

# **From Snakes to Storms:**

## **Implementing Mobile GIS at the South Florida Water Management District**

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## **Abstract**

Mobile GIS/GPS is currently utilized by the South Florida Water Management District for numerous applications and projects requiring the gathering and dissemination of high quality spatially referenced field data. Mobile technology has expanded rapidly throughout the District with the declining costs of professional grade GPS receivers and the introduction of low cost Mobile GIS software. While this expansion has its benefits for daily District operations, it also creates numerous issues: incorrect receiver settings, lack of metadata and inconsistent GIS/GPS datasets, to name a few. Because of these and other issues, an enterprise wide Mobile GIS strategy needed to be developed and implemented. The key objectives in this strategy included a Mobile GIS/GPS standards document, standard operating procedures, the creation of custom toolbars, task specific forms and a comprehensive internal training program for users.

## **1.0 Introduction**

The use of Mobile Geographic Information Systems (GIS) and Global Positioning Systems (GPS) technology is expanding rapidly throughout the South Florida Water Management District (SFWMD). Mobile GIS is defined as the means of collecting and using spatially enabled data in a portable format. This is primarily done by using industry standard GIS software in conjunction with a portable hardware device, such as a laptop computer, personal digital assistant (PDA) or Tablet PC. GPS is defined as a space based navigation system maintained and operated by the Department of Defense. It consists of a nominal constellation of 24 satellites in high altitude orbits. Its primary mission is to provide passive, real-time, 3-D positioning, navigation and velocity data for land, air and sea based applications (both military and civilian).

The declining costs of professional grade GPS receivers, the accessibility of resource grade GPS receivers and the introduction of low cost Mobile GIS software have contributed to the proliferation of this technology at the SFWMD. While this expansion has its benefits for daily District operations, it also creates some issues; incorrect receiver settings, lack of metadata and inconsistent GIS/GPS datasets.

The GIS Working Group tasked the Mobile GIS/GPS Subcommittee with creating the standards for the SFWMD and presenting these results by May 1, 2004. The subcommittee utilized its current resources to create District wide standards that will ensure the consistent and accurate use of Mobile GIS/GPS data for daily District operations and CERP related activities.

### **Mobile GIS/GPS Subcommittee Objectives:**

- Mobile GIS/GPS Standards document for the acquisition of hardware and software that meets the needs of all departments
- Standard Operating Procedures for GPS receiver settings, data capture, and Mobile GIS data layer creation
- Creation of applications, toolbars, template forms, and metadata forms for District wide data collection
- Development of a comprehensive internal training program

## **2.0 Overview**

### **2.1 Mobile GIS**

Mobile GIS is a task oriented mobile mapping and geographic information system (GIS) technology which provides database access, mapping, GIS, and global positioning system (GPS) integration to users out in the field via handheld and mobile devices. Mobile GIS software works in conjunction with all professional and resource grade GPS systems to capture real-time GPS data on a field computer. Mobile GIS integrates:

- GIS Software
- GIS Data
- Non-GIS Data
- Global Positioning System
- Mobile Hardware (Laptop, PDA, or Tablet PC)

Mobile GIS/GPS is utilized by the District for numerous applications and projects requiring the gathering and dissemination of high quality spatially referenced field data. Mobile GIS enables the District to use the information from enterprise databases in the field, as well as gather data in the field for uploading to enterprise databases. Current District Mobile GIS/GPS applications include:

- Water Quality/Water Monitoring Site/Station coordinates for the Registration Process
- Vegetation Management
- EOC Applications (Secondary Assessment & Damage Assessment Teams)
- Right-of-Way
- Regulation Permit Compliance
- Unique requests (e.g. Mapping Exotics)

### **2.2 GPS**

The Global Positioning System (GPS) is a space based navigation system maintained and operated by the Department of Defense. It consists of a nominal constellation of 24 satellites in high altitude orbits. Its primary mission is to provide passive, real-time, 3-D positioning, navigation and velocity data for land, air and sea based applications (both military and civilian). GPS satellites orbit the earth every 12 hours at an altitude of 14,000 miles from the earth's center. Each satellite is equipped with four atomic clocks, which keep the time to an extremely high degree of accuracy. They each broadcast their precisely timed radio signals through the atmosphere and onto the earth's surface at the speed of light. The signals from each satellite arrive at any particular point on or above the earth's surface at slightly different times. This timing is proportional to the distance between the satellite and that particular point.

A ground based receiver contains a sensitive antenna and a timetable (or almanac) for the satellites. It measures the time difference between the arrivals of the signals and compares it with the timetable. With the application of trigonometry, the longitude, latitude and altitude of the receiver can be calculated. Three satellites are needed to calculate the longitude and latitude, and a fourth satellite is needed to calculate the altitude. Additional satellites simply increase the accuracy.

The quest for greater and greater accuracy has created an assortment of variations on basic GPS technology. One technique, called "Differential GPS," involves the use of two ground-based receivers. One monitors variations in the GPS signal and communicates those variations to the other receiver. The second receiver can then correct its calculations for better accuracy. Another technique called "Carrier-phase GPS" takes advantage of the GPS signal's carrier signal to improve accuracy. The carrier frequency is much higher than the GPS signal which means it can be used for more precise timing measurements.

The aviation industry has also developed a type of enhancement for GPS called the "Wide Area Augmentation System" (WAAS). 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 (WRS's). Each of these precisely surveyed reference stations receive GPS signals and determine if any errors exist. These WRS's are linked to form the U.S. WAAS network. 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 linked up 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) that are within the broadcast coverage area of the WAAS. These communications satellites also act as additional navigation satellites for the aircraft, thus, providing additional navigation signals for position determination.

The WAAS will improve basic GPS accuracy to approximately 7 meters vertically and horizontally, improve system availability through the use of geostationary communication satellites (GEO's) carrying navigation payloads, and to provide important integrity information about the entire GPS constellation which involves the use of a geostationary satellite as a relay station for the transmission of differential corrections and GPS satellite status information. The geostationary satellite provides corrections across an entire continent.

GPS is used freely by the military and civilian public to support land, sea, and airborne navigation, surveying, GIS Mapping, geophysical exploration, geodesy, conservation research, habitat modeling, vehicle location systems, farming, transportation systems, archaeology, fishing and a wide variety of other additional applications. GPS is used at the District to accurately determine the coordinates of such geographic features as new Structures (point features), Canal Networks (line features) and Wetland Areas (polygons features). Mobile GIS incorporates GPS data in order to create real time GIS layers in the field.

### **3.0 GPS Receiver Categories**

GPS is an essential element of Mobile GIS data gathering. Selection of the proper GPS receiver for a particular project is critical to its success. Receiver selection is to be based on the following criteria:

- Application for which the receiver is to be used
- Accuracy requirement for data being gathered
- Operation environment
- Cost

GPS receivers range from high cost, high accuracy geodetic quality to low cost, low accuracy “resource grade” or recreational models. District owned and operated GPS receivers can be separated into roughly 3 main categories: Resource Grade (Level 1), Professional Grade (Level 2) and Survey Grade (Level 3).

#### **3.1 Resource Grade GPS Receivers (Recreation/Navigation)**

Currently several types of inexpensive resource grade, non-differentially corrected receivers are in use at the District. The accuracy of this type of hand held receiver is around 7-10 meters Circular Error Probable (CEP) without differential correction. While accuracy for these receivers has increased since Selective Availability has been turned off by the Department of Defense, they are still not accurate enough to gather coordinates for input into the District’s numerous corporate databases that require high accuracy. These units, however, can be used for trip planning, emergency operations and navigation.

#### **3.2 Professional Grade GPS Receivers**

Professional Grade GPS systems are capable of achieving positional accuracy of less than one meter. The receivers also incorporate differential GPS corrections from government operated differential navigation reference stations or the WAAS for highly accurate coordinate data gathering.

#### **3.3 Survey Grade GPS Receivers**

Survey Grade GPS receivers are professional GPS receivers used by Surveyors for high precision position determination. Survey grade GPS receivers are extremely accurate and expensive systems that require long acquisition time for high accuracy data gathering. These systems are not covered in this document.

## **4.0 Mobile GIS/GPS Positional Accuracy Standards**

### **4.1 Resource Grade Accuracy**

Many mobile applications at the District do not need or require the high level of positional accuracy of a professional grade GPS Receiver. The accuracy needed for this type of application will be roughly 7 - 10 meters (CEP) without differential correction; however, accuracy can vary significantly. The following applications may be used with a resource grade (navigational) receiver:

- Emergency Operations: Disaster and Secondary Assessment Teams (DAT & SAT)
- Trip planning, navigation and routing

### **4.2 Professional Grade Accuracy**

Sub-meter is the standard positional accuracy that is required for all Mobile GIS data created for entry into all corporate District databases and enterprise GIS environments. District managers and GPS professionals have agreed that this level of accuracy meets the needs of both internal and external customers and it is feasible with current equipment. While the positional accuracy of resource grade GPS receivers has increased nearly ten times since the government turned off Selective Availability (SA), this type of receiver is still not accurate enough to gather spatial information for input into the District's corporate databases.

This standard can be maintained with professional grade GPS equipment currently available at the District. These professional grade systems are capable of sub-meter accuracy (Root Means Squared - RMS)\* and 2 meter accuracy (2dRMS)\* after differential correction and specified procedures are followed.

\*Note: Root Means Squared is defined as approximately 68% of the positions are within the specified value. 2dRMS means that approximately 95% of the positions are within the specified value. It should be noted when RMS is moved to a higher confidence level (2dRMS), the procedures are at least as important as the measuring equipment.

### **4.3 Survey Grade Accuracy**

Survey grade GPS receivers are professional GPS receivers used by Surveyors for high precision position determination. Survey grade GPS receivers are extremely expensive systems that require long acquisition time for high accuracy data gathering. These systems are not routinely used for GIS data gathering and will not be used for Mobile GIS/GPS field data gathering at the SFWMD.



## 5.0 Hardware and Software Standards

### 5.1 Hardware

#### 5.1.1 Mobile GIS/GPS Systems

The following systems are the recommended standard devices for GPS hardware at the South Florida Water Management District.

#### Professional Grade GPS/Mobile GIS Devices

##### 5.1.1.1 Trimble's GeoXT - Professional Grade GPS

The Trimble® GeoXT is the “all in one” standard professional grade sub-meter GPS receiver with EVEREST™ multi-path rejection technology. This handheld device from the GeoExplorer® CE series, combines sub-meter GPS with a Microsoft® Windows Mobile® version 5.0 operating system in a rugged (dustproof, water resistant) case. The unit includes integrated Bluetooth® for wireless connectivity to other Bluetooth enabled devices, including cell phones and PCs. The GeoXT runs multiple applications, connects to the Internet, and has a familiar user interface that is similar to the SFWMD desktop environment and an all day battery with an advanced TFT outdoor color touch screen with backlight integrated. The unit can be integrated with the user's desktop for 2-way communication. This unit requires no additional hardware for data collection.



##### 5.1.1.2 Trimble ProXR/Recon – Combination Professional Grade GPS

The GPS Pathfinder® is the standard “stand alone” professional grade GPS for the SFWMD. The ProXR receiver is a powerful, easy-to-use GIS data collection and data maintenance system that provides real-time sub-meter accuracy. This unit combines real-time beacon, WAAS, EGNOS, and GPS capabilities in a single receiver. This unit will require the use of the Trimble® Recon handheld which is the standard PDA device for Mobile GIS/GPS at the District. This unit is designed for the extremes of Mobile GIS fieldwork. Compact and rugged, it exceeds military specification for drop, vibration, immersion, and operating temperatures. Mobile technology is changing quickly and the Trimble Recon is designed to keep up. The operating system is Microsoft® Windows Mobile™ 2003 for Pocket PCs. The Trimble Recon handheld works seamlessly with Trimble's GPS Pathfinder® receivers (ProXR, ProXRS).



#### 5.1.2 PDA Usage

Mobile GIS/GPS requires an extremely rugged PDA device to withstand the various extreme weather conditions found throughout the District. While the IPAQ from HP is considered the industry standard for a PDA, its housing is not rugged enough to withstand the elements and is not considered an option for standard Mobile GIS/GPS data gathering

#### 5.1.3 Centralized/Departmental Hardware Inventories

The purchase of these units by Departments/Divisions is permitted. All purchases are coordinated by the GIS Section/Systems Administrator to ensure standards are maintained. Additionally, this allows inventory to be recorded and firmware updates to be performed. Departments/Divisions are responsible for ensuring that their staffs follow the standards and protocols explained in this document for data collection. It is the responsibility of the Department/Division to budget for this purchase.

#### **5.1.4 Research and Development**

Changes to GPS hardware available in the market place occurs rapidly, as does most Information Technology related hardware. It is important for the SFWMD to maintain the hardware and software standards set out here for several reasons, one being for budgeting and planning and the other to ensure GPS accuracy levels are met. The said improvements and the introduction of new GPS hardware products offer the SFWMD the ability to gain cost savings without losing accuracy.

The process for researching and testing new or improved GPS hardware is as follows:

1. The SFWMD employee who is interested in the product contacts the Systems Administrator of the GIS Integrated Applications Section and presents documentation of the product.
2. The Systems Administrator, working with the GIS Application Developer (Mobile), contacts the vendor and arranges to either have a demonstration of the product by the vendor to selected SFWMD GPS “experts” (members of the Mobile GIS/GPS Subcommittee) or have the vendor provide a unit for temporary use by SFWMD GPS “experts” for testing. Under no circumstances is a new GPS hardware product to be purchased by the SFWMD for strictly testing purposes.
3. Mobile GIS and GPS staff (members of the Mobile GIS/GPS Subcommittee) conduct series of tests to verify the following about the product:
  - a. GPS accuracy
  - b. Interoperability with SFWMD approved Mobile GIS/GPS software and hardware
  - c. Ease of use, durability for field work, data collection/post-processing
  - d. Review potential maintenance agreements, technical support, and firmware upgrades
4. Test results and recommendations regarding the product are written and submitted to the GIS Working Group.
5. The GIS Working Group reviews the report.
  - a. If the report recommends the new product, the GIS Working Group presents this to the IT Steering Committee for approval so that a budget item can be added to the system
  - b. If the report recommends not approving the new product, the report is passed on to the employee (and his/her supervisor)

#### **5.1.5 Transition to Hardware Standards**

The implementation of the Mobile GIS/GPS standards did not eliminate the fact that many brands and models of Mobile GIS/GPS hardware existed and are being used at the SFWMD. This did not prohibit the immediate implementation of the standards. SFWMD only permits data gathered at sub-meter accuracy using the Mobile GIS/GPS hardware listed in this section to be entered into enterprise databases. The reason for this is to prevent inaccurate data being used for decision making purposes, issuing of permits, and/or other high profile projects (e.g. CERP). Additionally, it will reduce long terms costs by eliminating the need of SFWMD employees to re-gather GPS data to meet the enterprise database accuracy requirements.

### 5.1.5.1 Professional Grade

The following professional grade units are known to exist at the SFWMD, these are sub-meter accurate and their data will be permitted into an enterprise database. These are older units and over the next few years should be budgeted for replacement. Trimble has phased-out these units from their product line and will no longer support them.

Trimble Ag 122                      Trimble Pro-XL                      Trimble NT300D

The following professional grade units are known to exist at the SFWMD, but are not sub-meter accurate and do not meet the minimum standard for a professional grade unit. The data collected from these units is not permitted in enterprise databases. These units can still be used for navigational purposes.

Trimble GeoExplorer 3              Trimble Basic+                      Trimble GeoXM  
Trimble GeoExplorer 3 with BOB

### 5.1.5.2 Resource Grade

Existing resource grade GPS hardware units are allowed to be used by SFWMD employees for navigational and routing purposes only. These units are not used for gathering GPS data for SFWMD projects or use in enterprise databases. The resource grade GPS hardware units listed here are known to exist at the SFWMD and are used strictly for the purposes of navigation and routing:

Garmin GPS12                      Navman 3450                      Magellan 315  
Garmin 76                              GPSMap 176C                      Garmin GPS 5  
Garmin GPS Plus                      Teletype CF GPS Card              Pharos GPS Card

### 5.1.5.3 Other Existing Units

It is also realized that various PDA devices are in use at the SFWMD for Mobile GIS/GPS data collection. These units are being transitioned to the newer rugged devices explained in this document.

## **5.2 Software**

### **5.2.1 ArcPad 7.0 Mobile GIS Software**

ESRI's ArcPad is the District's standard Mobile GIS/GPS data collection gathering software. ArcPad provides database access, mapping, GIS and GPS integration to users out in the field via handheld and mobile devices. Since it is an ESRI product, its interface is similar to other GIS standard software products used at the District. Data collection with ArcPad is fast, easy, and significantly improved with immediate data validation and availability. ArcPad is installed by IT on all GeoXT and Recon devices. Requests for this software are approved by the GIS Section/System Administrator to ensure compliance is met with the standards, as well as inventory information.

### **5.2.2 ArcPad Studio 7.0 (Application Builder)**

ESRI's ArcPad Studio is the District standard for mobile application development. Custom forms and templates will be available in a Mobile GIS Forms library that will be accessible via the SFWMD Intranet at the GIS Web Portal. If additional programming is needed, a request is submitted to the IT/GIS Applications Section.

### **5.2.3 GPS Correct Software**

Trimble's GPSCorrect software provides the added ability to perform post-processing on shapefiles created in ArcPad and conduct mission planning. This software is installed by IT at the time the hardware is configured and ArcPad software is installed.

### **5.2.4 Pathfinder Office Software**

GPS Pathfinder Office is the standard GPS processing software that is distributed as needed for standalone GPS work. This would be for use with the ProXR and ProXRS without use of a Mobile GIS solution. The software enables users to pre-plan their field sessions for more productive field work. The data dictionary editor creates custom pick-lists, automatic repeat feature, and numeric values so that collecting of many features and attributes is easy and accurate. In the field the data dictionary prompts the field crew to enter specific information ensuring data integrity and compatibility with your GIS or database once back in the office. Additionally, Pathfinder Office allows for the post-processing of data files to gain greater accuracy, to upload and download data from the GPS hardware unit, and for differential correction.

### **5.2.6 Transition to Software Standards**

The implementation of the Mobile GIS/GPS standards did not eliminate the fact that many brands and versions of Mobile GIS/GPS software existed and were being used at the SFWMD. ESRI is the SFWMD standard for GIS software which applies to Mobile GIS as well. Existing software, other than the ESRI standard, will be transitioned as soon as possible to meet the standards and to integrate with the SFWMD enterprise GIS software platform.

## 6.0 Metadata

Metadata is information about a data set, or “data about data”. In essence, metadata explains **who, what, when, where, why** and **how** about every piece of data. The South Florida Water Management District strives to have metadata that is FGDC compliant, meaning that the metadata is created and kept in a standard format that was defined by the Federal Geographic Data Committee (FGDC). This standard is called the Content Standard for Digital Geospatial Metadata (CSDGM). The objectives of this standard are to provide a common set of terminology and definitions for the documentation of GIS data. SFWMD accomplishes this by creating and maintaining metadata using ESRI’s ArcCatalog Metadata tools.

There are two categories of data for Mobile GIS/GPS collected data, in regards to metadata collection. The first category is data that is collected to feed into other Enterprise GIS Datasets or other Enterprise databases, such as DBHydro, this is called **Transfer Data**. The second category is data that is collected with the intent to publish on the Enterprise GIS Library directly, this is called **Publishable Data**.

### 6.1 Transfer Data

Transfer Data is GIS data that is collected in the field with the intent to feed into other datasets. This type of data must have a minimal amount of metadata. The data steward for the enterprise dataset is responsible for assuring the metadata is FGDC compliant. The metadata for the transfer data needs to provide the Enterprise Data Steward with enough information to make the transfer data usable.

The following items are collected on Transfer datasets:

#### GPS Stats:

- PDOP
- Number of satellites
- Equipment used
- Accuracy of equipment

#### Collection Information:


- Name of collector(s)
- Date and time of collection
- Location of collection; general description
- Purpose of collection; why was this data collected
- Description of what is being collected
- Where the data is going to reside; Enterprise GIS dataset or Enterprise database
- Name and details of related projects; e.g. CERP Project, Critical Restoration Project
- How the data was post-processed; Software package, any processing
- Projection data was collected in and/or converted to
- Attribute Information; definitions of any attribute information that was collected by the data logger

## **6.2 Publishable Data**

Publishable data is GIS data that is collected in the field with the intent to publish in the Enterprise GIS Library. This type of data must have a complete set of metadata. The metadata standards for Enterprise GIS data is published in a Data Steward Manual. In addition to the information required by the SFWMD standard, publishable GIS data collected by GPS must also include all of the GPS information described on the previous page for the transfer data. This information should reside as a process step in the FGDC compliant metadata.


## 7.0 Operating Guidelines

A detailed, 37 page Mobile GIS/GPS Standard Operating Procedures Manual was prepared in addition to the Standards which includes detailed descriptions on configuration of ArcPad software and Mobile GIS/GPS receivers. Following is an example of a quick reference guide that was put together to allow field personnel to efficiently work through any problems that may come up in the field in regards to settings, collecting data, resets, etc.






### GeoXT/ArcPad Quick Reference Guide




By Erik Henning and Rick Householder








This Quick Start Guide should be used as a handy reference for setting up and using the GeoXT Mobile GIS field unit for District related data gathering. This guide assumes a standard Land Management load set, the SPWMD Toolbar and a basic understanding of the principles of Mobile GIS.

#### To Start



- Turn the GeoXT on by pressing the large button on the bottom of the unit (shown on right). 
- Once on, the unit will display the Windows Mobile 2003 startup screen.
- Activate ArcPad by tapping **Start** and then selecting **ArcPad**. 
- Once ArcPad is active you can check or set the GPS setting by tapping the dropdown arrow next to the **Options Button** and selecting **GPSCorrect**. Under **Setup** there will be three types of settings, the proper settings are below. 




- Once the GPS settings have been established hit **X** to close out of **GPSCorrect Options**.
- To satckcheck the ArcPad GPS Options, tap the **Options Button** on the menu bar.  The proper settings are below.



#### Open an Existing Map

- Once in ArcPad, open an existing map (aprx by clicking on the file folder  in the upper left hand corner and navigating to your map.
- Check to see if all the layers are present by tapping the **Layers Button**. 

#### Creating a New Map

- If desired, a new map can be created by selecting **File – Dropdown – New Map** from the ArcPad Menu Bar. This will allow you to create a fresh blank map in which to add new layers.
- Layers can be added to the blank map by tapping the **Add Layers Button**. 

#### Creating or Appending Layers

- You can add or append existing layers in ArcPad. Follow the steps on the following page to create Point, Line or Polygon features.

### Capturing Point Features

1. Add your **Point Feature** shapefile to the map and confirm it has been selected for editing by tapping the **Layers Button** and adding a check mark to the right of the feature under the **Pencil** column.
2. Activate the GPS by tapping the **GPS Activate** button. Then tap the **GPS Position Window**. The window will display the usable satellites in black and will display '3D' when ready for gathering coordinates.
3. With the point feature set to edit, the point button (just right of the logo) will be highlighted. To capture a point feature, tap the point button and choose either manual or GPS gathering option. To place a manual point, simply tap the screen where you would like to place the point and an entry form will appear. To gather a GPS location, tap the arrow to the right and select **Capture Point** (as shown right). A GPS point will be gathered at that location and an entry form will appear.
4. After the form appears, fill in the appropriate attributes and select **OK**, the Point will be saved as an individual shapefile record and will be displayed in the map view.
5. A new Point can be deleted from the shapefile at any time by selecting it with the **Arrow** button and deleting it with the **Delete** button.



### Capturing Line Features

1. Add your **Line Feature** shapefile to your map and confirm it has been selected for editing.
2. With the polyline feature set to edit, the **Polyline Button** (just right of the point) will be highlighted. To capture a line feature, tap the polyline button and choose either manual or GPS gathering option. To place a manual line, tap the screen where you would like to start the line, double click on the screen where you would like to continue the line. When finished, un-depress the polyline button and the entry form will appear. To gather a GPS line location, tap the arrow to the right of the button and select **Capture Vertices**. The GPS will create the line based on your movement.
3. Once the Line feature has been GPS mapped, un-depress the **Capture Vertices** Button and then the **Polyline** Button; this action will cause the entry form to pop up to establish the associated attributes with the new coordinates. Fill in the appropriate attributes and then select **OK**, the polyline will be saved as an individual shapefile record.
4. A new Line can be deleted from the shapefile at any time by selecting it with the **Arrow** Button and deleting it with the **Delete** Button.



### Capturing Area Features

1. Add your **Polygon** feature shapefile to your map and confirm it has been selected for editing.
2. With the polygon feature set to edit, the **Polygon Button** (just right of the point) will be highlighted. To capture a polygon feature, tap the polygon button and choose either manual or GPS gathering option. To place a manual polygon, tap the screen where you would like to place the polygon and continue to double click until the polygon is complete. Once the polygon is finished, un-depress the button and an entry form will appear. To gather a GPS polygon location, tap the arrow to the right and select **Capture Vertices** (as shown on the right). The GPS will create the polygon based on your movement.
3. Once the polygon is complete, un-depress the **Capture Vertices** Button and then the **Polygon** Option Button; this action will cause the entry form to pop up to establish the associated attributes with the new feature. Fill in the appropriate attributes and select **OK**, the polygon will be saved as an individual shapefile record.
4. A new Polygon can be deleted from the shapefile at any time by selecting it with the **Arrow** Button and deleting it with the **Delete** Button.



### Performing Resets

There may be a point in your data collecting when the GeoKT fails to respond. If this occurs, please follow the steps below:

#### To perform a Soft Reset, follow these steps:

1. Hold down the power button until the screen flashes (about 5 seconds).
2. Immediately let go of the button, and let the unit reset. You will then see the welcome screen.
3. Resume normal operations.

#### To perform a Hard Reset, follow these steps:

1. Hold down the power button until the screen goes black (Hint: Longer than the Soft Reset).
2. Restore to a previous backup (unit should prompt).
3. Resume normal operations.



## 8.0 SFWMD Applications

Mobile GIS has found its way into numerous projects and applications since its inception at the South Florida Water Management District. Two particularly notable applications include mapping invasive exotic species in the Everglades and mapping flooded areas after hurricanes and storm events.

### 8.1 Mapping Exotics

Invasive exotic species have been an ongoing issue for the District. Millions of dollars have been spent to combat such exotics as Melaleuca, Brazilian Pepper and the Old World Climbing Fern. Recently, a new invader was identified by field crews, the Burmese Python. The snake, which is native to Southeast Asia, is an extremely large member of the python family and is imported into the US by reptile hobbyists and sold as pets. As many of these snakes grow too large for their owners to handle, many are released into the Everglades. In this warm, rodent abundant environment, the Python population has exploded endangering all native species that the snake can catch – even alligators. With this ever growing threat, a way was needed to track the snake's spatial distribution and activity.

The first attempt at mapping the creatures was to gather their location with a handheld GPS and place the coordinates on a map (Fig. 1). The Python map would give the District an idea at the possible number and extent of the pest. After learning of the rapid growth, it was decided that much more information was needed regarding each sighting. It was determined that Mobile GIS may be a more efficient method to map the creatures in terms of both spatial and vital field information. Utilizing ArcPad 6.0.3 and ArcPad Application Builder, custom forms (Fig. 2) were created and loaded on GPS enabled HP IPAQ's. The system allowed field personnel to use Mobile GIS to track snakes in terms of spatial position, appearance, size and activity. This vital information supports the agency in its mission to eliminate these exotics and future invaders from the Everglades.



Fig. 1



Fig. 2

## 8.1 Mapping Flood Events

Disaster management has been a hot topic in Florida in the last several years with the state getting hit by hurricanes five times in two seasons. The South Florida Water Management District has been at the forefront of emergency response and disaster management utilizing rapid flood assessment teams called “SATS” (Secondary Assessment Teams). These highly specialized teams are activated upon the occurrence of a hurricane or rain-event that causes local flooding within the SFWMD borders. During a typical event, the teams are activated and sent to the impacted area. Once there, they would assess the situation and hand draw flooding boundaries on paper maps along with notes regarding the particulars of the flooding event. These drawings and notes would be returned to the District’s EOC to be converted to shapefiles for use in creating storm situation maps.

While effective, the process was extremely time consuming and inefficient, often lagging hours behind actual field conditions. After extensive review of the performance, Mobile GIS was enlisted to help remedy the situation for the 2004 season. Utilizing ArcPad 6.0.2 and ArcPad Application Builder, a custom application was created which included flood specific shapefiles and custom forms (Fig. 1). After testing, it was decided that the application should also include local streets, critical facilities and imagery to assist the field crews in the event that a storm were to take down both street signs and known landmarks. The application was deployed on eight HP IPAQ’s with incorporated Pharos GPS cards (Fig. 2). With the SAT Mobile application in place, field crews were able to rapidly respond to flooding calls and map local flooding based on their GPS position and enter important situation notes using predetermined, drop down entries. Using the enhanced system, the teams were able to quickly map multiple areas and send or deliver the data back to the EOC in a fraction of the time. Once downloaded, the data was simply copied on to pre-made base maps. This system has dramatically cut down field collection and process time during emergency situations.

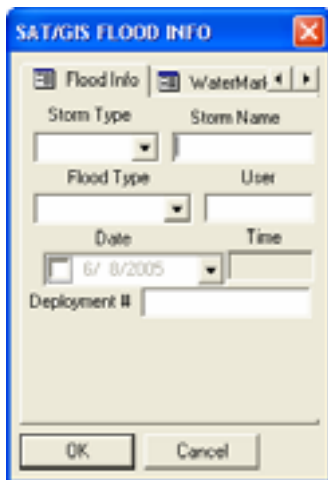


Fig. 1



Fig. 2



## 9.0 Custom Toolbars

Custom toolbars have been created in ArcPad Studio to provide additional functionality or simplicity to the default tools. The SFWMD Toolbar (in the red circle shown below) loaded on the GPS devices provide quick access to the point, line and polygon capture tools, as well as other tools like identify, find, go to, measure, select, delete, zoom, pan, refresh and more.

**Used to capture point features**

**Used to capture line features**

**Used to capture polygon features**

**Used to identify, find, go to, measure, select, and delete features**

**Used to zoom and pan**

**Used to refresh**

## 10.0 Mobile GIS/GPS Training

Proper training and maintenance of equipment is vital to the quality of the data. The District currently offers three in house training courses.

### 1. Introduction to Mobile GIS/GPS Training - *Using the GeoXT & ArcPad*

This course is a basic introduction to working with the Trimble GeoXT handheld GPS unit running ESRI's ArcPad software. The course is one full day divided between classroom lecture and hands on experience in the field. All work is performed on the GeoXT without the use of desktop computers. Some of the items covered in this course include:

- What is mobile GIS/GPS?
- How is mobile GIS/GPS used at the SFWMD?
- What is the Trimble GeoXT?
- What is ArcPad?
- The new SFWMD Toolbar
- How to set up your GeoXT
- How to get data into your GeoXT
- How to collect field data with your GeoXT
- What is a custom form?
- How to get your newly acquired data back to your desktop

There is no prerequisite for this course other than the requirement of each student to come equipped with their own GeoXT and charger. This class is limited in size to 12 students because of the need for a low teacher to student ratio.

### 2. Advanced Mobile GIS/GPS Training - *Using the GeoXT & ArcPad with ArcMap*

This course is an advanced course for working with the Trimble GeoXT handheld GPS unit running ESRI's ArcPad software. This course provides the students with highly developed Mobile GIS/GPS skills and a superior understanding of the GeoXT and ArcPad software.

The course is one full day divided between classroom lecture and hands on experience in the field. A combination of the GeoXT and desktop computers is used. Some of the items covered in this course include:

- Detailed setup of your GeoXT and ArcPad
- What data to use in your GeoXT
- How to get data into your GeoXT using ArcMap
- How to collect accurate and complete data with your GeoXT
- A comprehensive look at the SFWMD Toolbar
- Basic custom form creation

- Syncing your GeoXT with your desktop
- Integrating data with ArcMap

The prerequisites for this course are the successful completion of the Introduction and Advanced Mobile GIS/GPS Training courses. Students are asked to come equipped with their own GeoXT and charger. This class is limited in size to 12 students because of the need for a low teacher to student ratio.

### **3. Special Topics in Mobile GIS/GPS - Topic I: Creating and Using Custom Forms in ArcPad**

This course is an advanced course for working with the Trimble GeoXT handheld GPS unit running ESRI's ArcPad software. This course focuses on creating and using custom forms using ESRI's ArcPad and ArcMap software as well as other special topics related to field data gathering.

The course is one full day divided between classroom lecture and hands on experience in the field. A combination of the GeoXT and desktop computers is used. Some of the items covered in this course include:

- What is a custom form?
- Why use a custom form?
- How to create effective forms in ArcPad
- How to create effective forms in ArcMap
- What is ArcPad Studio?
- How to collect accurate and complete data with forms
- Using forms with the SFWMD Toolbar

The prerequisites for this course are the successful completion of the Introduction and Advanced Mobile GIS/GPS Training courses. Students are asked to come equipped with their own GeoXT and charger. This class is limited in size to 12 students because of the need for a low teacher to student ratio.

## 11.0 Conclusions

There have been a number of recurring issues that have come up through the ongoing process of implementing a Mobile GIS strategy at the SFWMD. Some issues are minor, some are major, but it's assumed that there will always be some new issue right around the corner.

The biggest issue during the implementation has been getting staff across the District to adhere to the new standards. People have been doing things a certain way for a long time and change often comes slowly. Due to deadlines, employees will occasionally deviate from the prescribed procurement process and obtain hardware and software on their own. They will then try and load the software and set up the hardware without consulting any documentation. This can lead to the application being stored in the wrong location, data being stored in incorrect files and not collecting data at the required accuracy. Obviously, this leads to problems of wasted time and resources. It is the hope of the District that with time, employees will understand the importance of adhering to standards and even embrace them.

Another obstacle of full implementation is properly training users. Even with a multi-tiered training program, users are not always absorbing the functionality and uses of Mobile GIS. The difficulty lies in the experience of the users. Many users enter training with an enthusiasm and willingness to learn the technology. Others come with little experience in GIS, GPS, or even basic computing skills and some are reluctant to learn new concepts. When confronted with the latter type, it is extremely hard to win them over as to the advantages of this technology. As stated earlier, many employees have done things 'their' way for a long time and are often reluctant to change. This issue will hopefully get better with time as the District adopts this technology from the top down. The longer the latter group is exposed to the benefits of Mobile GIS, the more comfortable they should feel and will increasingly start accepting its advantages.

Upgrading of the hardware and software is also an important issue to bring up. With the recent release of ArcPad 7.0, the District has had to try and develop some methodologies that allow for an easy migration to the new standard. Due to the size of the agency, it is not as easy as getting new or upgraded software and loading it. There are over 50 current ArcPad (6.0.3) users at the District and over 30 new GeoXT's on order which will be using ArcPad 7.0. It would be extremely unproductive to have a mixed version of the software. This means upgrading the 50+ current users while obtaining and rolling out the 30+ new units. This is quite a challenge in regards to logistics, budget and the training program. This issue is ongoing as will be the case for some time.

Overall, the implementation of Mobile GIS at the South Florida Water Management District has gone extremely well. Management has accepted the need as well as the standards and with time, this will trickle down to the employees. The issues encountered were mainly expected in an environment like the District with over 1700 employees of varying skill sets. This ongoing process will continue to evolve along with the technology and the workforce.

## **12.0 Glossary**

### **ArcSDE**

This is the SFWMD standard from ESRI for storing spatial data. SDE is a Spatial Database Engine that is a service that “sits” on top of any Relational Database Management System (Oracle, SQL Server, IBM DB2)

### **CEP**

Circular Error Probable (CEP) is the value of the radius of a circle, centered at the actual position that contains 50% of the position estimates. If a GPS position measurement is accurate to 10 meters CEP, this means that there is a 50% probability that your measurement lies INSIDE a circle with a radius of 10 meters. This also means that there is a 50% probability that the measurement lies OUTSIDE the 10 meter radius circle.

### **Custom Forms**

A custom form is a Graphical User Interface that permits field data personnel to input attribute information regarding a point, line or polygon. For example the name of a structure or canal.

### **Datum**

A datum is a mathematical model of the earth. Latitude and longitude coordinates are always relative to a datum. Most local datums model the earth for a small region, for example NAD83 for North America. WGS84 is a common world datum and is used as a default for most GPS receivers. WGS84 is virtually identical to NAD83.

### **Differential Correction**

Differential correction is a process used to remove the errors that have a detrimental effect on the accuracy of a GPS-derived position. Differential GPS (DGPS) employs two or more receivers. One receiver, called the base station, is placed at a known point and operated simultaneously with a field receiver called a rover. Errors in individual positions are determined by comparing differences observed between the base and the rover. Because the base station elevation mask is higher than the rover, this ensures that the base and the rover are using at least the same satellites. Therefore, the errors associated with the base should be the same as the errors affecting the rover.

### **Elevation Mask**

This is the lowest elevation, in degrees, at which a GPS receiver will track a satellite.

### **Firmware**

Firmware is programming that is inserted into programmable read-only memory (programmable ROM), thus becoming a permanent part of a computing device. Firmware is created and tested like software (using microcode simulation). When ready, it can be distributed like other software and, using a special user interface, installed in the programmable read-only memory by the user. Firmware is sometimes distributed for printers, modems, and other computer devices.

### **Geographic Information System (GIS)**

GIS refers to a computer-based system for capturing, storing, managing, manipulating, analyzing and displaying geographically referenced information (spatial data).

## **Global Positioning System (GPS)**

GPS refers to a method of obtaining accurate location information using Department of Defense (DOD) satellites. The system consists of 24 orbiting satellites that provide location coordinates to ground-based receivers for positioning, navigation, time dissemination, and other research.

## **Multipath**

This is defined as interference similar to 'ghosts' on a television screen, which occurs when GPS signals arrive at an antenna having traversed different paths. Multiple paths may arise from reflections off structures near the antenna. Multi-path error can be reduced using suppression technology.

## **PDA**

Personal Digital Assistant. This is a handheld, compact computer used to gather data in the field.

## **PDOP**

PDOP (Position Dilution of Precision) is a measure of satellite geometry. It consists of a mathematical calculation that accounts for each satellite's location relative to the other satellites in the constellation to predict the accuracy of positions obtained with that constellation. PDOP is the best overall indicator of accuracy, although PDOP alone does not guarantee good positions. Generally speaking the lower the PDOP is the higher the accuracy. A constellation of satellites with a PDOP of 4 or below is likely to yield highly accurate positions. A PDOP between 5 and 8 is acceptable. A PDOP greater than 8 is considered poor and will not meet accuracy standards published with the GPS unit.

## **Point Feature**

A point is a single X,Y coordinate that represents a geographic feature that is too small to be displayed as a line or area. A point can be used to represent features for which only one geographic location is needed. Point features can include water control structures, well locations and weather stations.

## **Post Processing**

The process of correcting GPS field data using a computer linked to a base station. A stationary and roving GPS receiver are used but rather than transmit the correction data in real time, the raw "pseudorange" distances to the satellites are stored at both receivers. After the mapping field data gathering is over, the data from the two receivers is "post processed" in a computer to reduce the effects of the errors. This has the advantage of not requiring a real time radio link, but its disadvantages are that the roving receiver does not know an accurate position until after the field data gathering (making it unsuitable for high accuracy navigation).

## **Real Time Measurements**

This is defined as GPS and Differential Correction measurements that are obtained almost instantaneously in the field.

## **Resource Grade GPS Receivers**

A type of handheld inexpensive GPS receivers used for recreational activities. Receiver types include Garmin, Magellan and Eagle. These types general navigation but should not be used for high accuracy site registration.



### **Professional Grade Differential GPS Receivers**

This is a type of GPS receiver system that is a combination beacon receiver for real-time differential corrections and high-performance GPS receivers. The receivers use the free differential GPS corrections from government-operated differential GPS navigation reference stations. These types of GPS receivers consistently achieve higher accuracy than the recreational GPS receivers.

### **RMS**

Root Means Squared means that approximately 68% of the positions are within the specified value. 2dRMS means that approximately 95% of the positions are within the specified value.

### **RTCM**

Radio Technical Commission for Maritime Services. Commission set up to define a differential data link to relay GPS correction messages from a monitor station to a field user.

### **Selective Availability (SA)**

This is the artificial degradation of the satellite signal by the Department of Defense. The error in position can cause a location to be off by as much as 100 meters. Selective Availability was officially turned off May 1, 2000 but can be reactivated at any time at the discretion of the DOD.

### **SNR**

This is defined as the Signal to Noise Ratio (SNR) value of each satellite that is currently being tracked. This is the strength of the signal. If a signal is too weak and does not meet the SNR Mask, it will not be used for positions. A SNR of 6 or more is considered good.

### **Sync/Synchronization**

This is defined as the ability to upload and download information between a desktop pc and a personal digital assistant. This can be done either through the use of a "cradle" type device that the PDA sits in and is connected to the desktop via a serial port or through a USB connection.

## 13.0 Appendix A - Acknowledgments

### GPS Information Sources

Trimble Regional Sales Office  
James M. Robeson (888) 782-1997 Toll Free  
GPSERV, Inc. (850) 656-6075 Local  
605 Crescent Executive Court  
Suite 300 (877) 778-1752 Pager  
Lake Mary, FL 32746  
Jim@GPServ.com

Trimble ProXR Receiver Manual  
Trimble Navigation Limited  
Surveying & Mapping Division  
645 North Mary Avenue  
Post Office Box 3642, Sunnyvale, CA

<http://www.Trimble.com>

Using ArcPad and ArcPad Application Builder Software  
<http://www.esri.com/software/arcpad/index.html>  
<http://www.esri.com/software/arcgis/arcgis/arcpad-appbldr/index.html>

RAD Division GPS SOP  
Environmental Monitoring & Assessment Department  
South Florida Water Management District

DEP Global Positioning Systems Standards  
Departmental of Water Facilities  
Florida Department of Environmental Protection  
2600 Blairstone Road, Tallahassee Florida 32399-2600

The Geographers Craft  
Global Positioning System Overview  
<http://www.colorado.edu/geography/gcraft/notes/gps>

The Hewlett-Packard Company  
3000 Hanover Street  
Palo Alto, CA 94304-1185  
<http://www.hp.com/>

## 14.0 Appendix B – Specifications

### Trimble - GeoXT

#### Standard features

##### System

- Microsoft Windows Mobile 2003 software for Pocket PCs
- 206 MHz Intel StrongARM processor
- 512 MB non-volatile Flash data storage
- Outdoor color display
- Ergonomic cable-free handheld
- Rugged and water-resistant design
- All-day internally rechargeable battery
- Bluetooth wireless

##### GPS

- Submeter accuracy
- Integrated WAAS1/EGNOS2
- RTCM real-time correction support
- NMEA and TSIP protocol support
- EVEREST multipath rejection technology

##### Software

- GPS Controller for control of integrated GPS and in-field mission planning
- GPS Connector for connecting integrated GPS to external ports
- File Explorer, Internet Explorer, Pocket Outlook (Inbox, Calendar, Contacts, Tasks, Notes), Pocket Backup, Transcriber, Pocket Word, Pocket Excel, Pictures, Windows® Media Player, Bluetooth File Transfer, Calculator, ActiveSync®

##### Accessories

- Support module with power supply and USB data cable
- Getting Started Guide
- Companion CD includes Outlook 2002 and ActiveSync 3.7.1
- Hand strap
- Pouch
- Stylus

#### Optional Features

##### Software

- TerraSync
- GPSCorrect for ESRI® ArcPad®
- GPS Pathfinder® Tools Software Development Kit (SDK)
- GPS Pathfinder Office
- Subscription to GPS Pathfinder Express service

##### Accessories

- Serial clip for field data and power input
- Vehicle power adaptor 3
- Portable power kit 3
- External antenna
- Pole-mountable ground plane
- Baseball cap with antenna sleeve

- BoB™ (Beacon-on-a-Belt) differential correction receiver<sup>3</sup>
- Hard carry case
- Null modem cable<sup>3</sup>
- Backpack kit

## Technical specifications

### Physical

Size	.21.5 cm × 9.9 cm × 7.7 cm (8.5 in × 3.9 in × 3.0 in)
Weight	.0.72 kg (1.59 lb) with battery
Processor	.206 MHz Intel StrongARM SA-1110
Memory	.64 MB RAM and 512 MB internal Flash disk
Power	
Low (no GPS)	.0.6 Watts
Normal (with GPS)	.1.4 Watts
High (with GPS, backlight, and Bluetooth)	.2.5 Watts
Battery	.Internal lithium-ion, rapidly rechargeable in unit, 21 Watt-hours

### Environmental

#### Temperature

Operating	.-10 °C to +50 °C (14 °F to 122 °F)
Storage	.-20 °C to +70 °C (-4 °F to 158 °F)

Humidity .99% non-condensing

Casing .Wind-driven rain and dust-resistant per IP 54 standard

Slip-resistant grip, shock- and vibration-resistant

### Input/output

Communications .Bluetooth for wireless connectivity  
USB via support module, serial via optional DE9 serial clip adaptor

#### Bluetooth

Certification .Bluetooth type approvals are country specific.

GeoExplorer series handhelds are approved for use with Bluetooth in the USA. For a complete list of other countries with Bluetooth approval please refer to [www.trimble.com/geoxt\\_ts.asp](http://www.trimble.com/geoxt_ts.asp).

#### Profiles

Both client and host support .Serial Port , File Transfer (using OBEX)

Client support only .Dial-Up Networking, Lan Access Profile

Host support only .Basic Imaging, Object Push

Display .Advanced outdoor TFT, 240 × 320 pixel, 65,536 colors, with backlight

Audio .Microphone and half duplex speaker, record and playback utilities

Interface .Anti-glare coated touch screen, Soft Input Panel (SIP) virtual keyboard

2 hardware control keys plus 4 programmable permanent touch buttons

Handwriting recognition software, Audio system events, warnings, and notifications

### GPS

Channels .12

Integrated real-time .WAAS1 or EGNOS2

Update rate .1 Hz

Time to first fix .30 sec (typical)

Protocols .NMEA (GGA, VTG, GLL, GSA, ZDA, GSV, RMC),

TSIP (Trimble Standard Interface Protocol)

### Accuracy (RMS)<sup>4</sup> after differential correction

GPS Pathfinder postprocessing<sup>5</sup> .Submeter

GPS Pathfinder carrier postprocessing<sup>6</sup>

With 10 minutes tracking satellites . . . . .30 cm

Real-time . . . . .Submeter

*1 WAAS (Wide Area Augmentation System). Available in North America only. For more information, see <http://gps.faa.gov/programs/index.htm>.*

*2 EGNOS (European Geostationary Navigation Overlay System). Available in Europe only. For more information, see <http://www.esa.int/export/esaSA/navigation.html>.*

*3 Serial clip also required.*

*4 Horizontal accuracy. Requires data to be collected with minimum of 4 satellites, maximum PDOP of 6, minimum SNR of 4, minimum elevation of 15 degrees, and reasonable multipath conditions. Ionospheric conditions, multipath signals or obstruction of the sky by buildings or heavy tree canopy may degrade precision by interfering with signal reception. Accuracy varies with proximity to base station by + 1 ppm for postprocessing and real time, and by + 5 ppm for carrier postprocessing.*

*5 Postprocessing with GPS Pathfinder Office software or GPS Pathfinder Express service.*

*6 Requires collection of carrier data. (Only available with the GPS Pathfinder Office software).*

## **Timble - ProXR Series**

### Standard features

#### GPS

- Integrated GPS/beacon/SBAS receiver
- Integrated GPS/beacon/SBAS antenna
- Real-time differential correction sources:
  - Coast Guard radiobeacon
  - WAAS1/EGNOS2
  - EVEREST multipath rejection technology
- RTCM input/output
- NMEA output
- Base station mode

#### Accessories

- International AC re-charger and power supply
- Rechargeable system batteries (8 hours of field use)
- Ergonomic backpack carrying system
- 3 meter antenna cable

### Optional features

#### Software

- TerraSync data collection and maintenance software
- GPScorrect™ for ESRI® ArcPad®
- Custom application built using the GPS Pathfinder Tools Software Development Kit (SDK)
- GPS Pathfinder Office software
- Subscription to GPS Pathfinder Express service

#### Field device

- Field device running Microsoft® Windows® CE operating system, such as:
  - GIS TSCe field device
  - Trimble Recon handheld
  - GeoExplorer series handheld
- Field device running Microsoft Windows desktop operating system

#### Accessories

- Vehicle kit (includes cigarette lighter power adaptor, quick release, 2 quick release adaptors, and magnetic mount)

### Technical specifications

#### Physical

##### GPS receiver

Size . . . . . 11.1 cm × 5.1 cm × 19.5 cm (4.4 in × 2.0 in × 7.7 in)

Weight . . . . . 0.76 kg (1.68 lbs)

##### Antenna

Size . . . . . 15.5 cm diameter × 10.8 cm high (6.1 in × 4.2 in)

Weight . . . . . 0.49 kg (1.08 lbs)

Power . . . . . 6 Watts (maximum), 10 to 32 VDC

#### Environmental

Temperature  
 Operating . . . . . -20 °C to +65 °C (-4 °F to +149 °F)  
 Storage . . . . . -30 °C to +85 °C (-22 °F to +185 °F)  
 Humidity . . . . . 100% fully sealed  
 Receiver casing . . . . . Dustproof, splashproof, shock-resistant; sealed to 5 psi  
 Antenna casing . . . . . Dustproof, waterproof, shock-resistant

**GPS**

General . . . . . 12 channel, L1/CA code tracking  
 carrier phase filtered measurements, multibit digitizer  
 Antenna . . . . . Right-hand, circular polarized;  
 omnidirectional; hemispherical coverage  
 Integrated real-time . . . . . WAAS1 or EGNOS2  
 Update rate . . . . . 1 Hz  
 Time to first fix . . . . . 30 seconds (typical)  
**Accuracy (RMS)<sup>3</sup> after differential correction**  
 GPS Pathfinder postprocessing<sup>4</sup> . . . . . 50 cm  
 GPS Pathfinder Office carrier postprocessing  
 With 5 minutes tracking satellites . . . . . 30 cm  
 With 10 minutes tracking satellites . . . . . 20 cm  
 With 20 minutes tracking satellites . . . . . 10 cm  
 With 45 minutes tracking satellites . . . . . 1 cm  
 Real-time . . . . . Submeter<sup>5</sup>

*1 WAAS (Wide Area Augmentation System). Available in North America only. For more information, see <http://gps.faa.gov/programs/index.htm>.*

*2 EGNOS (European Geostationary Navigation Overlay System). Available in Europe only. For more information, see <http://www.esa.int/export/esaSA/navigation.html>.*

*3 Horizontal accuracy. Requires data to be collected with minimum of 4 satellites, maximum PDOP of 6, minimum SNR of 4, minimum elevation of 15 degrees, and reasonable multipath conditions. Ionospheric conditions, multipath signals or obstruction of the sky by buildings or heavy tree canopy may degrade precision by interfering with signal reception. Accuracy varies with proximity to base station by + 1 ppm for postprocessing and by + 5 ppm for carrier postprocessing.*

*4 Postprocessing with GPS Pathfinder Office software or GPS Pathfinder Express service.*

*5 RTCM SC-104 standard format broadcast from a Trimble reference station. Accuracy varies with proximity to base station.*

*Specifications subject to change without notice.*

## **Trimble - Recon**

### Standard features

#### System

- Rugged and water-resistant design
- Microsoft Windows Mobile 2003 software for Pocket PCs
- All-day internally rechargeable battery
- Outdoor color display
- 400 MHz Intel XScale processor
- 128 MB non-volatile Flash data storage
- Two CompactFlash slots for memory and Bluetooth cards

#### Software

- Microsoft ActiveSync
- Microsoft File Explorer
- Microsoft Pocket Excel
- Microsoft Pocket Internet Explorer
- Microsoft Pocket Outlook: Inbox e-mail client, contacts, calendar, notes, tasks
- Microsoft Pocket Word
- Microsoft Windows® Media Player
- Sprite Pocket Backup
- Transcriber (handwriting recognition)

#### Accessories

- International AC re-charger (100–240 V)
- 10 screen protectors
- 2 stylus pens
- Getting Started Guide
- Hand strap
- Microsoft ActiveSync for desktop PC
- USB data cable

### Optional features

#### Software

- GPSCorrect™ for ESRI® ArcPad®
- TerraSync™
- GPS Pathfinder Tools Software Development Kit (SDK)
- GPS Pathfinder Office
- Subscription to GPS Pathfinder Express service

#### Accessories

- 12 V vehicle charging cable
- CF-Cap™ CompactFlash expansion slot seal
- GPS range pole bracket
- PowerBoot™ module
- Screen protectors
- Stylus 2-pack

### Technical specifications

#### Physical

Size . . . . . 16.5 cm × 9.5 cm × 4.5 cm (6.5 in × 3.75 in × 1.75 in)



Weight . . . . . 0.49 kg (17 oz) with battery module  
Processor . . . . . 400 MHz Intel PXA250 XScale CPU  
Memory . . . . . 64 MB high-speed SD-RAM, ~5.8 MB reserved  
Onboard non-volatile NAND Flash (128 MB internal Flash disk, ~16 MB reserved)  
Battery . . . . . Internal 3800 mAh NiMH, rechargeable in unit

**Environmental**

Operating temperature . . . . . -30 °C to +60 °C (-22 °F to +140 °F)  
Storage temperature . . . . . -40 °C to +70 °C (-40 °F to +158 °F)  
Humidity . . . . . MIL-STD-810F, Method 507.4  
Sand and dust . . . . . IP67, MIL-STD-810F, Method 510.4, Procedures I and II  
Water . . . . . sealed against accidental immersion (1 m for 30 minutes)  
IP67, MIL-STD-810F, Method 512.4, Procedure I  
Drop . . . . . withstands drop from 1.22 m (4 ft)  
MIL-STD-810F, Method 516.5, Procedure IV  
Vibration . . . . . vibration resistant, MIL-STD-810F, Method 514.5

**Input/output**

Expansion . . . . . 1 × Type I and 1 × Type II CompactFlash slots  
CF-Cap seal protects from rain, wind, and dust  
Display . . . . . 240 × 320 pixel (¼ VGA) color TFT with LED front light  
Interface . . . . . TFT touch screen, 10 hardware control keys  
Soft Input Panel (SIP) virtual keyboard and Transcriber software  
Audio system events, warnings, and notifications  
Communications . . . . . Standard 9-pin male D-shell RS-232 serial port  
USB-slave port, DC power port

## **ESRI - ArcPad**

### **Installing ArcPad 7 on Windows 2000 or XP**

#### **Minimum System Requirements**

Processor	PC-Intel® 450 MHz (or higher)
Operating System	Microsoft Windows 2000 or XP
RAM	256 MB
Free Disk Space	Approximately 100 MB
Desktop Synchronization Software	Microsoft ActiveSync 3.8 (or higher), if you intend to install ArcPad 7 on a Windows Mobile computer
Microsoft XML (MSXML) Parser	MSXML 4.0 Service Pack 2

Note: To use the ArcPad Tools for ArcGIS Desktop, ArcGIS Desktop ArcView, ArcEditor, or ArcInfo 9.0 or higher is required.

### **Installing ArcPad 7 on Windows Mobile or Windows CE**

#### **Minimum System Requirements**

Processor	ARM-based processors, including the following —Intel® (StrongARM®, XScale™) —Texas Instruments (OMAP) —Atmel —Samsung
Operating System	Windows Mobile: —2003, 2003 Second Edition, 5.0 Windows CE: - —4.2, 5.0
Memory	64 MB RAM
Free Storage Space	—Approximately 9 MB to install ArcPad —Approximately 512 MB or less for optional additional components
Desktop Synchronization Software	Microsoft ActiveSync 3.8 (or higher)
Microsoft XML (MSXML) Parser	MSXML 4.0 Service Pack 2

## **ESRI - ArcPad Application Builder**

### **System Requirements**

The following system requirements are for ArcPad Studio, the desktop application for customizing ArcPad. However, the customization files created with ArcPad Studio can be used with ArcPad on any device that meets the system requirements for ArcPad.

### **Operating System**

- Windows XP (including Tablet PC)
- Windows 2000

### **Customization Environment**

Many of the customization and personalization tasks are performed directly using ArcPad Studio and require little or no programming. For more complex tasks, ArcPad exposes an extensive object model that can be accessed by writing JScript and VBScript code.

### **Microsoft XML Parser**

The ArcPad Application Builder requires Microsoft XML Parser MSXML 4.0 Service Pack 2 (SP2) or higher. This parser should be installed on your desktop PC before starting ArcPad Studio. It can be obtained from Microsoft's Download Center.

## **Trimble - GPS Correct**

### Features and options

- Fully integrated with ESRI ArcPad 6.0 or later
- Choice of any Trimble GPS Pathfinder receiver or GeoExplorer series handheld
- Choice of Microsoft Windows CE device or PC field computer

### GPS integration and control

- Simple GPS and real-time configuration
- Enhanced graphical skyplot and satellite information
- Detailed real-time status information
- Mission planning for satellite prediction in the field

### GPS accuracy

- Real-time differential correction (available sources depend on GPS receiver used)
- Improved position accuracy by differential postprocessing of GPS data
- Easy differential correction of GPS positions in ESRI ArcPad Shapefiles
- Choice of office processing software or online service for differential correction and export to GIS
- SuperCorrect™ logging option for:
  - improved accuracy
  - postprocessing of all data, including data corrected in real-time, and data collected when satellites visible in the field and at the base are different
  - postprocessing with different GPS quality control settings from those used in the field (with the GPS Pathfinder Office software)
- Optional velocity filter for better accuracy in high-multipath locations

### GPS receivers and accuracy specifications

#### Receiver Real-time differential Postprocessed

GPS Pathfinder Power submeter submeter + 1 ppm

GPS Pathfinder Pro XR submeter 50 cm + 1 ppm

GPS Pathfinder Pro XRS submeter 50 cm + 1 ppm

GPS Pathfinder Pocket 2–5 m 2–5 m

GeoXT™ handheld submeter submeter

GeoXM™ handheld 2–5 m 2–5 m

### GPS postprocessing options

To differentially correct GPS data logged by GPScorrect, and merge corrected data with Shapefiles, one of the following is required:

- GPS Pathfinder Office version 2.90 or later
- Subscription to the online GPS Pathfinder Express service ([www.trimble.com/express](http://www.trimble.com/express))

### Recommended hardware

#### Windows CE device

Operating system . . . . . Windows CE version 2.11, 2.12, 3.0, or 4.x (CE .NET)

Processor type . . . . . MIPS, SH3, ARM, or XScale processor

Processor speed . . . . . 70 MHz

Memory . . . . . 16 MB RAM

at least 8 MB free memory (for ArcPad and GPScorrect installation)

Input/output . . . . . Serial cable and RS-232 serial port (or appropriate adapter)

Display . . . . . Color or grayscale touch screen (240 x 320 pixels or larger)

Reflective screen (or other screen suitable for outdoor viewing)

### Windows .eld device

Operating system . . . . . Windows 95, 98, Me, NT 4.0, 2000, or XP  
Processor type . . . . . Intel Pentium CPU  
Processor speed . . . . . 70 MHz  
RAM . . . . . 32 MB  
Free disk space . . . . . 3 MB  
Input/output . . . . Serial cable and RS-232 serial port (or appropriate adapter)

### Tested devices

Tested devices are listed at [www.trimble.com/gpscorrect](http://www.trimble.com/gpscorrect).

Note: Check ArcPad documentation for any additional requirements.

### Recommended hardware

#### Windows CE device

Operating system . . . . . Windows CE version 2.11, 2.12, 3.0, or 4.x (CE .NET)  
Processor type . . . . . MIPS, SH3, ARM, or XScale processor  
Processor speed . . . . . 70 MHz  
Memory . . . . . 16 MB RAM  
at least 8 MB free memory (for ArcPad and GPScorrect installation)  
Input/output . . . . Serial cable and RS-232 serial port (or appropriate adapter)  
Display . . . . . Color or grayscale touch screen (240 x 320 pixels or larger)  
Reflective screen (or other screen suitable for outdoor viewing)

#### Windows .eld device

Operating system . . . . . Windows 95, 98, Me, NT 4.0, 2000, or XP  
Processor type . . . . . Intel Pentium CPU  
Processor speed . . . . . 70 MHz  
RAM . . . . . 32 MB  
Free disk space . . . . . 3 MB  
Input/output . . . . Serial cable and RS-232 serial port (or appropriate adapter)

### Tested devices

Tested devices are listed at [www.trimble.com/gpscorrect](http://www.trimble.com/gpscorrect).

## **Trimble - Pathfinder Office**

### Features and options

#### GPS accuracy

- Improve GPS position accuracy through differential postprocessing
- Postprocess real-time differential GPS data to improve accuracy and consistency
- Review and edit GPS data before you transfer it to a GIS
- Compatible with any Trimble® GPS Pathfinder receiver or GeoExplorer® series handheld

#### GIS compatibility

- Import data from popular GIS, CAD, and database formats
- Export data into a wide variety of GIS, CAD, and database formats
- Create data dictionaries to ensure data collected is consistent with GIS requirements

#### Work.ow

- Plan GPS field sessions to ensure productive use of field time
- Set up multiple field computers with the same files and settings
- Automate data transfer, differential correction, and data export

#### Recommended hardware

Operating system . . . . . Microsoft® Windows® 95, 98, Me, NT 4.0 or later, 2000, XP, or XP Tablet PC Edition

Processor type . . . . . Pentium

Processor speed . . . . . 400 MHz

Memory . . . . . 64 MB RAM

Free disk space . . . . . 160 MB

Input/output . . . . . RS-232 serial port and USB port

#### Available languages

- English • German • Russian
- Portuguese • Spanish • Korean
- French • Chinese (Simpli.ed) • Japanese

#### Field software options

- TerraSync™ software
- GPSCorrect™ extension for ESRI® ArcPad® software
- Applications developed using GPS Pathfinder Tools Software Development Kit (SDK)

#### GPS receivers and accuracy (RMS)<sup>1</sup> specifications

##### Receiver Real-time Postprocessed Postprocessed differential differential carrier<sup>2</sup>

GPS Pathfinder Power submeter submeter 1 cm

GPS Pathfinder Pro XR submeter 50 cm 1 cm

GPS Pathfinder Pro XRS submeter 50 cm 1 cm

GPS Pathfinder Pocket 2–5 m 2–5 m not available

GeoXT™ handheld submeter submeter 30 cm

GeoXM™ handheld 2–5 m 2–5 m not available

#### Supported formats

##### Supported import and export formats

##### Import formats

- AutoCAD DXF

- dBASE
- ESRI Shapefiles
- MapInfo MIF
- Microsoft Access MDB

#### Export formats

- ARC/INFO (for NT and UNIX) Generate
- ESRI Shapefiles
- AutoCAD DXF (with or without blocks)
- dBASE
- GRASS
- IDRISI Vector
- MapInfo MIF
- MGAL
- Microsoft Access MDB
- Microstation DGN
- PC-ARC/INFO Generate
- PC-MOSS

#### Vector background formats

- AutoCAD ASCII DXF (.dxf)
- AutoCAD binary DXF (.dxf)
- ESRI Shapefiles (.shp)
- Trimble SSF format (.ssf, .cor, .phs, .imp)

#### Raster (image) background formats

- JPEG (.jpeg)
- MrSID (.sid)
- TIFF (.tif)
- Windows bitmap (.bmp)

#### Web map servers

- ArcIMS
- OpenGIS

#### Supported base file and compression formats

##### Base .le formats Compression types

- Trimble DAT format • EXE
- Hatanaka (Compressed RINEX) • GZ
- RINEX • ZIP
- Trimble SSF format

## 15.0 Author Information

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