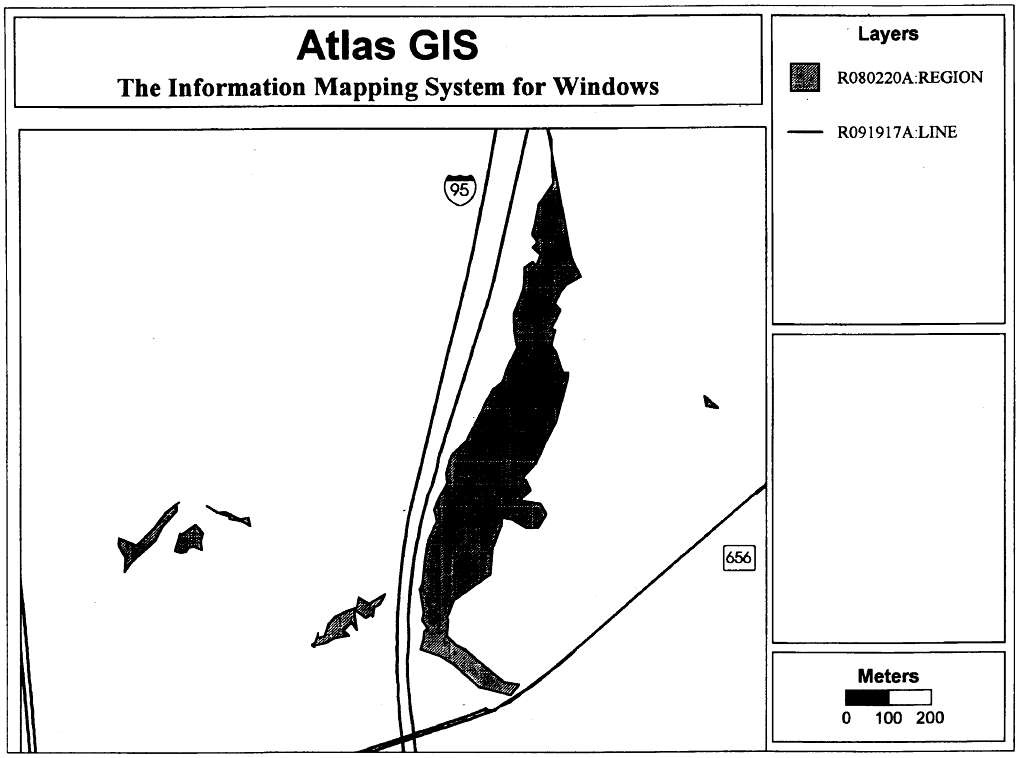

Figure 9. GPS files downloaded into Atlas GIS.

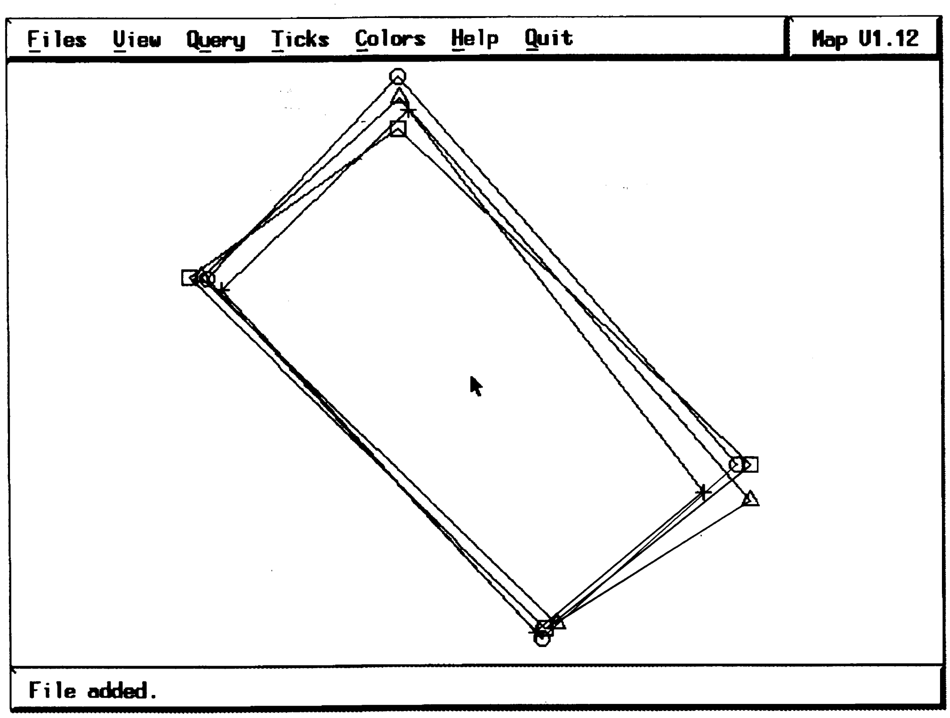

Figure 10. Repetitive polygon delineation for a single parcel.

DISCUSSION

Accuracy

When collecting environmental data by GPS, the accuracy needs of the data set being constructed should be considered. Most of VDOT's environmental data is collected for planning purposes, and the scale and detail level normally allows for significant error in the data's true accuracy. The data obtained in this study is accurate enough for most Environmental Division databases. Bridge locations obtained by GPS, for example, are more accurate than the data set (TIGER files) to which they were combined. This is likely to be the case with many Environmental Division combination data sets.

In nearly all the GPS results, the values for all differentially corrected points were within 10 meters of the actual location of the particular feature. Collecting more signal readings for the same location (oversampling) reduced the error factor further. Errors of one to six meters were obtained when at least 10 readings were averaged to a single point, as shown in Table 1. Trimble (1994) states that errors are typically in the range of five meters circular error probable (CEP). The CEP range is the radius of the circle in which 50 percent of the points collected can be expected to be found. The multiple point data obtained in this study are more accurate than the CEP of 5 meters.

The statistical analyses of the point data revealed that the two base stations produced different error factors during postprocessing. Because the difference in the distance between the two base stations and the sampling locations was minimal, the differences between the data sets were probably due to software problems known to have been occurring in the base station files in Raleigh at the time of collection.

The statistical analyses also revealed that the error associated with point data declined somewhat when more points were collected and averaged to determine a single location value. Accuracy was best when collecting and averaging a minimum of 100 points. Trimble (1994) indicates that at least 120 points should be collected and averaged to locate a single data point.

Because line and polygon data are also composed of points, their associated errors should be similar to those for point data. For example, a linear feature 100 meters long could be expected to have an error value in its length calculation of no more than 20 meters, since any point (including the first and last) could be in error by as much as 10 meters in any direction. Polygon data is subject to the same error factor. Obviously, the longer the line or the larger the polygon, the smaller the potential 10 meter error factor becomes to the line or area measurement. Consequently, short linear features should be collected as point data, not line data.

Both sets of polygon data collected were acceptable. The wetland data closely matched the area values calculated by VDOT's Survey Division. Considering the terrain, irregular shape, and size of the areas, these values are very convincing. The repeatability and accuracy of the area calculations was also good in the small area calculations (Table

2). However, polygons which are small in one dimension should not be collected as area data, as the error factor may distort the area calculation or the shape of the feature.

Causes of Error

Several common causes of error in GPS data collection were discussed earlier in this report. Most of these errors can be minimized by differential correction with base station information. The largest errors found in this study were caused by multipath (ghosting) and by the base and rover receivers reading different satellites. Multipath errors are caused by the satellite signals being reflected off objects before being collected by the receiver. The resulting time delay causes a miscalculation of the distance between satellite and receiver. Heavy tree cover made this error common in much of the wetland delineation (Figure 11). The effects of multipath can be reduced by collecting additional points at single locations.

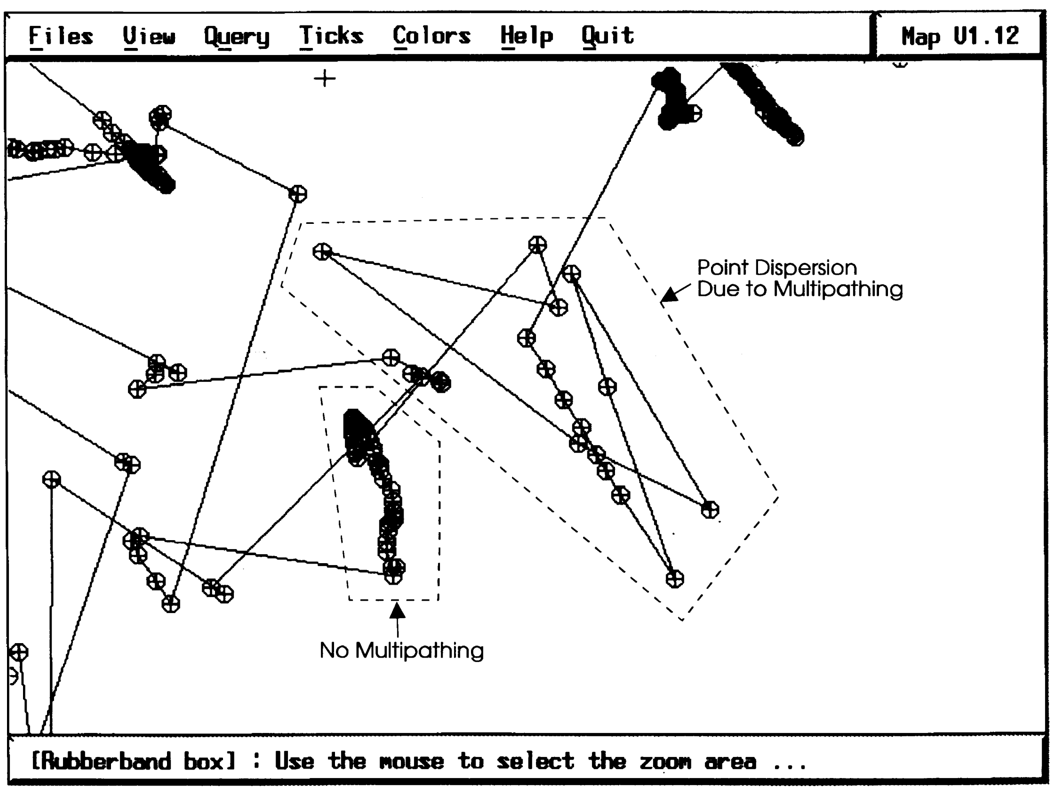

Figure 11. Effects of multipath on point data collection in wetland area.

A satellite recording discrepancy also occurred during wetland delineation. A small wetland that was recorded by simply registering points in each of its four corners was miscalculated when data recorded for the northeast corner was not differentially corrected. The roving receiver and the base receiver collected different satellite information and the point was dropped by the postprocessing software. Normally, dropping a single point would not create a problem when collecting a polygon file. However, since this file was made up of only four points (thereby creating a rectangle), the area value was nearly cut in half. Errors of this type are relatively uncommon. Base receivers typically store more satellite data, since it is not known which satellites are being received by the roving receiver. The greater the distance between the base station and the roving receiver, the greater the chance for an error of this type. According to Trimble Navigation (1994), the distance between the base and rover should not exceed 500 kilometers. Increasing the roving receiver's elevation mask will also help ensure that the base and rover receivers record signals from the same satellites.

While data transfer to a GIS or CADD environment was successful, some unexpected problems arose. When a VDOT consultant uploaded the wetland delineations to a CADD system, the coordinate systems for the wetland data (UTM) and the consultant's road design data (VDOT project coordinates) failed to match properly, because the consultant was using a coordinate system unique to VDOT. To remedy the problem, five point locations which could be identified in the field and in the consultant's digital data were recorded with GPS. These control points were combined with the wetland files and then matched with the corresponding points in the consultant's database, placing the wetland areas in the proper location. Such control points will probably be necessary for any data intended for use with VDOT's project coordinate system, as opposed to a standard coordinate system.

Benefits

GPS technology captures data quickly, accurately, and cheaply, producing more complete and more reliable data sets for VDOT and its consultants. The GPS data sets can also be transferred easily from system to system, making information easier to maintain, update, and distribute to VDOT employees, consultants, and customers, allowing for more efficient decision-making.

CONCLUSIONS

(1) Hand-held GPS receivers are an acceptable way to collect data for the Environmental Division.

(2) Point data can be collected with an expected error of less than six meters using a Trimble GeoExplorer, differentially corrected and averaged using base station information from North Carolina.

(3) The error associated with the collection of point data can be reduced by collecting and averaging at least 100 epochs for each point.

(4) Line data (collected without averaging) can have an error factor of approximately 10 to 20 meters.

(5) Area data of less than 0.5 hectares will have an expected error of approximately five percent. As the size of the polygon increases, the error percentage will decrease.

(6) GPS data can be downloaded to a variety of GIS environments with few compatibility problems.

RECOMMENDATIONS

(1) District Environmental personnel should begin to collect and develop GPS data sets for direct transfer to VDOT's geographic information system as it becomes available over the next few years. This information will be useful in the GIS, and much of the data can be used outside the GIS environment now.

(2) Most of the data should be collected as point data. By transferring point data into a GIS environment, attribute data can be assigned to the location.

(3) When possible, all point data should be collected for a minimum of 10 seconds and averaged to help eliminate errors associated with selective availability and multipath. If at all possible, a minimum of 100 epochs should be collected for each point.

(4) Only plots greater than 0.5 hectares should be collected as area data, to prevent inaccuracies in area calculation.

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APPENDIX A

GPS Data Collection Steps

Below are the general steps one would follow to collect data with a mapping grade GPS receiver. This description is very general, in the hope that it will apply to various brands of mapping grade receivers. For more complete and specific information on data collection and options available for a specific model or brand, refer to the user's manual for the receiver.

Pre-field Procedures

* determine what the end product (data) will be used for
* estimate accuracy requirements needed
* determine the coordinate system to be used
    - latitude/longitude
    - Universal Transverse Mercator
    - State Plane
* evaluate general collection environment
    - topography
    - vegetation cover
    - other obstructions to satellites
* select base station to be used
    - Raleigh
    - Washington
    - other
* download satellite forecast data (almanac)
    - satellite prediction graphs
    - number of visible satellites
    - expected position dilution of precision (PDOP)
* determine optimal date and time for data collection
* set collection parameters
    - determine the file types to be collected
        - point
        - line/polygon
    - set feature logging rate
    - set feature logging minimum number of positions
    - set elevation mask
    - set SNR mask
    - set PDOP mask
* program data dictionary into receiver

Field Procedures

* turn receiver on and allow it to calculate its current position
    - determine satellite tracking number
    - determine current PDOP
* open file to begin collecting data
    - manually record starting time and feature recorded
* collect desired number of points for each feature
* pause or close file(s) as needed

Post-field Procedures

* download data to PC via GPS software package
* determine hours needed for base station data overlap
    - download selected hours
    - combine consecutive base station files
* differentially correct rover files with corresponding base station files
* save corrected files for display or transfer
    - display w/GPS software
    - specific GIS format
    - ASCII format

APPENDIX B

Steps to Download GPS Data to Atlas GIS

Below is an outline of the steps used to convert data collected with a Trimble GeoExplorer mapping grade receiver to a format compatible with Atlas GIS. The GeoExplorer software, GEO-PC, allows for direct conversion to some GIS packages; however, Atlas GIS is not one of these.

GEO-PC Format to ASCII Format

* start GEO-PC
    - go to OUTPUT menu
        - select GIS
        - select ASCII
    - on the next item specify
        - coordinate system
        - units
        - data type
    - on the FILE menu specify
        - input file(s)
        - output file
    - select RUN to carry out the conversion

The selected files are now in ASCII format, but must be edited before conversion into Atlas GIS files.

ASCII Format Editing

* open the ASCII file with DOS text editor
    - label each feature with desired name or number
    - place a comma after the feature label
    - specify the number of coordinate pairs making up that feature
        - for a point feature this number would be 1
        - for lines the number must be preceded with a "-"
    - repeat this process for each feature in the file
* save the edited ASCII file with the extension ".bna"

The files are still in ASCII format, but now have an extension and structure that can be accepted by the Atlas conversion program, Atlas Import/Export.

Running Atlas Import/Export

* enter the Atlas directory
* initiate the program with the initials "ie"
* specify the input file name
  extension must be ".bna"
* specify the output file name
  same as input but with extension ".agf"
* specify the number of names each of the features has (up to 4)
  use /na and then insert the number of names for features
* identify the coordinate system used
  use /coord and insert the coordinate system abbreviation
  default is latitude-longitude in decimal degrees
  also indicate the zone number if UTM is used

example: ie R111824a.bna R111824a.agf /na 1 /coord UTM 17

The new file with the extension ".agf" can be displayed and manipulated in Atlas GIS