Class Notes – Design, Capture, Edit, And Integration Of Resource-Grade Trimble® GPS Data

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Revised March 15, 2004

(Portions adapted from Trimble® documentation)

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Chapter 1 – Background And General Issues

Proliferation Of GPS Applications

Not that many years ago, GPS was the domain of surveyors, hardcore wireheads, NASA, and the military. Today, GPS applications are all around us. A few examples include:

- Surveying, mapping, and GIS (Trimble, Leica, Rockwell, Corvallis Microtechnology, etc.);
- Recreational navigation (Garmin, Magellan, etc.);
- Vehicle navigation and location (StreetMap, OnStar, AVL, etc.);
- Rental car monitoring (renters can be charged for speeding and driving off-road);
- Cell phones (big brother knows where callers are);
- Aviation and maritime point-to-point navigation;
- Mining and agricultural machine control;
- Search and rescue dogs; and
- Virtual cattle fences.

Grades Of GPS Receiver

Resource management agencies commonly use both recreational-grade and resource-grade GPS receivers. Each grade is appropriate for some uses, and inappropriate for others. Although resource-grade receivers are the focus of this class, a brief comparison of the two illustrates their general uses, capabilities, and limitations.

- **Recreational-grade** - Used for recreational navigation, as well as for low-standard data capture and mapping, about $100 - $500. Examples include Garmin and Magellan models.
- **Resource-grade** - Used for data capture and mapping to National Map Accuracy Standards (Primary Base Series quad map features, for instance), about $4,000 - $10,000. Trimble examples include the GeoExplorer series, GeoXT/XM, ProXL, and ProXRS.

Table 1.01 compares basic characteristics of resource-grade and recreational-grade GPS receivers.

Table 1.01 – Comparison of resource-grade and recreational-grade GPS receivers.

Item	Resource-Grade Receivers	Recreational-Grade Receivers
Cost	Relatively high, $4,000 - $10,000.	Relatively low, $100 - $500.
Differential correction methods	Post-processing. Real-time and WAAS correction, if so equipped.	No post-processing. Real-time and WAAS correction, if so equipped.
Feature attribution	Extensive feature attribution is possible using data dictionaries.	Very limited feature attribution is possible using waypoint or tracklog names.
Control of position quality	Receivers can be configured to achieve different levels of GPS position quality. GPS positions are captured only when signal quality standards are met.	Receivers cannot be configured to achieve different levels of GPS position quality. GPS positions are captured indiscriminately.
Data lineage	Output files document data collection parameters. Data quality and lineage can be assessed subsequent to capture.	Output files do not document data collection parameters. Data quality and lineage cannot be assessed subsequent to capture.

Item	Resource-Grade Receivers	Recreational-Grade Receivers
National Map Accuracy Standards (NMAS)	Varies by type of receiver/antenna, as well as obstructions, but generally considered to meet NMAS if: • PDOP mask is set to 8 or less; • SNR mask is set to 6 or more, or to Trimble's recommended default setting for that model of GPS receiver; • Position mode is set to 3D only; • Data have been differentially corrected (post-processed, real-time, or WAAS); • Base files (for post-processing) come from a 3rd-order survey base station within 500 km (310 miles) of the rover collection site; and • Rates of line densification are adequate to capture a feature's actual alignment.	May meet NMAS (particularly in open, unobstructed terrain) in either autonomous, real-time corrected, or WAAS-corrected modes. In practice, however, lack of signal quality documentation and data lineage prevents presumption that NMAS standards have been achieved.

Typical Resource-Grade Receiver Components

Depending on the model, resource-grade receivers may include these components:

- GPS receiver;
- Data logger;
- Rechargeable or disposable battery pack;
- External antenna and cable;
- Data transfer cable/cradle;
- Battery charger; and
- Carrying strap/lanyard and case.

Receiver/Data logger Firmware

GPS receivers/data loggers run a form of software known as firmware. Check equipment against Trimble's web site to verify that current firmware is installed.

`http://www.trimble.com/support.html`

Example procedures for determining which version of firmware is installed on several common GPS receivers/data loggers are described below.

- **GeoExplorer II** – Firmware version is displayed during startup, **`Version 2.20`**, for instance.
- **GeoExplorer 3** – Select ***SYS - Setup – About***.
- **GeoXT/XM** – Tap ***Start – Settings - Control Panel – System – General***.

Updates to currently owned firmware are typically available by free download from Trimble. Firmware upgrades, however, may not be free.

To be eligible for subsequent updates and upgrades, be sure to register all newly purchased GPS equipment and software with Trimble.

Pathfinder Office Software

GPS practitioners with TerraSync-based receivers (like a GeoXT) will need version 2.90, or better, of the Pathfinder Office (PFO) software installed on their PC. PFO 2.80 is generally adequate for those without TerraSync-based receivers.

To see if free software updates are available, check Trimble's web site, or click ***Help – Check for new GPS Pathfinder Office updates now…*** in Pathfinder Office. Usually, PFO upgrades are not free.

Installing Pathfinder Office on a Windows 2000 PC requires administrator privileges.

Accuracy

GPS positions are not absolute! Their accuracy depends on many factors, including those described below.

- Technical sophistication of a receiver, as well as its antenna and firmware;
- Receiver settings for PDOP, SNR, and elevation mask;
- Signal interference created by the atmosphere, terrain, vegetation, other obstructions, and multi-path environments;
- Method of differential correction employed (post-processing, real-time beacon, or real-time WAAS); and
- Quality of, and distance to, base station file providers. All base stations are not created equal.

As it turns out, GPS position accuracy is really a matter of statistics. Along with that, comes the standard statistical irony that greater ambiguity about a GPS feature's actual position must be accepted in order to have a higher level of confidence about the position's quality.

In order to have a technically meaningful basis for evaluating a position's quality, its accuracy must be framed in terms of the measures described below.

- **Circular Error Probable (CEP)** – The horizontal radius of a circle enclosing 50% of the GPS positions collected at a single point.
- **Root Mean Square (RMS)** - The horizontal radius of a circle enclosing about 68% of the GPS positions collected at a single point.
- **Two Degree Root Mean Square (2DRMS)** - The horizontal radius of a circle enclosing about 95% of the GPS positions collected at a single point.

Table 1.02 reports Trimble's estimate of horizontal accuracy (meters RMS) under **ideal, controlled conditions**.

Table 1.02 – Trimble's estimate of horizontal accuracy (meters RMS) under ideal, controlled conditions.

	Horizontal Accuracy (Meters RMS, 68% confidence)			
Correction Method	GeoExplorer Pocket GeoXM	ProXL	GeoXT	ProXR/XRS
Uncorrected (autonomous)	15	15	15	15
Real-time beacon	2-5	1-5	<1	1-5
Post-processing	2-5	1	<1	0.5

Follow this link to review reports of GPS receiver performance under "real world" conditions, as well as the Forest Service draft GPS data accuracy standard.

http://www.fs.fed.us/database/gps/gpsusfs.htm

National Map Accuracy Standards Make GPS Receiver Settings Important

National Map Accuracy Standards (NMAS) require features portrayed on 7.5-minute Primary Base Series quad maps to be within 40 feet (12.2 meters) of their true position. Refer to **Table 1.01** for resource-grade GPS receiver settings generally considered to meet NMAS.

Prior to inclusion in corporate GIS datasets, features receive a **Source Code** and **Method Code** documenting their lineage, or pedigree. GPS features that meet NMAS receive a **Source Code** of "**02**" and a **Method Code** of "**02**", indicating that they are eligible for inclusion in updates of 7.5-minute Primary Base Series quad maps. GPS features that do not meet NMAS receive a **Source Code** of "**24**" and a **Method Code** of "**02**", indicating that they are not eligible for inclusion in updates of 7.5-minute Primary Base Series quad maps.

Nevertheless, just because GPS data don't meet NMAS, don't think of them as being "one-time-use" or "throw-away" data! Yes, NMAS features are more desirable, but, in many cases, non-NMAS features are perfectly suitable for inclusion in corporate GIS datasets as long as they are tagged with the appropriate **Source Code** and **Method Code** described above.

GIS features are considered to be of GPS origin **only** if their coordinate system and datum are known, and they meet one of these conditions.

- GIS features are created directly from GPS data files, and no positions are added or moved.
- GIS features are generated from verbatim transcription of GPS coordinates, and no positions are added or moved.

Chapter 2 - How Does GPS Work?

GPS Has Five Basic Components

- **Satellite trilateration** – the fundamental basis of position determination.
- **Satellite ranging** – measuring distances from satellites to a position.
- **Accurate timing** – why consistent clocks and a fourth satellite are needed.
- **Satellite positioning** – knowing where satellites are in space.
- **Correcting errors** – correcting for various errors.

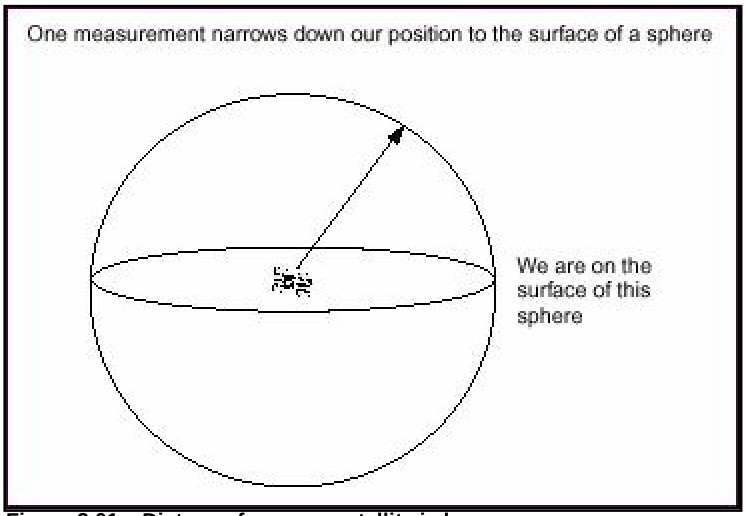


Figure 2.01 – Distance from one satellite is known.

Satellite Trilateration

If the distance from one satellite to a position is known (**Figure 2.01**), the position's location can be described as being on the surface of a sphere having the satellite at its center, and a radius equal to the known distance.

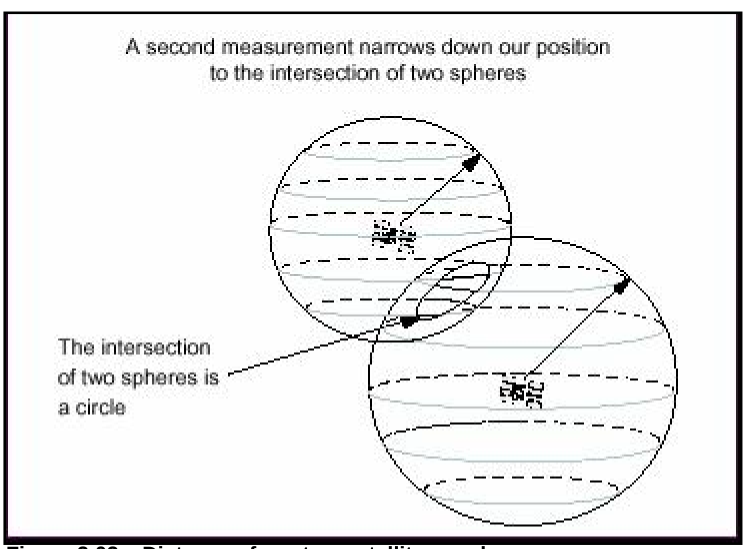


Figure 2.02 – Distances from two satellites are known.

If the distance from a second satellite to the position is also known (**Figure 2.02**), the position's location is narrowed down to the intersection of two spheres. The intersection of 2 spheres forms a circle.

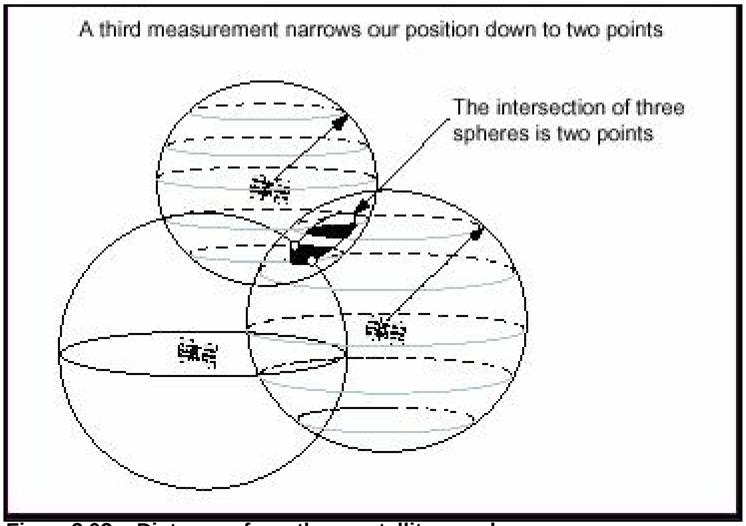


Figure2.03 – Distances from three satellites are known.

Knowing the distance from a third satellite to the position (**Figure 2.03**) restricts the position's location to the intersection of three spheres, only two possible points.

As it turns out, one of these points is way out in space (not anywhere near earth's surface), so, theoretically, the x, y, and z coordinates of the position are now known.

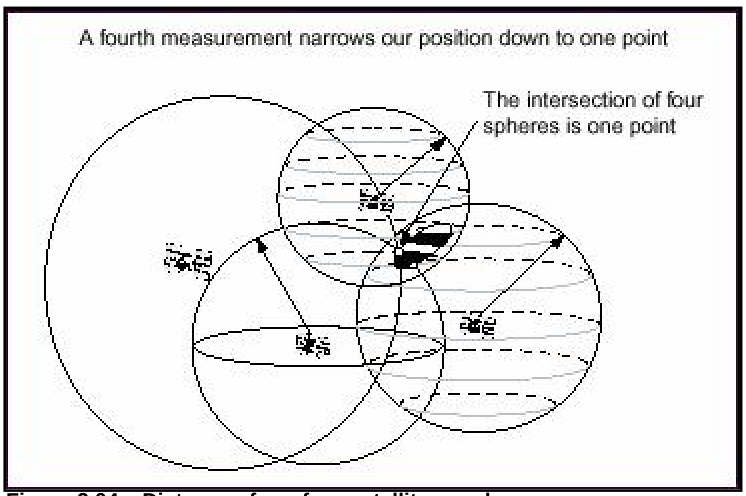


Figure 2.04 – Distances from four satellites are known.

In practice, however, a fourth satellite (**Figure 2.04**) is needed to account for clock and timing errors.

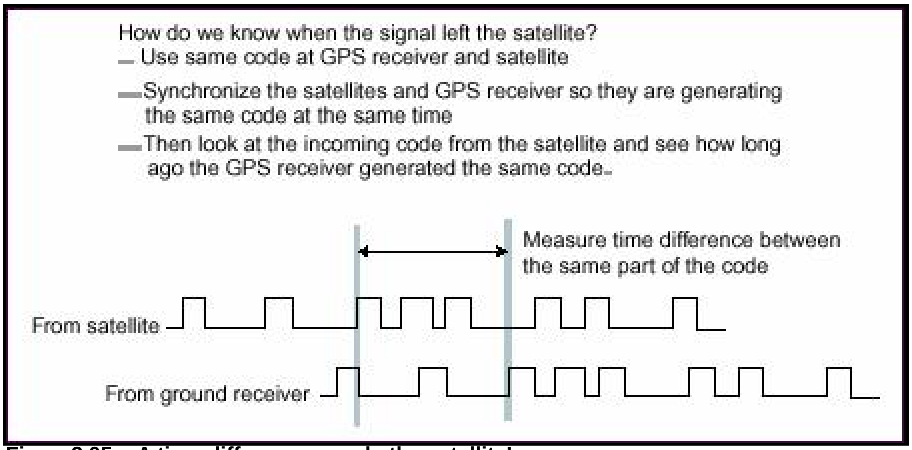


Figure2.05 – A time difference equals the satellite's range.

Satellite Ranging

When working perfectly, GPS receivers and GPS satellites generate a unique week-long code in perfect synchrony with one another. GPS receivers examine incoming code from each satellite and calculate how long ago the receiver generated that same bit of coded sequence, (**Figure 2.05**). This time difference is multiplied by the speed of light (about 186,000 miles per second) to establish the receiver's distance from each satellite. At that speed, light travels 1 meter in about 0.000000003 seconds!

GPS files can't exceed 7 day's length because duplicate segments of the unique week-long code will appear in different portions of the file, creating ambiguity about calculated positions.

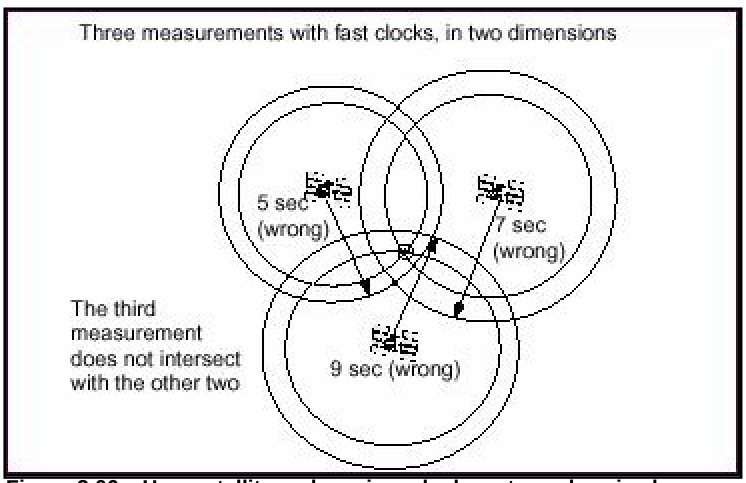


Figure 2.06 – How satellite and receiver clocks get synchronized.

Accurate Timing

Ranging calculations depend on highly accurate clocks because the unique week-long code has to be generated in both the receiver and satellites at exactly the same time. Satellites have extremely accurate atomic clocks, but these are too expensive and heavy to include with every GPS receiver. A clever process, however, permits a receiver to continuously synchronize its clock with satellite clocks by obtaining a measurement from a fourth satellite. How is this possible?

In the simplified, 2-dimensional example above (**Figure 2.06**), the inner circles around each satellite represent accurately calculated receiver-to-satellite ranges that result from perfectly synchronized satellite and receiver clocks. Note that the 3 inner circles all pass through a single point, the true position of the receiver.

The outer circles demonstrate what can happen when an imperfectly synchronized receiver clock mis-calculates satellite ranges. Note that the 3 outer circles fail to pass through a single point, creating ambiguity about the true position of the GPS receiver. This ambiguity alerts the receiver that clock synchronization errors exist.

When a GPS receiver gets a series of measurements that do not intersect at a single point, the receiver iteratively adds or subtracts time intervals until it achieves a solution permitting ranges from all satellites to pass through a single point. It then adjusts its own clock by that time differential.

Since three satellites are required to detect and resolve 2-dimensional clock errors (as illustrated above), a fourth satellite is needed to detect and resolve 3-dimensional clock errors.

Satellite Positioning

About twenty-four GPS satellites orbit the earth every 12 hours at an altitude of about 12,600 miles, four satellites in each of 6 orbital planes inclined at 55^{o} to the equator. The satellites' altitude is so great that there is little atmospheric drag, making their orbits extremely stable.

Earth-based tracking stations continuously monitor satellite orbit and clock performance, and transmit corrections or adjustments to satellites, as necessary. Satellites, in turn, transmit their orbital data (also known as ephemeris) to GPS receivers in the form of an "almanac". GPS receivers use the almanac to calculate satellite elevation and position, as well as PDOP parameters.

Correcting Errors

Ranging calculations assume that GPS signals travel at the constant speed of light. Unfortunately, the speed of light is only constant in a vacuum. As it turns out, GPS signals slow down as they penetrate the earth's ionosphere and troposphere. Trimble GPS receivers can make partial corrections for these delays.

Atomic clock errors and satellite orbit errors can occur, but they are usually very minor, and are continuously corrected by earth-based tracking stations.

Multi-path errors occur when GPS signals reflect off objects at, or near, the earth's surface. To a GPS receiver, reflected signals are nearly indistinguishable from straight-line signals, and occasionally result in an incorrect range being calculated. Advanced signal processing and antenna design help minimize multi-path errors.

Typical GPS Position Error Budget

Table 2.01 illustrates a typical error budget for corrected and uncorrected GPS positions. Note that differential correction makes total correction for clock and orbit errors, partial correction for ionospheric and tropospheric delay, and no correction at all for receiver noise or multi-path error.

Although these numbers may vary on any given day, their relative magnitudes provide an indication of their relative contribution to total error.

Table 2.01 – Typical GPS position error budget.

Typical Error In Meters (per satellite)	Uncorrected	Corrected
Satellite clock errors	1.5	0.0
Orbit errors	2.5	0.0
Ionospheric delay	5.0	0.4
Tropospheric delay	0.5	0.2
Receiver noise	0.3	0.3
Multi-path errors	0.6	0.6
Total	10.4	1.5

Chapter 3 – What Is PDOP?

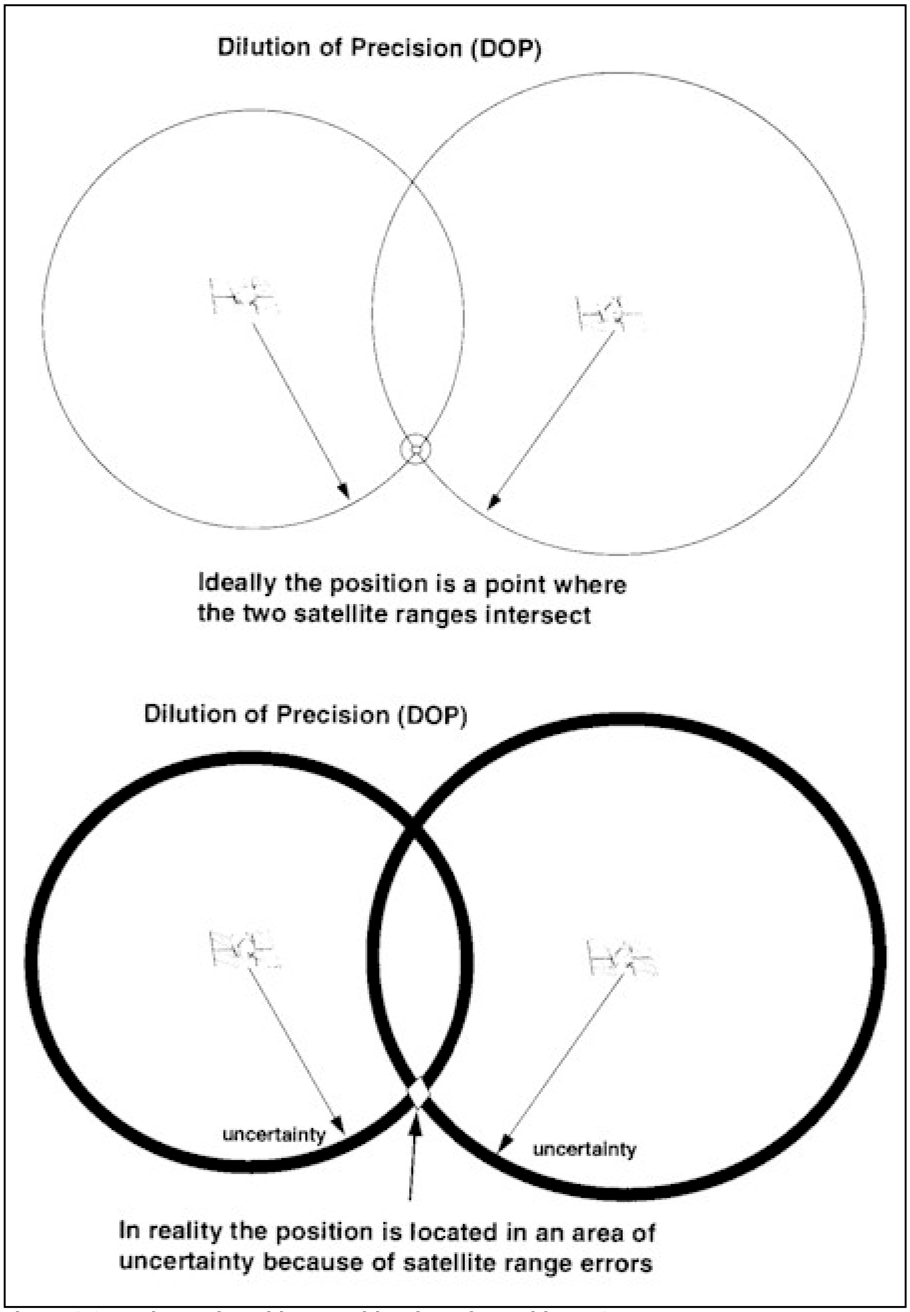


Figure 3.01 – Lines-of-position resulting from favorable PDOP.

Position dilution of precision (PDOP) is a measure of current satellite geometry, and is probably the single most important factor in capturing high quality GPS positions. Lower PDOP values produce more accurate GPS positions.

As a rule of thumb, “good” geometry, low PDOP, and more accurate GPS positions occur when satellites are well distributed across the sky.

As illustrated in **Figure 3.01**, well distributed satellites create lines-of-position that cross each other at more nearly perpendicular angles, creating cleaner position intersections.

On the other hand, “poor” geometry, high PDOP, and less accurate GPS positions result when satellites are arranged linearly, or are clustered in one quadrant of the sky.

Figure 3.02 illustrates that when satellites are too close together, or too widely scattered, they create lines-of-position that cross at more oblique angles, making clean position solutions more difficult.

As illustrated in the upper-left corner of **Figure 3.03**, the ideal minimum constellation has four satellites, three evenly spaced around the horizon, and one overhead. In this arrangement, horizontal error from each satellite is checked by measurements from opposing satellites, while the overhead satellite checks vertical accuracy of the other three.

Constellation geometry and PDOP fluctuate constantly as satellites proceed along their separate orbits, and as a GPS receiver’s view of the sky changes due to vegetation, terrain, or other obstructions.

Trimble GPS receivers will automatically suspend data capture whenever current PDOP exceeds a configuration setting known as the PDOP mask.

Trimble recommends a PDOP mask of 6 or less to ensure capture of high quality GPS positions. National Map Accuracy Standards (NMAS) specify a PDOP mask of 8 or less.

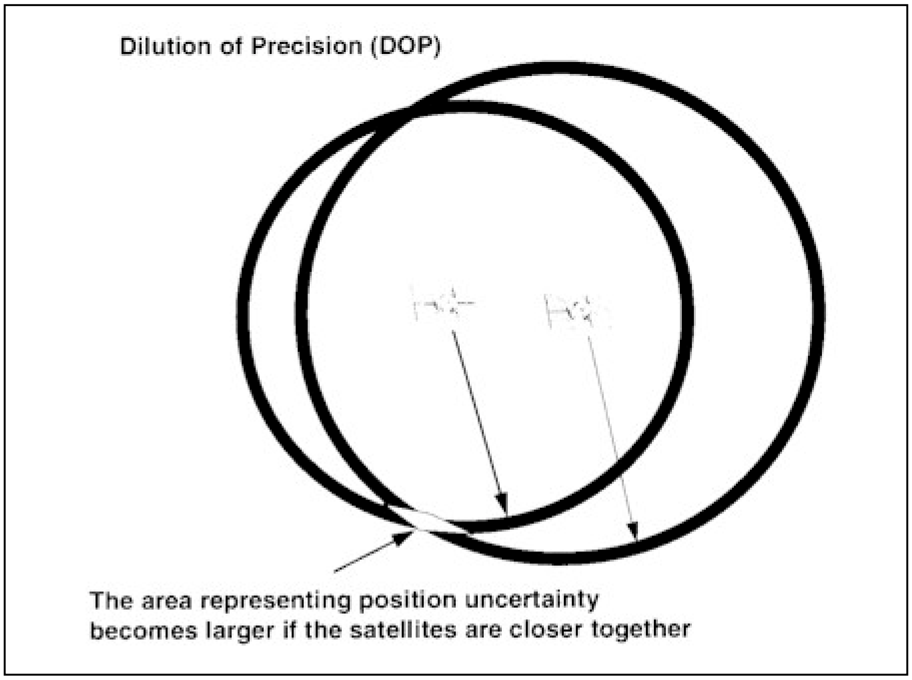


Figure 3.02 – Lines-of-position resulting from unfavorable PDOP.

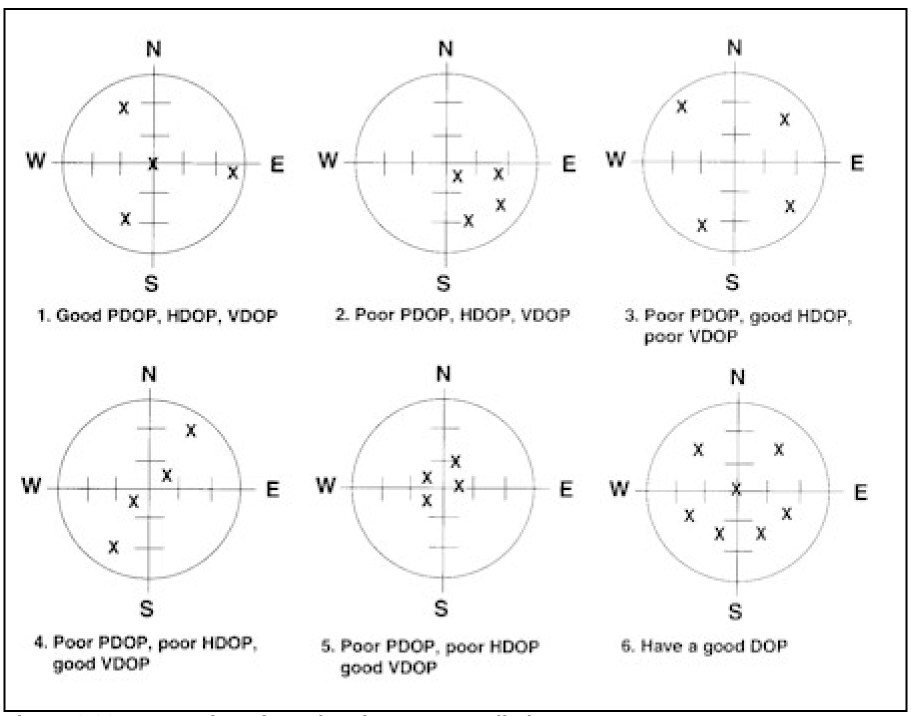


Figure 3.03 – Examples of good and poor constellation geometry.

Chapter 4 – Mission Planning

Pathfinder Office contains a mission-planning tool named Quick Plan. Although its predictions should never be viewed as a guarantee, it is an extremely useful tool for identifying time periods most likely to produce interruption-free data capture. It's sure to save time, and improve efficiency in the field.

In order to produce satisfactory results, Quick Plan needs a current GPS almanac, a digital file containing a complete accounting of satellite orbital data. Trimble GPS receivers collect a fresh almanac every time they are powered on for 15 – 20 minutes, and have a clear view of the sky. Click ***Utilities – Data Transfer…*** on the Pathfinder Office menu bar to transfer an almanac from a Trimble GPS receiver to a connected PC.

To start Quick Plan, click ***Utilities – Quick Plan…*** on the Pathfinder Office menu bar. Basic mission planning steps are outlined below.

- Specify a date for which mission planning is to occur.
- Specify a location for which mission planning is to occur. Locations may be selected from a world map or a list of cities, or entered as a coordinate pair from the keyboard.
- If the time zone displayed in the Status window (**Figure 4.01**) is inappropriate, click ***Options – Time Zone…*** and specify the time zone corresponding to the mission's location.
- If the almanac file displayed in the Status window (**Figure 4.01**) is not current, click ***Options – Almanac…*** and specify a fresh almanac file recently transferred from GPS receiver to PC.
- Click ***Graphs – Number SVs and PDOP*** to view a graph of satellite availability and PDOP, see **Figure 4.03**.

  The upper graph plots number of visible satellites (Nsats) against time of day. Remember that 4, or more, satellites are needed to produce 3D GPS positions.

  The lower graph plots PDOP against time of day. Trimble GPS receivers will suspend data capture whenever PDOP exceeds the configured PDOP mask setting.
- The Auto Time feature displays diagonally hatched blocks on the Number SVs and PDOP graph (**Figure 4.03**) that clearly identify likely data capture periods. Click ***Options – Auto Time…*** and configure as desired, using **Figure 4.02** as an example.
- For a tabular listing of likely data capture periods and their duration, click ***Options – List Times***, see **Figure 4.04**.
- Click ***Options – Elevation Mask…*** to edit current elevation mask setting. Increasing elevation mask from 15° (the default) to, say, 30°, better simulates data capture in dense vegetation or steep terrain that may restrict a GPS receiver's view of the sky, see **Figure 4.03**.
- Click ***Session – Edit Session…***, if desired, to edit date, time, and location parameters.
- Select the Number SVs and PDOP graph, or the List Times table, and click ***File – Print Graph…*** or ***File – Print Auto Time…*** to print a hard copy of the selected object.
- Click ***File – Exit*** to quit Quick Plan.

Trimble's Stand-Alone Planning Software

Trimble has updated Quick Plan, and released it as a stand-alone application named Trimble Planning Software. It is available by free download from:

http://www.trimble.com/planningsoftware.html

A QuickStart Guide for Trimble Planning Software is available from:

http://www.fs.fed.us/database/gps/gpsplanning/QuickStartTrimblePlanning.pdf

Figure 4.01 – Status window.

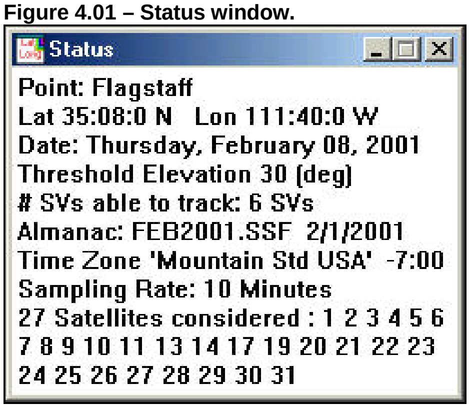


Figure 4.02 – Sample auto time configuration.

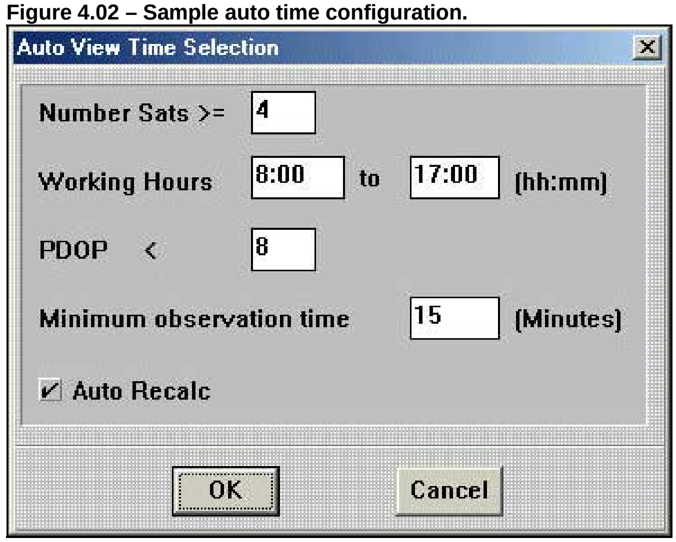


Figure 4.03 – Number SVs and PDOP graph with threshold elevation (elevation mask) set to 30°.

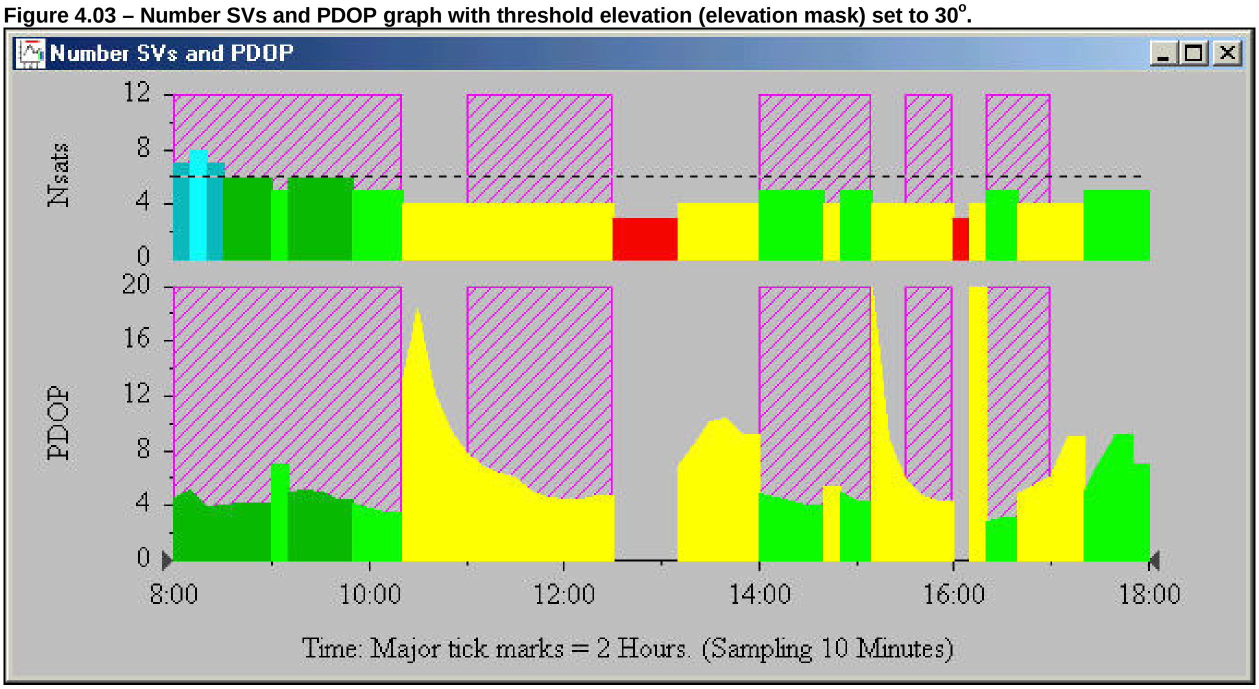
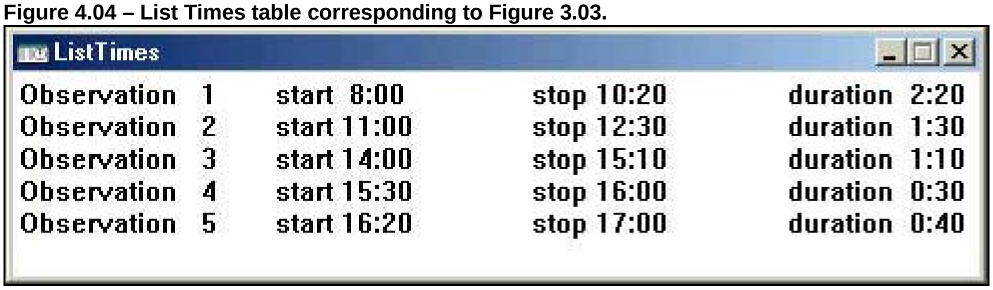


Figure 4.04 – List Times table corresponding to Figure 3.03.



Chapter 5 – Data Dictionaries

Data dictionaries permit a combination of many point, line, and polygon features to be captured in a single GPS file. They also provide a mechanism of enforcing consistent data structure, as well as some measure of data validation. In fact, designing a GPS data dictionary to match a corresponding GIS data structure greatly facilitates the process of appending newly acquired GPS data to an existing GIS coverage. When GPS data are exported, a GIS coverage bearing the feature's dictionary name is created for each feature represented in a data dictionary.

Open the data dictionary editor (**Figure 5.01**) by clicking ***Utilities – Data Dictionary Editor…*** on the Pathfinder Office menu bar. Follow these basic steps.

Define features - Features are point, linear, or polygonal objects like signs, roads, or pastures, respectively. Use the ***New***, ***Edit***, or ***Delete*** buttons below the Features pane. **Figure 5.02** illustrates the process of creating or editing a feature's definition.

Define attributes for each feature – Attributes are data about a feature, its name, height, or condition, for instance. Use the ***New***, ***Edit***, or ***Delete*** buttons below the Attributes pane. Basic attribute types include menu, numeric, text, date, and time, **Figure 5.03**. The form used to define each type of attribute is different. The form in **Figure 5.04** illustrates the process of creating or editing a menu-type attribute.

Right-click a feature or attribute to copy, paste, or rearrange its position in the sequence.

Existing Trimble data dictionaries may be copied and modified, the table structure of imported shapefiles (**`.imp`** format) can be converted to a data dictionary, and data dictionaries can be exported as text.

Figure 5.01 – The data dictionary editor.

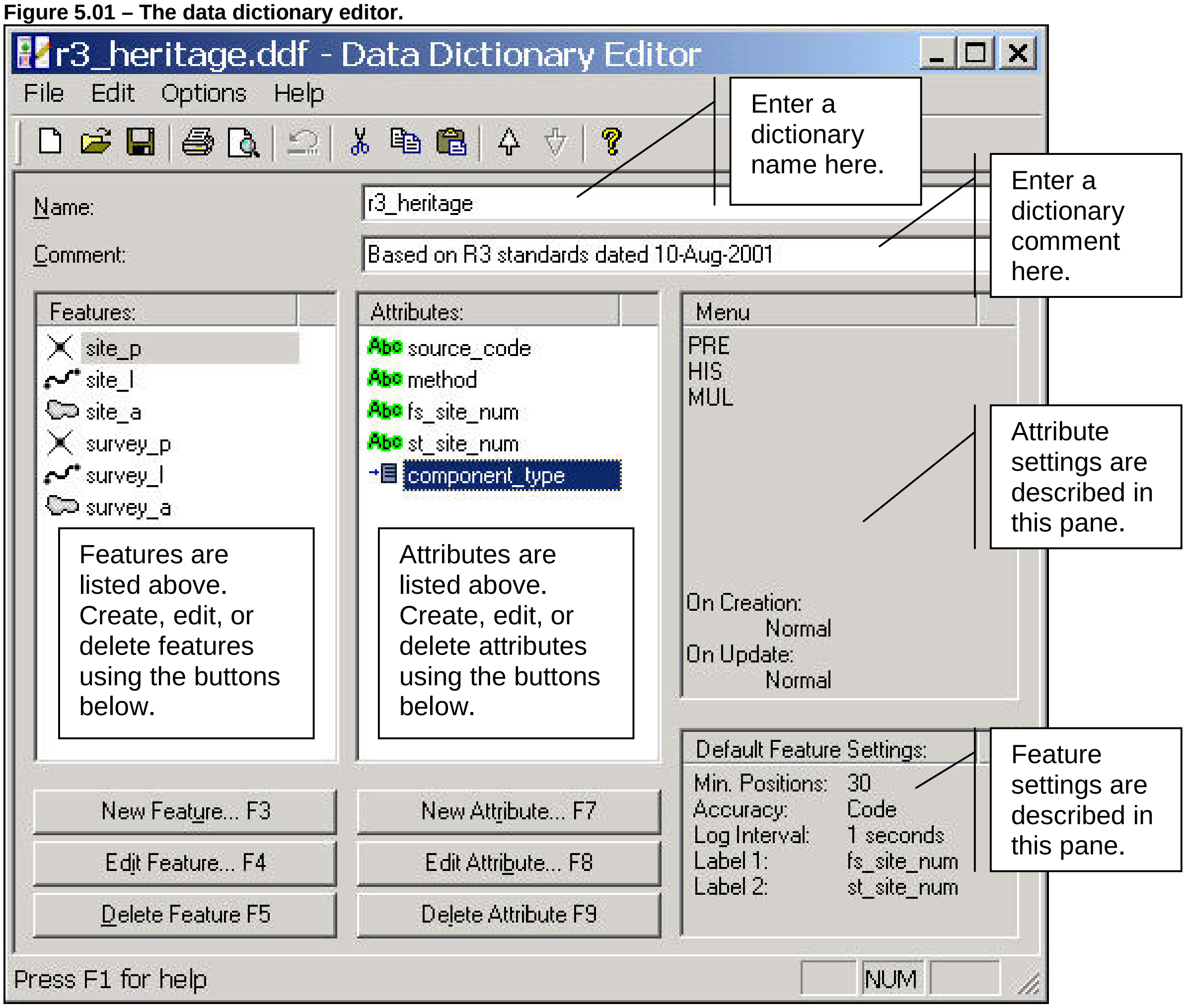


Figure 5.02 – Create or edit a feature's definition.

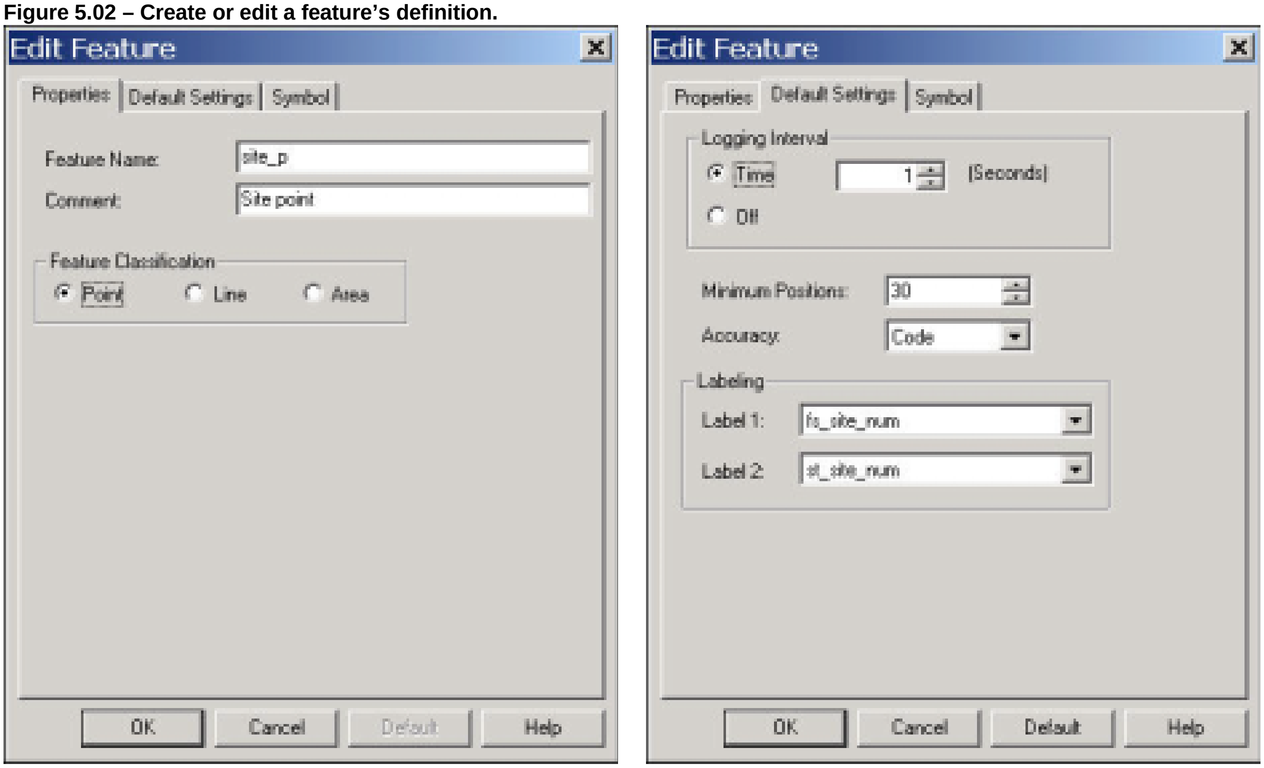


Figure 5.03 – Attribute types.

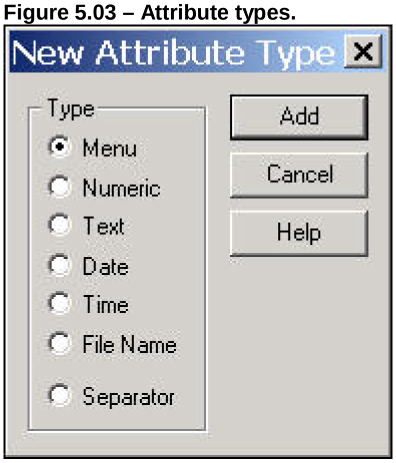
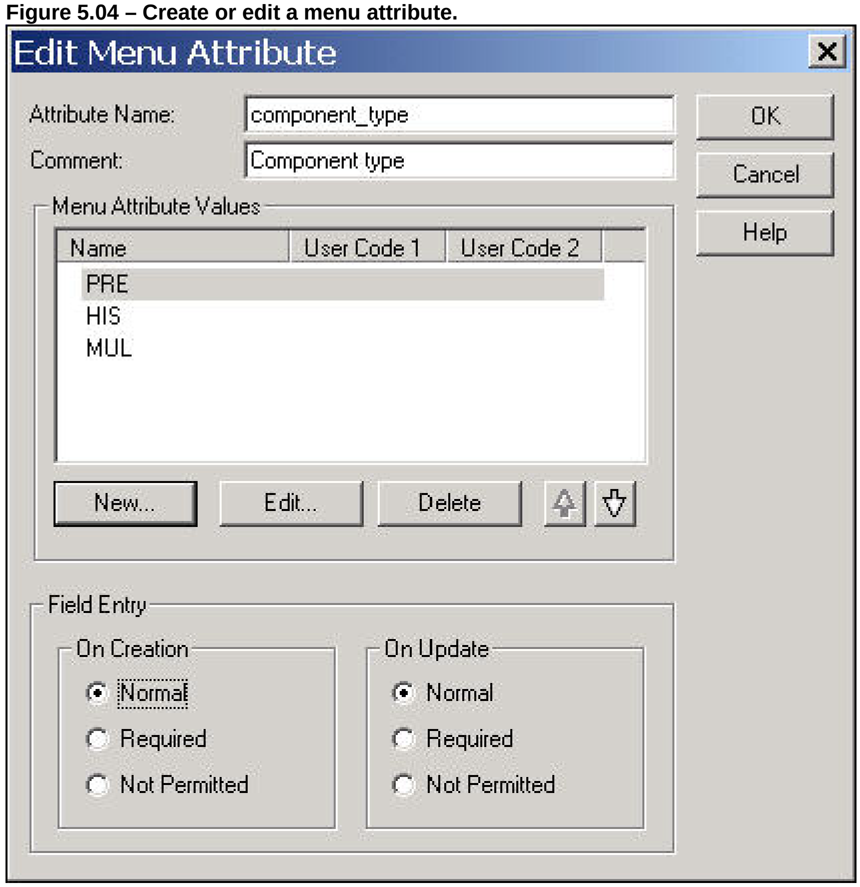


Figure 5.04 – Create or edit a menu attribute.



Chapter 6 - Receiver Configuration Settings

Receiver configuration settings determine the number, type, and quality of captured GPS positions. Trimble's recommended critical settings aren't always consistent from one model of GPS receiver to another, or when compared to National Map Accuracy Standards (NMAS), as illustrated in **Table 6.01**.

Table 6.01 – Trimble's recommended critical settings for rover GPS receivers compared to the NMAS requirement.

Item	GeoExplorer II	GeoExplorer3	GeoXT/XM	ProXL/XR	NMAS
Position Mode	3D	3D	3D	3D	3D
Elevation°	15	15	15	15	15
PDOP Mask	6	6	6	6	8
SNR Mask	5	4	4	6	6

The primary elements of GPS receiver configuration are briefly described below. These elements may be referred to by slightly different names, depending on the model of GPS receiver.

- **Point feature logging interval** – This setting determines the rate at which point feature positions are captured. Typically, this rate is set to a 1-second logging interval.
- **Line/area feature logging interval** – This setting determines the rate at which line and polygon feature positions are captured, usually a 5-second logging interval. In practice, however, varying the logging rate according to the receiver's anticipated velocity and the feature's complexity facilitates capturing enough positions to adequately convey the feature's alignment.
- **Not in feature logging interval (also known as the between feature logging interval)** – This setting determines whether or not positions will be logged that are not part of a point, line, or polygon feature. The default varies from model to model, but setting it to "OFF" prevents logging an unwanted string of "not in feature" positions while traveling between legitimate point, line, or polygon features.
- **Point feature minimum positions** – This setting determines the minimum number of positions needed to establish a point feature. Default settings for different receivers range from 3 to 180! Despite the setting, users can escape from a point logging session having fewer than the minimum required number of positions.
- **Position mode** – This setting determines whether 2D only, 3D only, or a mix of 2D and 3D positions are captured.

  The setting required to meet National Map Accuracy Standards (required for features appearing on 7.5-minute Primary Base Series quad maps, for instance), is **3D positions only**.
- **Elevation mask** – This setting determines minimum satellite elevation (above the horizon) necessary for a satellite's inclusion in a working constellation.

  The setting required to meet National Map Accuracy Standards (required for features appearing on 7.5-minute Primary Base Series quad maps, for instance), is **15°**.
- **SNR mask** – This setting determines the minimum acceptable signal-to-noise ratio necessary for a satellite's inclusion in a working constellation. High SNR is a good thing. Stronger signals produce cleaner positions.

  The setting required to meet National Map Accuracy Standards (required for features appearing on 7.5-minute Primary Base Series quad maps, for instance), is **6**, or Trimble's recommended default setting for that model of GPS receiver.
- **PDOP switch** – This setting determines the PDOP threshold for automatic toggling between 2D and 3D position logging when position mode is set to a mix of 2D and 3D. This setting doesn't apply in situations where position mode has been set to 2D only or to 3D only.
- **PDOP mask** – This setting determines maximum acceptable PDOP (position dilution of precision). Low PDOP is a good thing. Trimble GPS receivers automatically suspend data capture whenever current PDOP exceeds the PDOP mask.

The setting required to meet National Map Accuracy Standards (required for features appearing on 7.5-minute Primary Base Series quad maps, for instance), is **8**.

- **File prefix** – This setting determines the default file name prefix. The default file naming convention is RMMDDHHA where:
  - R is the file name prefix (R standing for "rover");
  - MM is the month;
  - DD is the date;
  - HH is the GMT hour; and
  - A is an alpha sequence when more than one file is collected during a single hour.

  Duplicate file names can be an issue in situations where several GPS receivers capture data simultaneously, and those data files are downloaded to a single GPS project folder. For example, if 3 people begin a GPS mission between 0900 and 1000 on June 15, the file name generated for each will default to R061516A. If these three files are subsequently downloaded to a single GPS project folder, each transferred file could over-write the previous one.

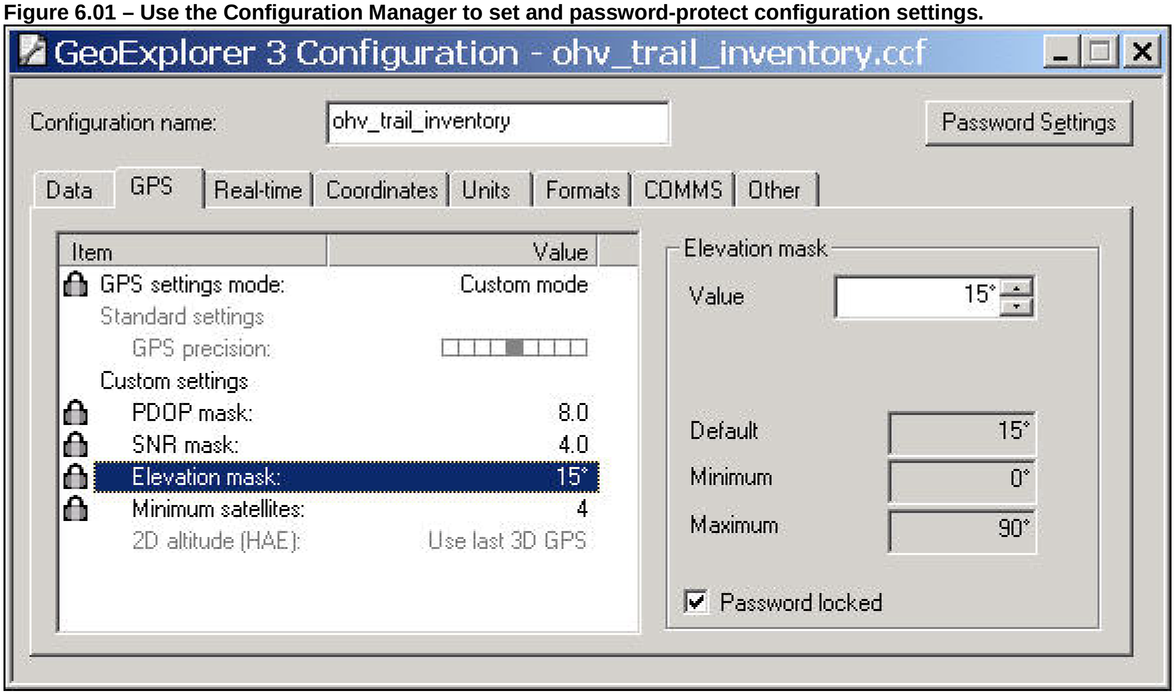
  This situation can be avoided by assigning a unique file name prefix to each GPS receiver used in a project.

  Another method of avoiding duplicate file names is to rename files manually, making sure that file naming conventions ensure uniqueness.

Configuration Files

Configuration files determine settings that control how data are collected, entered, and displayed, and can be used to lock some settings. Configuration files may prove useful, for instance, if many GPS units must be configured identically, or if inexperienced or undisciplined users make locked, password-protected settings necessary. Click ***Utilities – Other – Configuration Manager…*** on the Pathfinder Office menu bar to create configuration files (**Figure 6.01**) that can be transferred to GeoExplorer3 and TerraSync-based GPS units.

Figure 6.01 – Use the Configuration Manager to set and password-protect configuration settings.



Chapter 7 – Data Capture

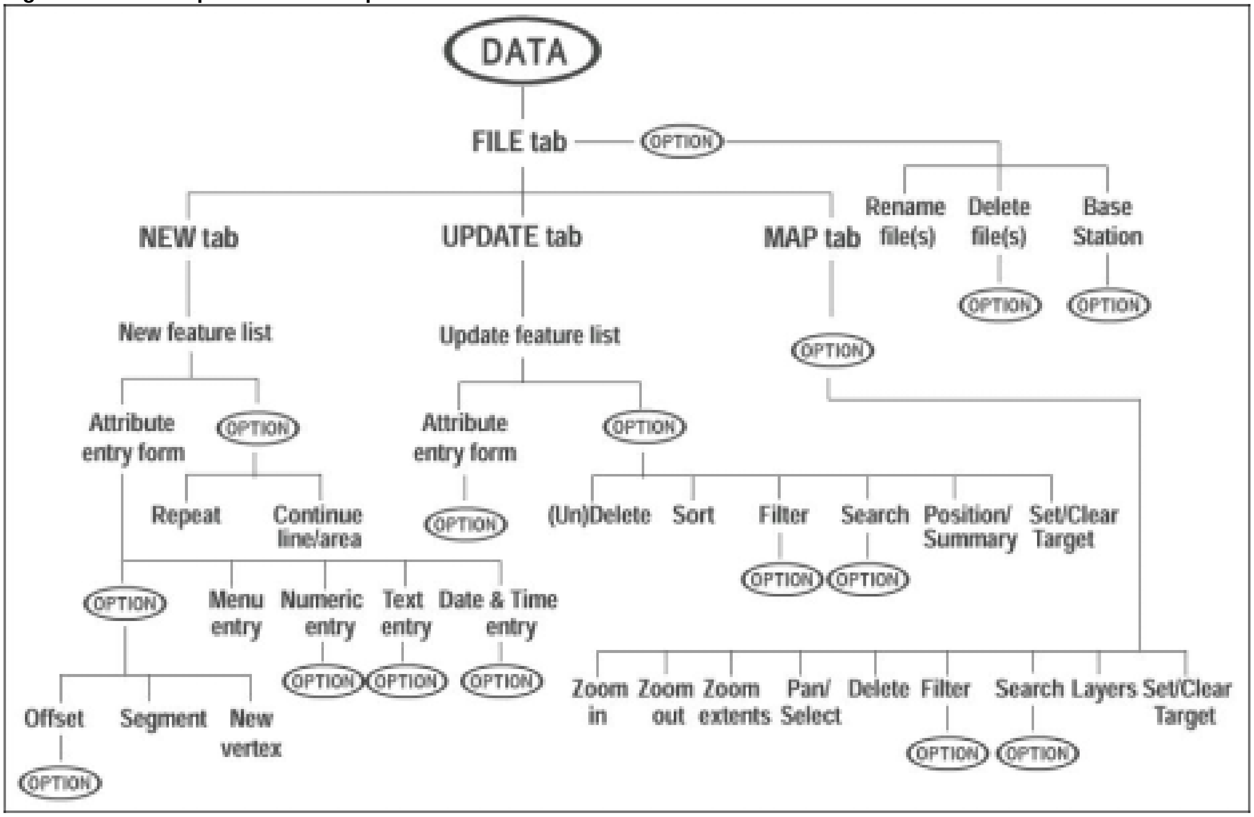
Menus And Procedures Vary By GPS Unit

Menu structure and operational procedures vary for each of the several models of GPS receiver currently in use. As such, it is impractical to prepare step-by-step data capture procedures that satisfy every situation.

Before attempting data capture, GPS practitioners must understand the menu structure and operational procedures (which buttons to push) of the GPS receiver in use. Menus and procedures are thoroughly discussed and illustrated in receiver-specific documentation from Trimble's web site. For instance, the Operation Guide for the GeoExplorer 3 can be viewed, searched, or downloaded from:

http://www.trimble.com/support_trl.asp?Nav=Collection-5549

Figure 7.01 – Example of the GeoExplorer3's DATA menu structure as illustrated in Trimble's on-line documentation.



Pre-Data Capture Checklist

A brief checklist worth consideration prior to data capture includes these items:

- Find out if features of interest have already been GPSed, or located by some other NMAS-compliant means. Try to avoid duplication of NMAS-compliant work.
- Use Quick Plan or Trimble Planning Software to determine the best time periods for data capture, especially if vegetation or terrain will make conditions difficult.
- Create new (or use existing) data dictionaries that match corresponding GIS data structures. Integrating GPS features with existing GIS datasets is facilitated when GPS data dictionaries match GIS data structures.

- Configure GPS receivers to be NMAS-compliant. Even if GPS features aren't destined for 7.5-minute Primary Base Series quad map updates, a little extra effort now may pay unforeseen dividends in the future. Remember that "collect it once, use it in many ways" is the fundamental principle of data collection and management.
- Develop a plan for file management.
- Develop a plan for integration of GPS features with existing GIS (or other) datasets.
- Be familiar with the menu structure and "pushing the buttons" on the GPS unit to be used.

Data Capture Tips

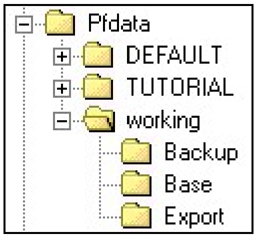
Some tips that will facilitate data capture, edit, and integration are described below.

- Capture linear data in one direction only, or log each direction as a separate feature. Capturing a single feature "out and back" creates a braided, intersecting line when transferred to GIS.
- Creating "furballs" complicates editing. Keep moving, or use ***PAUSE*** to suspend data capture when temporarily halted, nesting another feature, or departing from a feature's alignment.
- Feature alignment detail is being lost when excessively large intervals between successive GPS positions occur. Large gaps occur when logging intervals aren't coordinated with travel velocity, or when GPS practitioners aren't aware that data capture is being interrupted by high PDOP or poor signal reception. Practitioners must coordinate receiver velocity with logging interval, and proceed only when GPS positions are actually being logged.
- Use a data dictionary to assign captured GPS positions to a point, line, or polygon feature.
- Avoid collecting GPS positions unaffiliated with any feature by turning the ***Not In Feature Rate***, or the ***Logging Between Features*** parameter, to "***OFF***".
- Consider GPSing shared boundaries of adjacent polygons only once. Duplicating shared boundaries takes extra time and creates extra work in GIS because braided, intersecting arcs must be resolved. One way to avoid this situation is to capture the gross exterior boundary, and all interior boundaries, as lines. Polygons can then be built in Arc/Info. The downside of this approach is that polygon feature attributes can't be captured in a data dictionary.
- Understand the difference between files and features. A single file can contain many separate point, line, and polygon features.
- Be sure to capture a position at each corner, turning point, or wherever necessary to adequately convey an irregular feature's alignment.
- Exercise the discipline to wait out transitioning satellite constellations. Always use the ***Quick Plan*** utility for mission planning. Consider using a Quick Plan 15° elevation mask for open sites, and a 30° elevation mask for sites with dense vegetation or steep terrain.
- It is unsafe to drive ***and*** pay attention to a GPS receiver. In these cases, an assistant is needed.
- When in a vehicle, GPS receivers may be powered from a power point. In order to avoid damage from electrical spikes, however, Trimble recommends that GPS receivers be powered off and disconnected from the power point while the vehicle's engine is being started, or being shut down.
- Keep GPS antennas in a horizontal position for best results.
- Mounting antennas on a flat, metallic "groundplane" may improve antenna performance.
- Avoid mounting antennas on irregular metallic surfaces, such as an ATV rack.
- Weak batteries may reduce antenna performance.

- If temporary signal loss occurs while capturing line or area features, try moving back and forth along the feature's alignment for **short** distances in an attempt to re-acquire the signal. Remain on station at point features, however. If signal is not re-acquired with movement, wait until satellites transition to a more favorable arrangement. Situations will arise where dense vegetation, or close proximity to steep terrain, will make GPS data capture nearly impossible.
- Remember that all GPS data are logged and stored as WGS84 decimal degree latitude/longitude coordinates. Coordinate system and datum receiver settings are for display purposes only, and have no effect on the format of captured data.
- Use a data dictionary so that features can be attributed while on-site in the field.
- The GeoExplorer I and II can only contain one data dictionary at a time. A new data dictionary can not be loaded if files dependent on another data dictionary remain in memory.

Chapter 8 – Using Pathfinder Office Software

Pathfinder Office software facilitates many GPS data processing tasks. Click ***Help – Contents…*** to activate on-line help, or press the ***F1*** key at any time for context-sensitive help.



Filing Structure and Project Folders

The Pathfinder Office software installation process creates a default filing structure at **`c:\pfdata`**, as illustrated at left. Two project folders (**`DEFAULT`** and **`TUTORIAL`**) are also created during installation.

It's a good idea to create and use **project folders** as a way to organize GPS project work. For instance, separate project folders could be created to accommodate trail inventory, new fences, and cultural resource surveys.

Click ***File – Projects…*** to create, delete, modify, or select project folders. By default, new project folders are created under **`c:\pfdata`**, but they can be placed anywhere on the PC's hard drive, or on a network drive. Each project folder will contain sub-folders named **`Backup`**, **`Base`**, and **`Export`**.

Common File Types

Commonly encountered file types and extensions include:

- **`.cor`** – differentially corrected GPS data files;
- **`.ddf`** – data dictionary files; and
- **`.ssf`** – almanac files and uncorrected GPS data files. Adding a **`.cor`** extension to a **`.ssf`** file will not fool Pathfinder Office into mistaking an uncorrected data file for one that has been differentially corrected.

Units and Coordinate Systems

Although GPS data are always captured and stored as WGS84 decimal degree latitude/longitude coordinates, Pathfinder Office permits them to be viewed and reported in any unit, coordinate system, or datum.

Click ***Options – Units…*** and ***Options - Coordinate System…*** to specify how GPS data are displayed and reported on-screen. Remember, these settings have no effect on how GPS data are actually stored.

The coordinate system and datum selected will affect shape, size, distance, and direction, so it is best to adhere to local GIS or mapping standards. For example, on the Coconino National Forest in Arizona, set ***System*** to **`UTM`** (Universal Transverse Mercator), ***Zone*** to **`12 North`**, and ***Datum*** to **`NADCON (Conus)`**.

Data Transfer

Data transfer permits users to move data or almanac files from GPS receiver to PC (use the ***Receive*** tab), and data dictionary, configuration, image, shape, or waypoint files from PC to GPS receiver (use the ***Send*** tab). Remember to select the type of device (***GIS data logger on COM1*** or ***GIS data logger on WindowsCE)*** with which data transfer is sought.

Click ***Utilities – Data Transfer*** to access these utilities. When downloading data files, they'll be directed to the current project folder by default.

Open A GPS Data File

Open GPS data files by clicking ***File – Open…*** and selecting the desired file(s). Remember that **`.cor`** files have been differentially corrected, and **`.ssf`** files have not.

Multiple files may be opened simultaneously as read-only, meaning that no editing can occur. Editing can only occur with a single file open.

Background Files

If other files are needed to provide context in an editing situation, open them in background by clicking ***File – Background…*** and selecting the desired file(s). To display correctly, background files must be in the same coordinate system and datum as the current Map window display, and images must have a corresponding "world" file. Valid background file types include:

- Trimble (**`.ssf`** and **`.cor`**);
- AutoCAD (**`.dxf`**);
- ESRI (**`.shp`**); and
- Common image formats (**`.bmp`**, **`.tif`**, **`.sid`**, and **`.jpg`**).

Set A Map Scale

It may be desirable to maintain a consistent map scale during edit sessions. To set map scale, click on ***View – Scale – Map…***, and enter a desired scale factor. Scale will appear on the Map window header.

Apply Symbology

To apply different symbology (colors, line styles, or symbols) to each feature, click ***View – Layers – Features…***, and modify as desired. This menu also permits users to:

- View only selected features;
- Join or un-join GPS positions; and
- View "precision" circles for corrected files.

View Time Line

View the time span associated with each GPS feature by clicking ***View – Time Line***. Selecting a feature in the Map window will highlight the associated time block in the Time Line window.

View and Edit Feature Properties

Click ***Data – Feature Properties…*** to view and edit feature properties. Tabs in the Feature Properties window reveal summary, attribute, and precision properties, and buttons facilitate feature navigation and deletion. When features are deleted, their constituent positions remain as "not in feature" positions.

View and Edit Position Properties

Click ***Data – Position Properties…*** to view properties of a selected position and, if desired, delete it. The Position Properties window has buttons facilitating position navigation and deletion. Individual positions deleted using the Position Properties window can be individually undeleted.

Typically, edits are made only to differentially corrected files, as there is little sense editing a file containing potential GPS errors. Editing issues and techniques are discussed in subsequent chapters.

Print A Map

Click ***File – Plot Map…*** to compose and print a simple map of on-screen features and background files.

Figure 8.01 – Major features of Pathfinder Office.

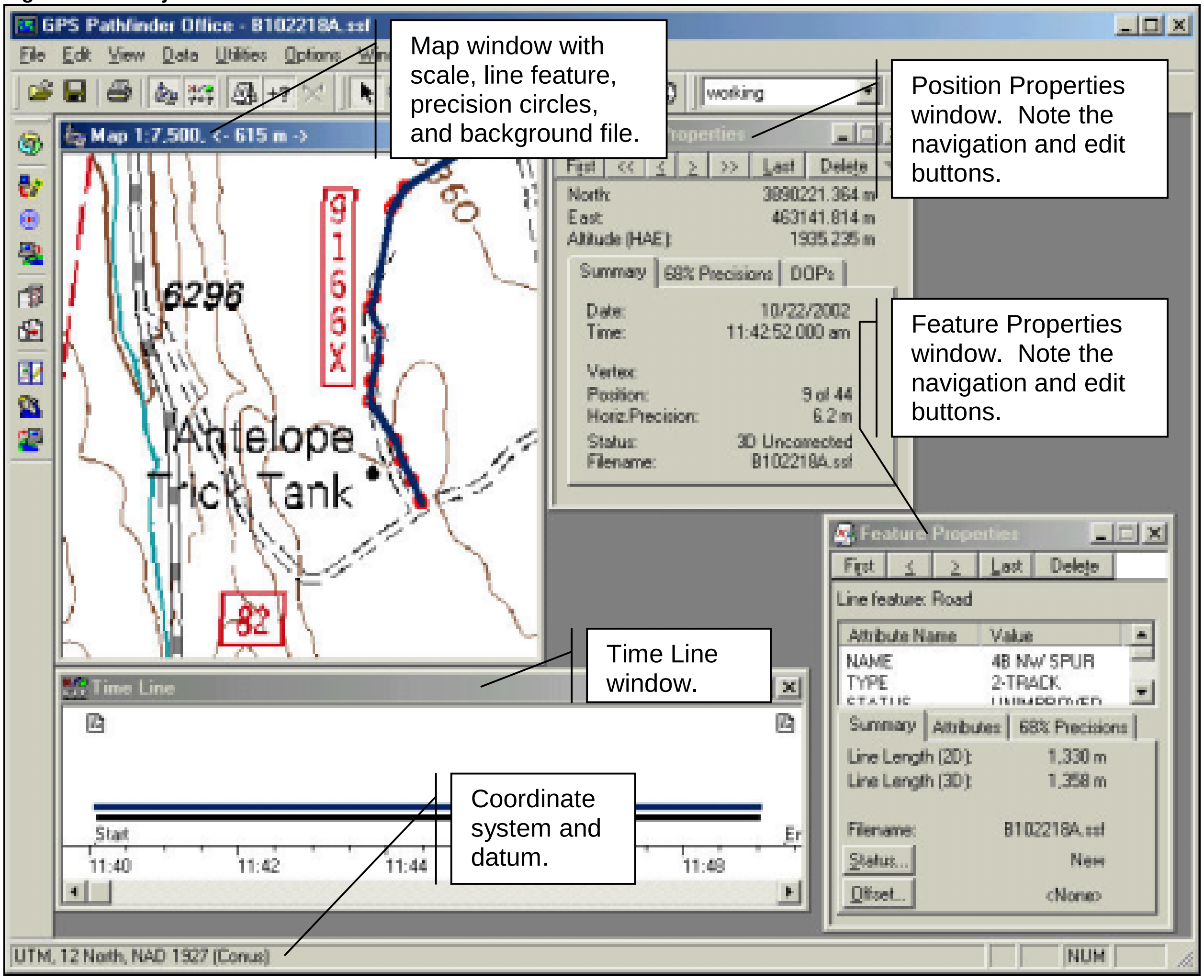
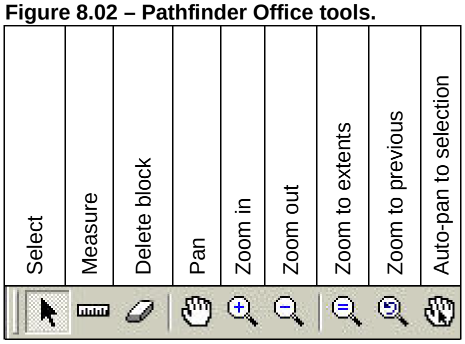
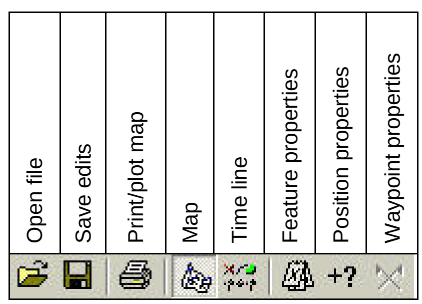


Figure 8.02 – Pathfinder Office tools.





Chapter 9 – What Is Differential Correction?

This chapter describes general concepts and methods of differential correction. Specific procedures for post-processing differential correction are described in Chapter 10.

Post-Processing

Currently, post-processing is the most common, most accurate, and most reliable form of differential correction. The method is referred to as post-processing because it occurs after rover file capture.

Recall that GPS receivers use the travel time of signals from GPS satellites to establish a position, and that each of those signals may experience some satellite clock, orbit, or transmission delay error. Signals reaching both base station and rover receivers contain nearly identical errors because they originate from the same satellites, and have traveled through the same slice of earth's atmosphere.

A base station receiver is permanently installed at a fixed location whose position has been determined by accurate survey. Instead of using GPS signal travel times to calculate its position, however, the base station works backwards. Using its known position, and the known position of satellites (from almanac orbital data), it figures out what the travel time of GPS signals from each individual satellite should be, and compares that expected travel time with the travel time it actually observes. Using this technique, the base station determines GPS signal travel time corrections (differentials) for each satellite at recurring time intervals, and logs them in a base station file.

During post-processing, GPS signal travel times from the rover file are adjusted using the base station's compilation of satellite-specific and time-specific corrections. Although contents of **Table 9.01** are wholly fabricated and over-simplified, they illustrate the general process of post-processing differential correction. At time 14:05:20, for instance, the base station detects that signals from satellite 3 are delayed by 6 nanoseconds. Since satellite 3 is included in the rover's constellation, the 6 nanosecond correction is applied to the rover's observed signal travel time for satellite 3 at time 14:05:20.

Typically, base stations log corrections for each satellite at 5-second or 30-second intervals. Since corrections are interpolated for rover positions that are logged mid-interval, base stations with a 5-second logging rate may provide better corrections because less interpolation is required.

Table 9.01 – Base stations compare expected GPS signal travel times from each satellite with those actually observed. The resulting satellite- and time-specific corrections are applied to a rover file's observed GPS signal travel times.

Base Station File					Rover File		
Time (GMT)	Satellites in the base station's constellation	Expected GPS signal travel time (ns) calculated from the base station's known position and satellite orbital data	Observed GPS signal travel time (ns) to the base station	Correction (ns)	Satellites in the rover's constellation	Observed GPS signal travel time (ns) to the rover	Corrected GPS signal travel time (ns) to the rover
14:05:15	1	98,711,091	98,711,093	-2	1	98,712,497	98,712,495
	2	67,741,935	67,741,936	-1	.	.	.
	3	91,256,991	91,256,998	-7	3	91,255,631	91,255,624
	.	.	.	.	.	.	.
	.	.	.	.	.	.	.
	.	.	.	.	.	.	.
14:05:20 (5 seconds later)	1	98,712,109	98,712,110	-1	.	.	.
	2	67,741,926	67,741,926	0	2	67,740,782	67,740,782
	3	91,256,972	91,256,978	-6	3	91,255,648	91,255,642
	.	.	.	.	.	.	.
	.	.	.	.	.	.	.
	.	.	.	.	.	.	.

Base Station Requirements

Though they have many technical requirements, base stations must meet two basic conditions in order to be used for post-processing differential correction.

- Their position must be established by what's referred to as a "third-order survey", an accurate, high-standard survey.
- They must be within 500 kilometers (about 310 miles) of the data capture area to ensure that both base station and rover receivers can "see" the same satellites. Distance from a base station also imparts a 1ppm "baseline" error, or 0.5 meters at 500 km distance.

Why Trimble Data Can Be Post-Processed And Data From Recreational-Grade Receivers Can't

Trimble GPS positions can be post-processed because the GPS signal travel times that generate positions are actually stored as part of the GPS data file, and can be matched with travel time corrections from a base station file.

Recreational-grade receivers calculate GPS positions using the same signals that Trimble receivers do, but the signals' travel time are not stored as part of the data file…only the actual GPS position coordinates are stored. As such, travel time corrections contained in base station files cannot be applied to recreational-grade GPS receiver data in a post-processing context.

Making Differential Corrections In Real-Time

For all intents and purposes, real-time differential correction works the same way post-processing differential correction does, except that corrections are broadcast to rover GPS receivers in real-time from land-based transmitters (beacons), or from satellites (wide area augmentation system, or WAAS). In order to benefit from real-time broadcasts, rover receivers must:

- Be equipped to receive and process real-time signals; and
- Remain in contact with real-time signals throughout data capture. Positions captured during lapses in real-time signal reception can be corrected with post-processing (Trimble only).

Real-time correction has several shortcomings. Land-based transmitters may have limited range, and their signals can be degraded or obstructed by vegetation or terrain. Because WAAS satellites are positioned over the equator, their signal coverage diminishes with distance from the equator, and is subject to degradation or obstruction by vegetation or terrain.

Trimble and recreational-grade GPS receivers can, if properly equipped and configured, utilize either land- or satellite-based real-time correction.

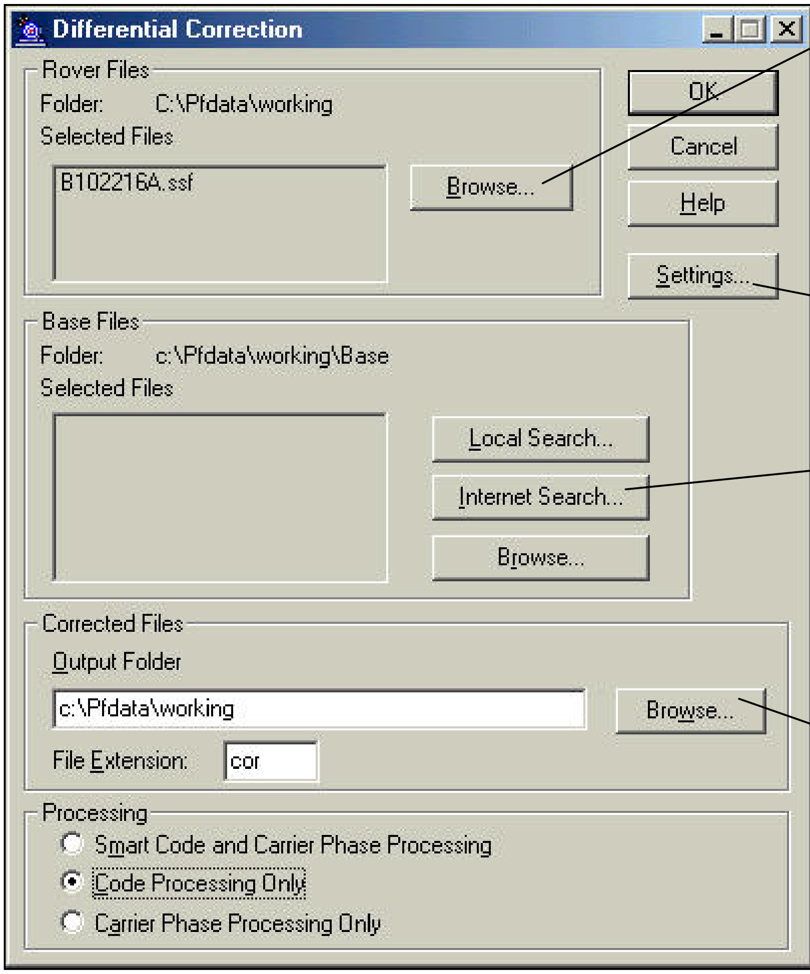
Differential Correction Only Fixes Timing Errors

It is important to remember that all forms of differential correction compensate **only** for satellite clock, orbit, and transmission delay errors. They are unable to remedy multi-path errors, or errors resulting from high PDOP or low SNR signals.

Chapter 10 – Post-Processing Differential Correction

Differential correction concepts were discussed in Chapter 9. This chapter describes the differential correction technique known as post-processing.

Click ***Utilities – Differential Correction…*** to initiate post-processing.



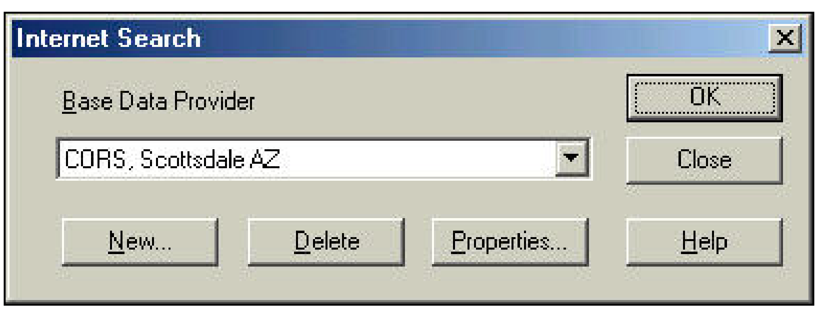
Rover files currently open in Pathfinder Office will appear in the ***Selected Files*** area. If additional rover files are to be corrected, click the ***Browse…*** button, and navigate to their location.

To view or change settings for ***Output***, ***Base Options***, ***Code Processing***, and ***Zipped Files***, click here.

Click ***Local Search…*** or ***Browse…*** if base files are available on local PC or network drives. Click ***Internet Search…*** to retrieve base files from on-line base data file providers.

Corrected files may be output to local PC or network drives.

For purposes of this example, assume that ***Internet Search…*** was clicked.



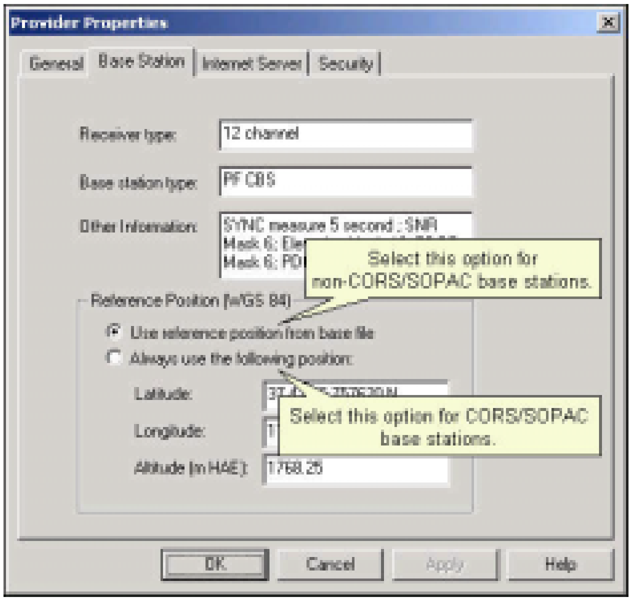
Click the drop-down arrow to select a base data provider from a list of those previously used.

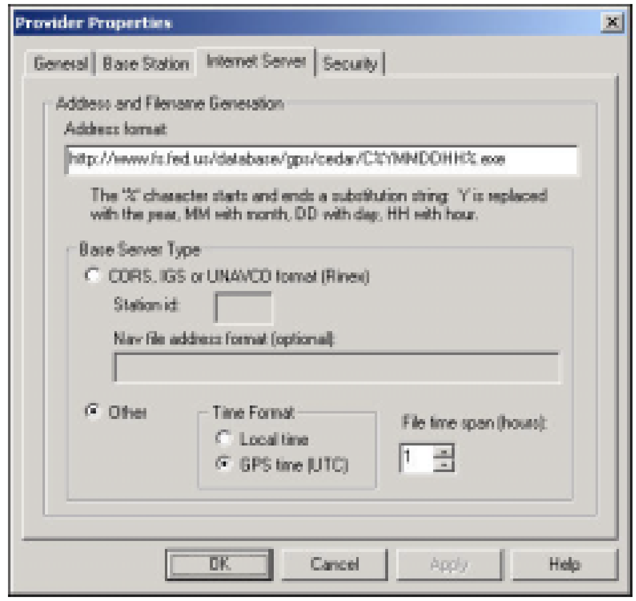
Click ***New…*** to add a new base data provider to the drop-down list. Make a selection from Trimble's list of providers, or create a custom provider profile for a local base station not on Trimble's list.

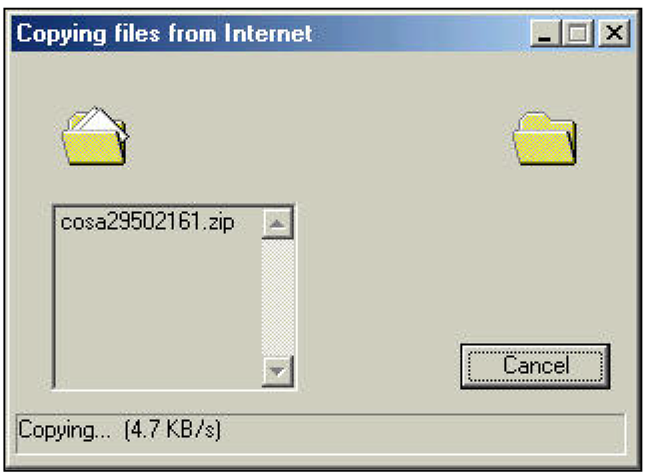
Click ***Delete…*** to delete a base data provider from the drop-down list.

Click ***Properties…*** to view or, if necessary, modify base data provider properties. These properties include base station contacts and location, technical specifications, internet/FTP information, and security settings. Occasionally, Trimble-provided internet/FTP information is incorrect, and must be edited. Examples of base data provider properties are illustrated on the next page.

Click ***OK*** when ready to proceed.





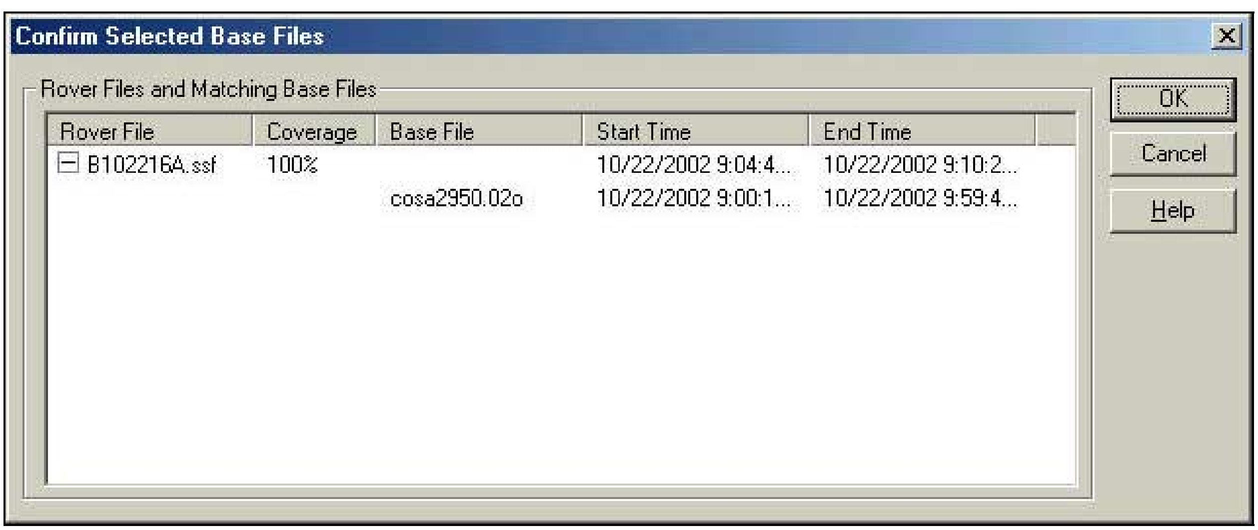


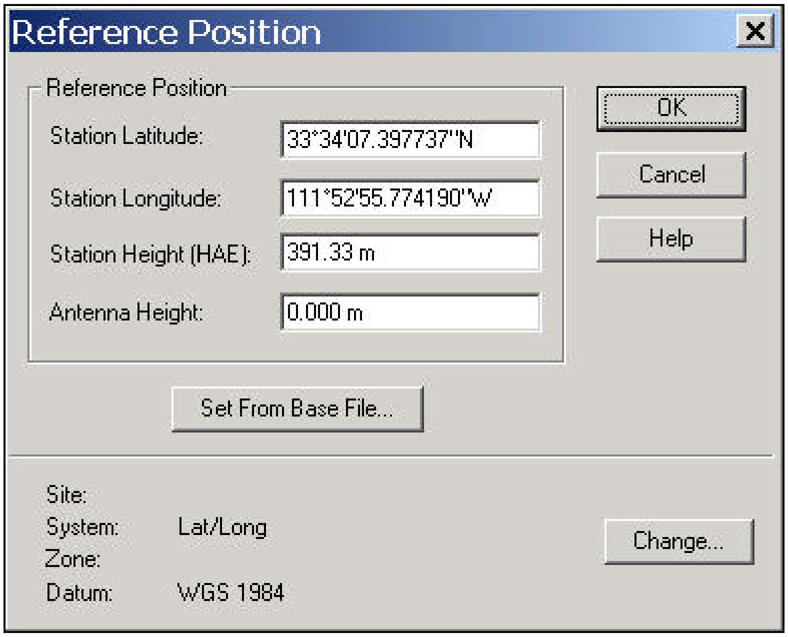
Base data files are copied from Internet or FTP servers to the **Base** subfolder of the current project folder.

Pathfinder Office will copy all base data files necessary (if available) to cover the rover file's time period.

Once all base data files are retrieved, rover and matching base files are displayed, as well as the percentage of base file coverage. In the example below, the base file spans the entire duration of the rover file, so coverage is 100%.

Click ***OK*** when ready to proceed.





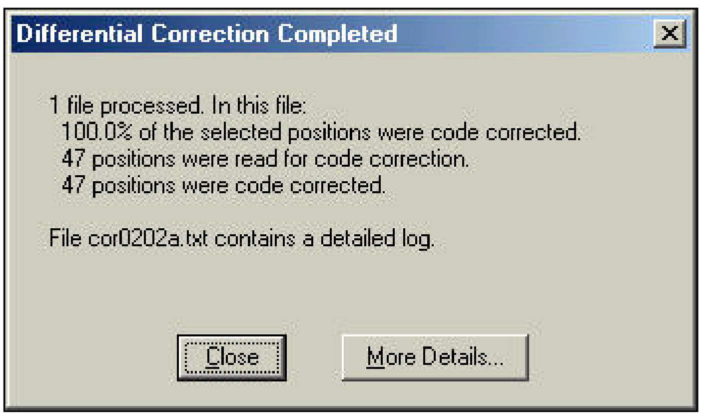
The base station's reference position is determined according to the option selected in base data provider properties (see illustration on preceding page), and presented for edit.

Remember, select the **`Use reference position from base file`** option for non-CORS/SOPAC base stations.

On the other hand, select the **`Always use the following position`** option for CORS/SOPAC base stations.

Do not edit the reference position in any way, unless it is positively known to be in error!

Click ***OK*** to return to the initial Differential Correction window.



Click ***OK*** in the Differential Correction window to proceed.

The differential correction process will occur and conclude as illustrated at left. Less than 100% correction indicates rover or base file problems.

Click ***Close*** to end the differential correction session, or ***More Details…*** to view potential reasons for incomplete correction.

Retrieve Base Data Files Manually

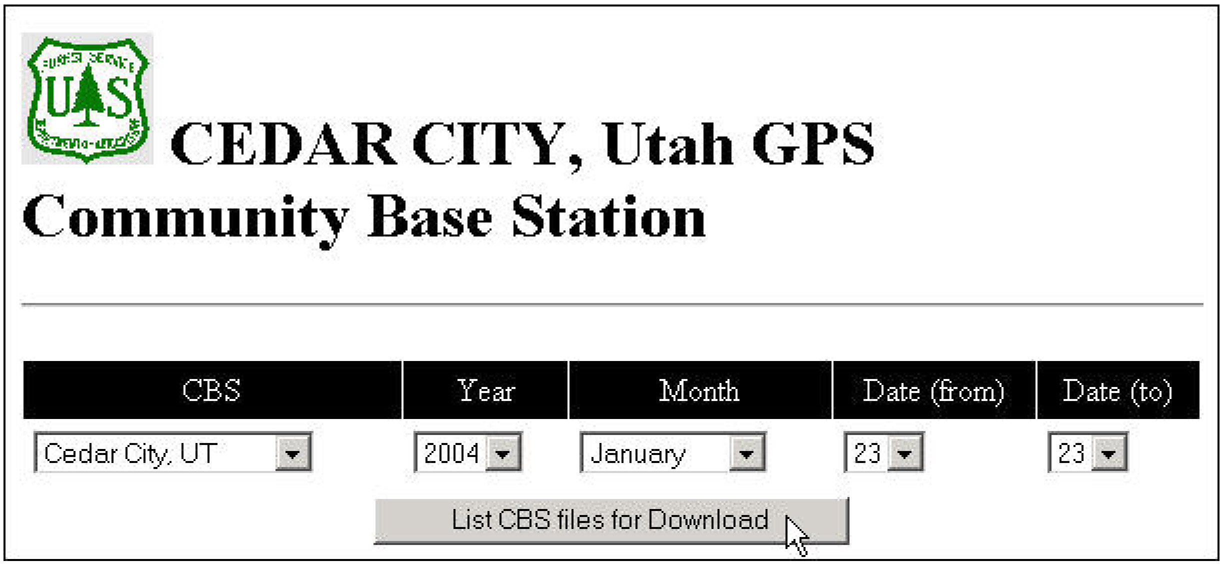
An alternative to automated, on-line, base data file retrieval is to copy base files manually from the desired Internet or FTP site. Base data file source references include:

> http://www.fs.fed.us/database/gps/cbsalpha.htm
>
> http://www.trimble.com/trs/findtrs.asp

Navigate to the desired site, select the date for which base data files are desired, and click ***List CBS Files For Download***. Select desired files from the resulting list, select ***Save This Program To Disk*** when prompted, and direct the file(s) to the **`Base`** subfolder of the current project folder.

Typically, files are in **`.zip`** or **`.exe`** format. Unzipping or opening these files produces base data files in the familiar Trimble **`.ssf`** format, or the Receiver Independent Exchange (RINEX) format. RINEX base data files will have a file extension ending with the letter "**`o`**".

Since base data files are now on a local PC or network drive, click ***Local Search…*** or ***Browse…*** in the initial differential correction window instead of ***Internet Search…*** when searching for base data files.

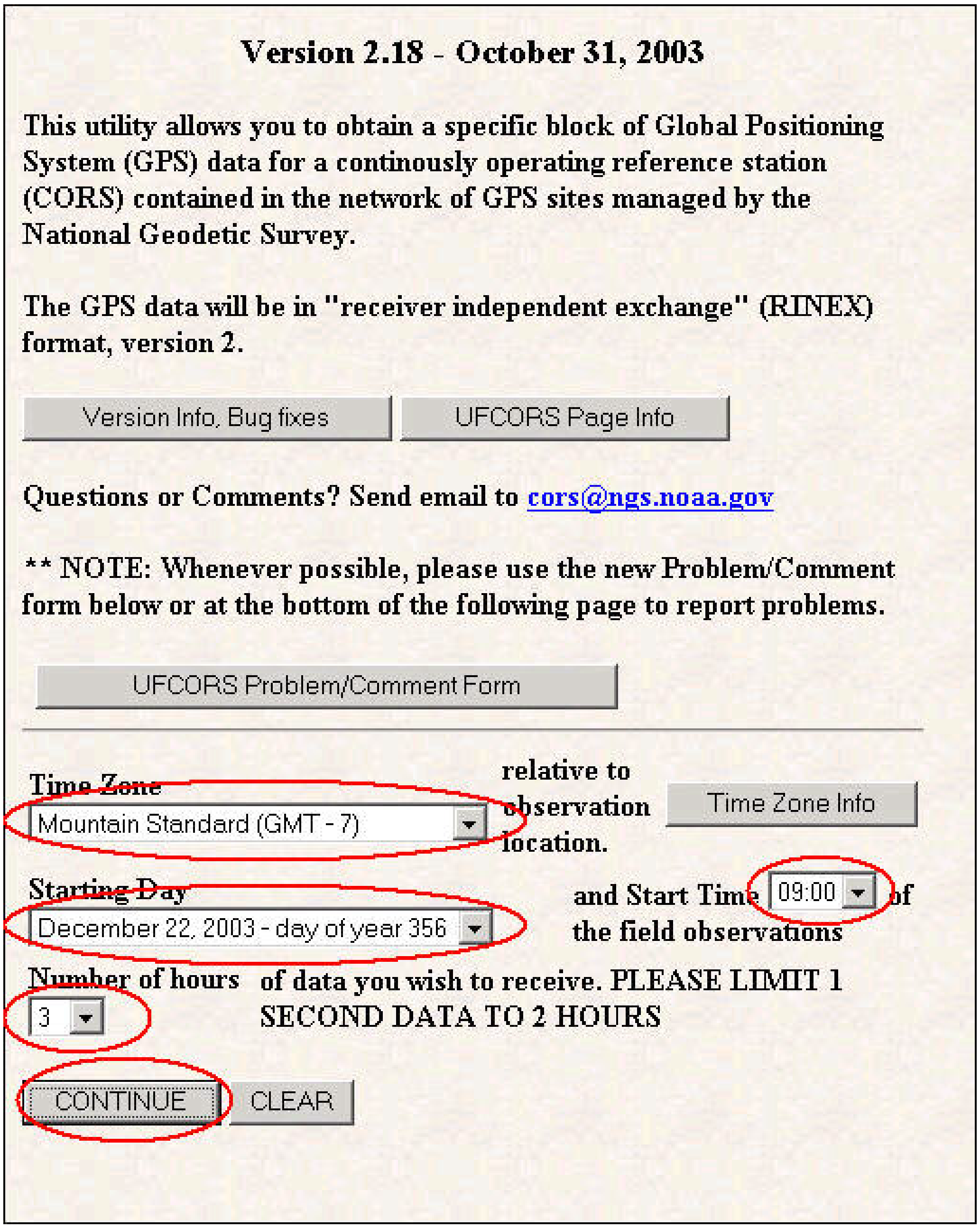


Retrieve Base Data Files From The User Friendly CORS Website

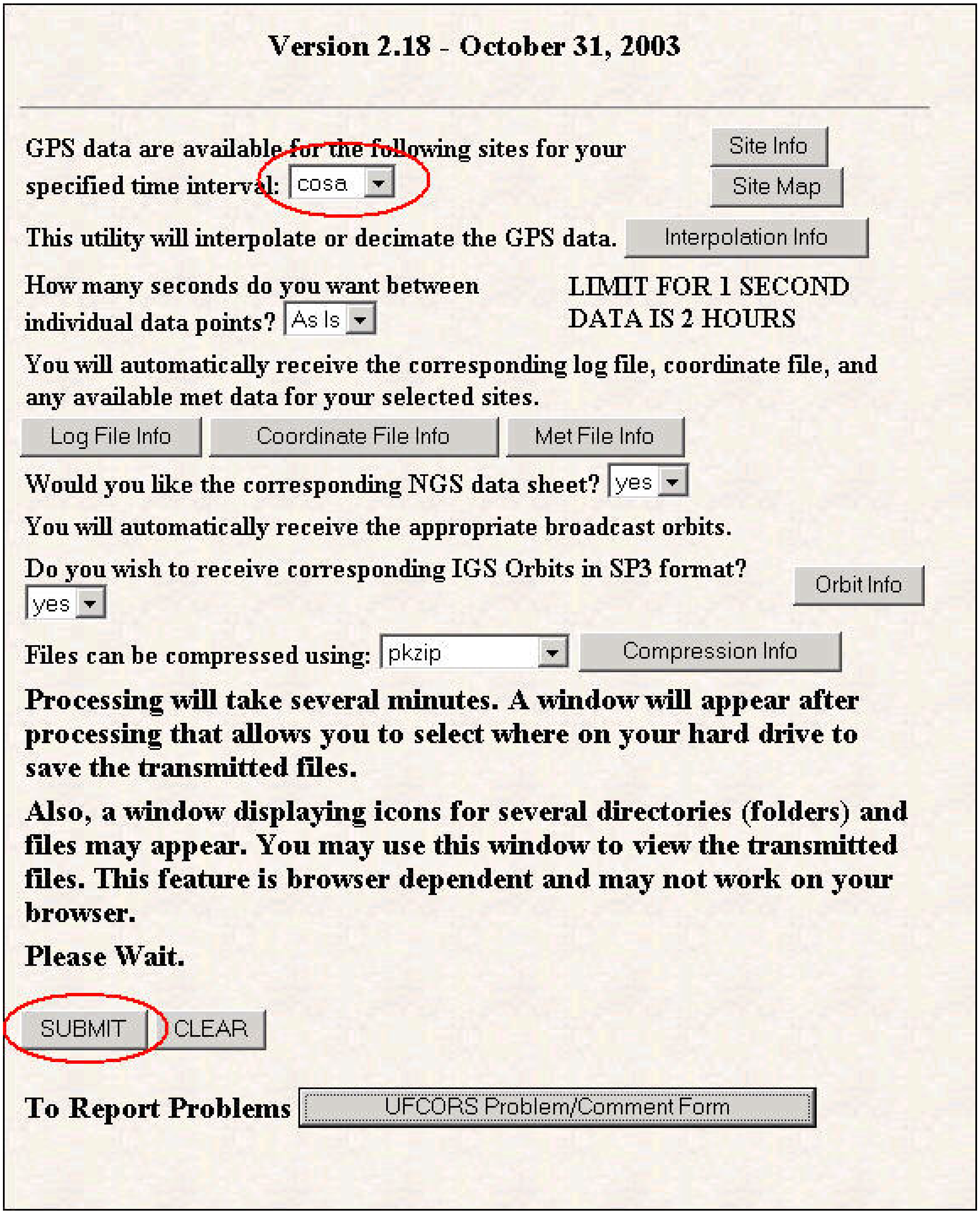
In years past, Trimble base stations were often the only source of base data files. Now, many Continuously Operating Reference Stations (CORS) are available as base data file providers. Access to CORS base data in Receiver Independent Exchange (RINEX) format is often available through Pathfinder Office software (although sometimes it doesn't work) and, directly, from the User Friendly CORS website.

http://www.ngs.noaa.gov/CORS/download1/

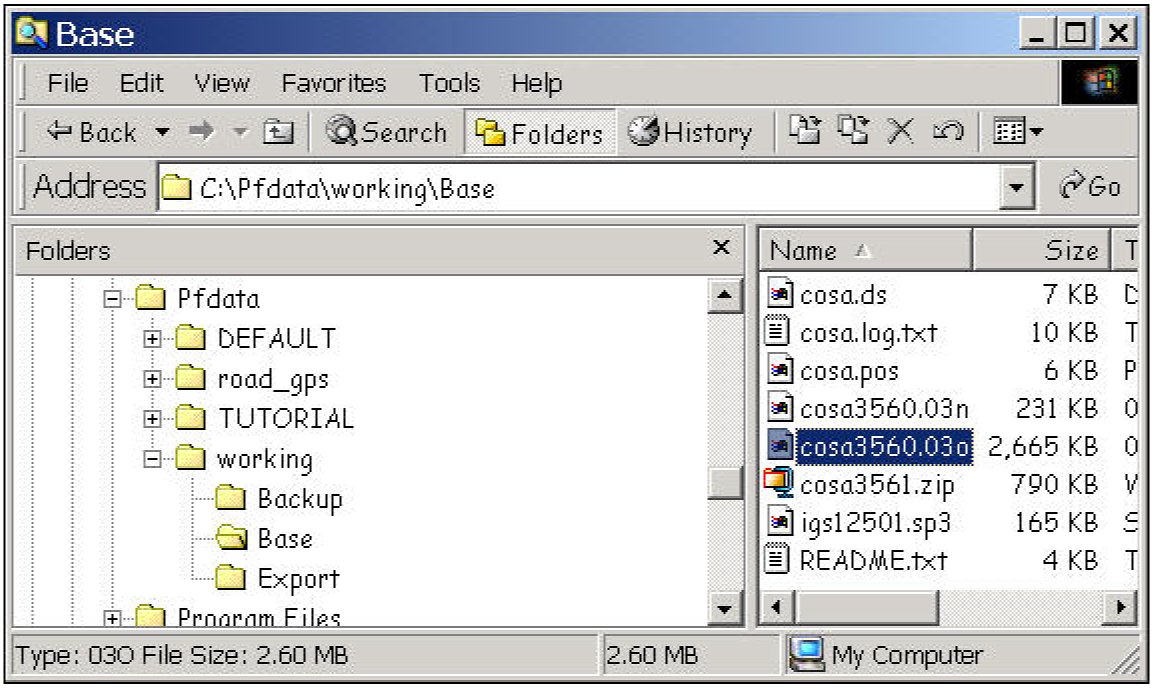
After navigating to the User Friendly CORS site, provide the information as indicated, and click ***CONTINUE***.



Next, provide the code (where indicated) for the CORS from which base data files are being sought, and click ***SUBMIT***. In this case "**cosa**" is the code for the Scottsdale, AZ CORS.



Direct the download **.zip** file to the **Base** subfolder of the current project folder.

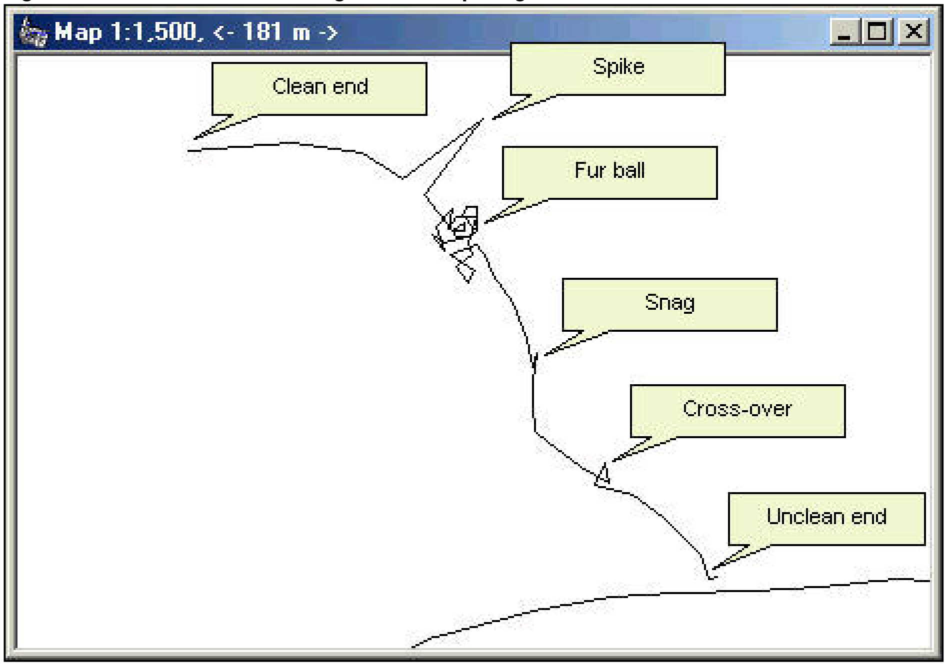


Unzipping the download file using WinZip produces seven files. The file containing base data in RINEX format will have a file extension ending with the letter "**o**".

Since base data files are now on a local PC or network drive, click ***Local Search…*** or ***Browse…*** in the initial differential correction window instead of ***Internet Search…*** when searching for base data files.

Chapter 11 – Editing GPS Data

Figure 11.01 – Common GPS irregularities requiring edit.



Even though GPS data files have been differentially corrected, they still require editing to remove any remaining irregularities, and produce clean, “map-worthy” feature alignments. Just because these irregularities aren’t apparent at 1:24,000 scale, doesn’t mean they can be ignored! **Figure 11.01** illustrates several common irregularities requiring edit.

Ideally, it should be the responsibility of those who capture GPS features to edit them within several days. No one knows better than they how the feature was actually aligned.

Editing involves careful review of each individual feature’s alignment, and deletion of all unwanted GPS positions. The goal of editing should be to remove as many annoyances as possible, while remaining faithful to the feature’s actual alignment. GPS positions cannot be moved or added on-screen. Turning precision circles “on” will aid identification of vertices available for edit.

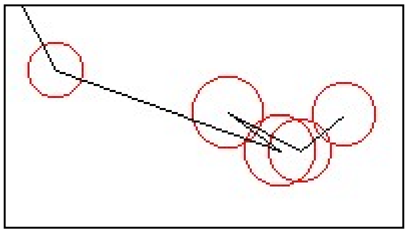
Basic Edit Tools

The most commonly used edit tools are described below.

- Use the **Zoom In** tool to zoom in on an area of interest.
- Use the **Zoom Out** tool to zoom out from an area of interest.
- Use the **Zoom To Extents** tool to zoom to the data file’s full extent.
- Use the **Zoom To Previous** tool to zoom to the Map window’s previous extent.
- Use the **Select** tool to select a feature or position.
- Use the **Pan** tool to move along the feature’s alignment in search of irregularities.
- Use the **Delete Block** tool to select and delete a block of GPS positions. Click ***Edit – Undelete All Positions*** to restore ***all*** deletions (even those made prior to the file last being saved), not just the most recent deletion.
- Use the **Save** tool to save edits at regular intervals, and when edits are complete.

A Typical Edit Session

Figure 11.02 – An unclean end.



A typical edit session includes these steps:

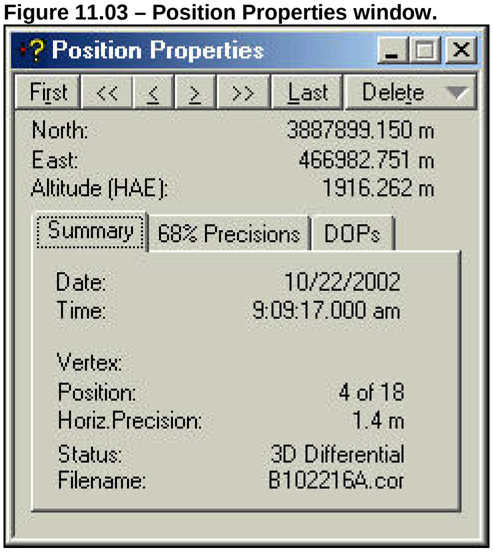
- Open a differentially corrected GPS data file.
- Zoom in to each end of each feature, and edit to produce a clean end, that, if appropriate to extend, would form a clean intersection with an adjoining like feature.
- Pan along each feature's alignment at a scale permitting careful, meaningful inspection, and edit out any irregularities and annoyances.
- Save edits at regular intervals, and when closing the session.

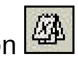
Other Edit Tools

Click the **Position Properties** button  to activate the **Position Properties** window, **Figure 11.03**. **Navigation buttons** along the top of this window permit sequential movement from position to position along feature alignments, and a **Delete/Undelete button** deletes and undeletes individual feature positions.

Data about the selected position are displayed in the window and tabs.

Figure 11.03 – Position Properties window.



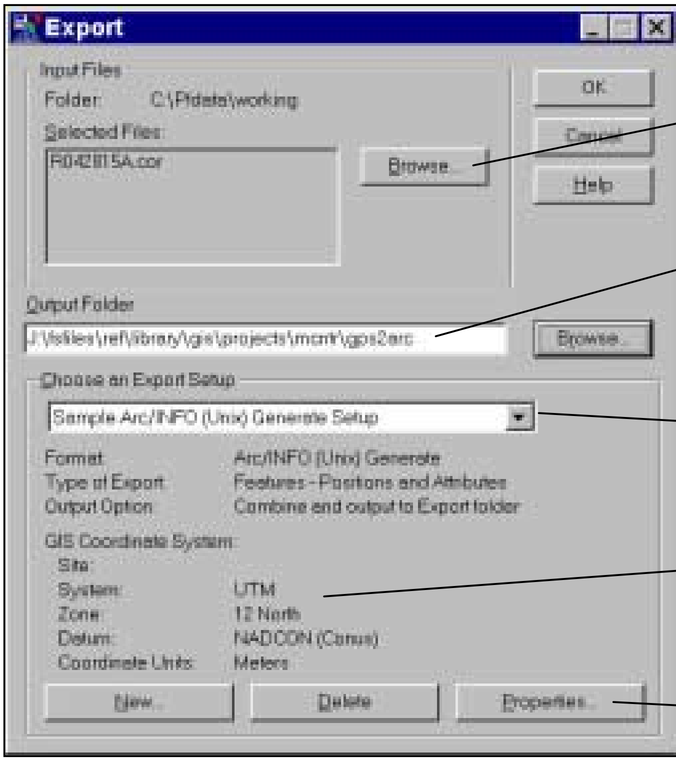
Click the **Feature Properties** button  to activate the **Feature Properties** window, **Figure 11.04**. **Navigation buttons** along the top of this window permit sequential movement from feature to feature. A **Delete/Undelete** button deletes and undeletes features.

When a feature is deleted, its constituent GPS positions remain, but its status as a feature, and its attributes, are stripped away.

Data about the selected feature are displayed, and its attributes may be edited in the **Attributes** tab.

Figure 11.04 – Feature Properties window.

Chapter 12 - Exporting Trimble GPS Features To Arc/Info



Click ***Utilities – Export…*** on the ***Pathfinder Office*** menu bar.

Use the upper ***Browse*** button to select edited, differentially corrected ***Input Files*** for export.

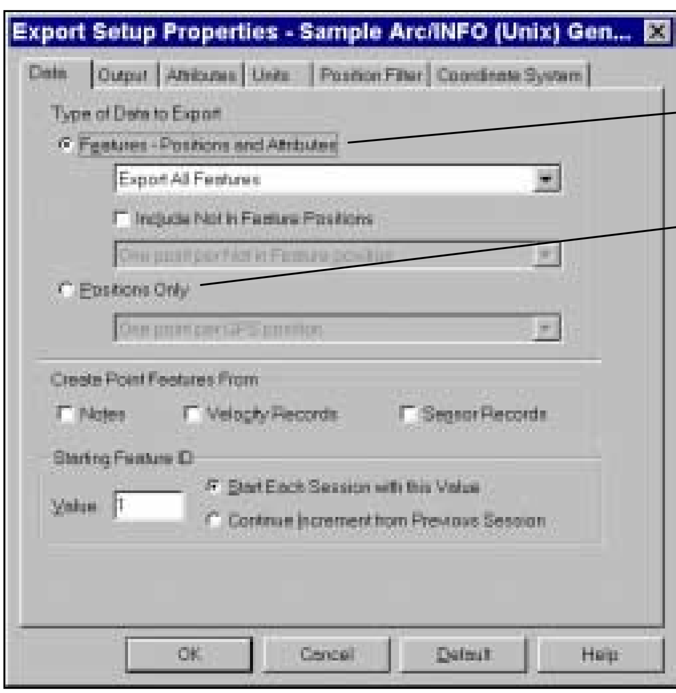
Type in the name, or use the lower ***Browse*** button, to identify the ***Output Folder*** where export files should be directed.

Select an existing export setup from the drop-down list, or click ***New…*** to create a new, customized setup.

System, Zone, Datum, and ***Coordinate Units*** should match those of the GIS being exported to.

Click ***Properties…*** to edit, or review, export settings.

Six tabs for ***Export*** settings are illustrated below.



Set up the ***Data*** tab as shown at left.

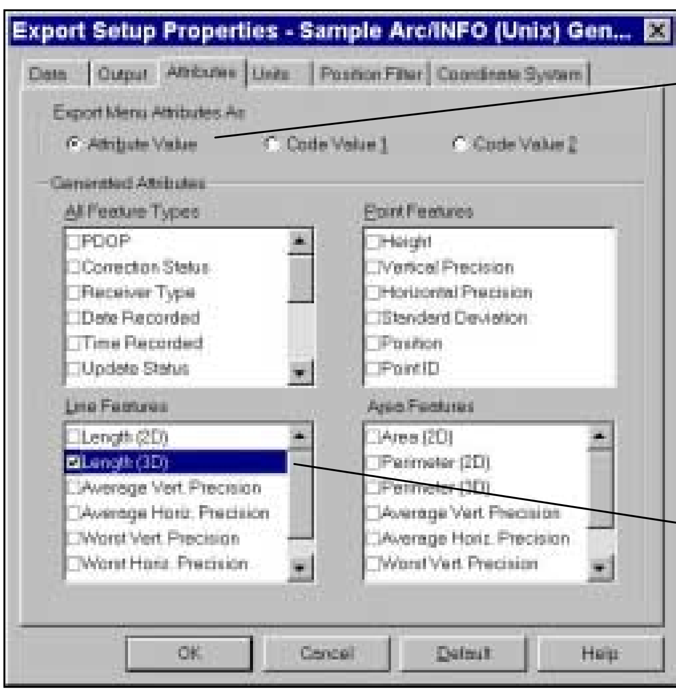
Typically, export would include ***Feature Positions And Attributes***.

If GPS positions weren't logged as part of a point, line, or polygon feature (not a recommended practice), select the ***Positions Only*** option, and make a selection from the drop-down list (***One Line Per Input File***, for instance).

Set up the ***Output*** tab as shown at left.

Make sure ***UNIX*** is selected as the ***System File Format***.

Export to ArcWorkstation coverages is supported by the ***Arc/Info (NT)*** (Windows) export setup.



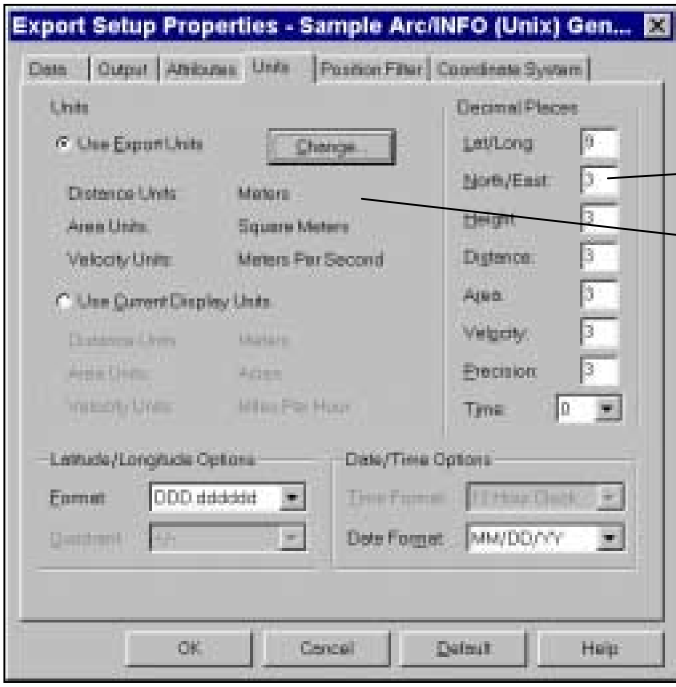
Set up the ***Attributes*** tab as shown at left.

Typically, ***Attribute Values*** are exported.

Attribute Values entered into a data dictionary during data capture can be transferred to an Arc/Info coverage right along with the feature's geometry.

Code Values are numeric codes associated with each ***Attribute Value*** in a data dictionary menu. For example, a data dictionary menu item might be "Fence", but its ***Code Value*** could be set to "522", the CFF code for fence.

In addition to ***Attribute*** and ***Code Values***, it may be useful to export other GPS ***Generated Attributes*** shown at left. For example, if the ***3D Length*** box is checked, slope length of each line feature will appear as a data item in the arc attribute table.

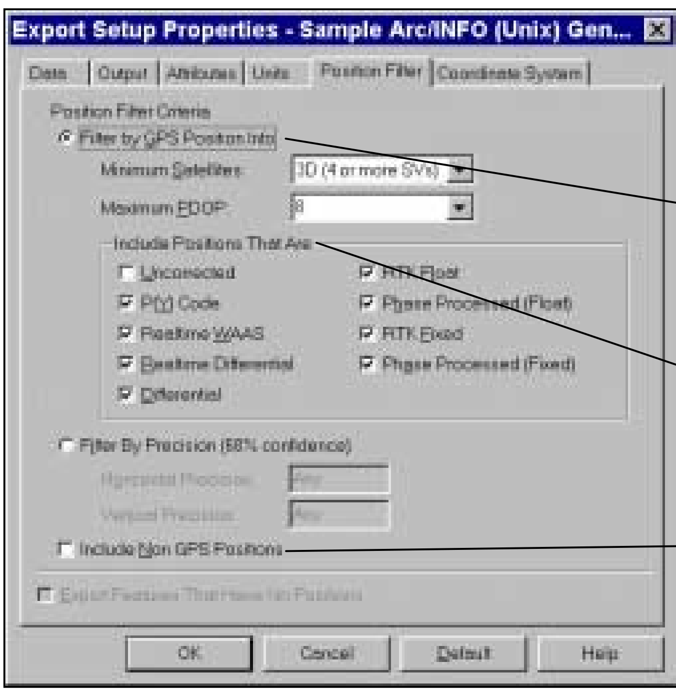


Set up the ***Units*** tab as shown at left.

Assuming export to a UTM coordinate system, the important items are:

North/East Decimal Places = 3

Distance Units = Meters



Set up the ***Position Filter*** tab as shown at left. This tab represents the final opportunity to enforce quality standards on GPS data prior to its export to GIS. Once exported, there is no way to assess GPS data quality!

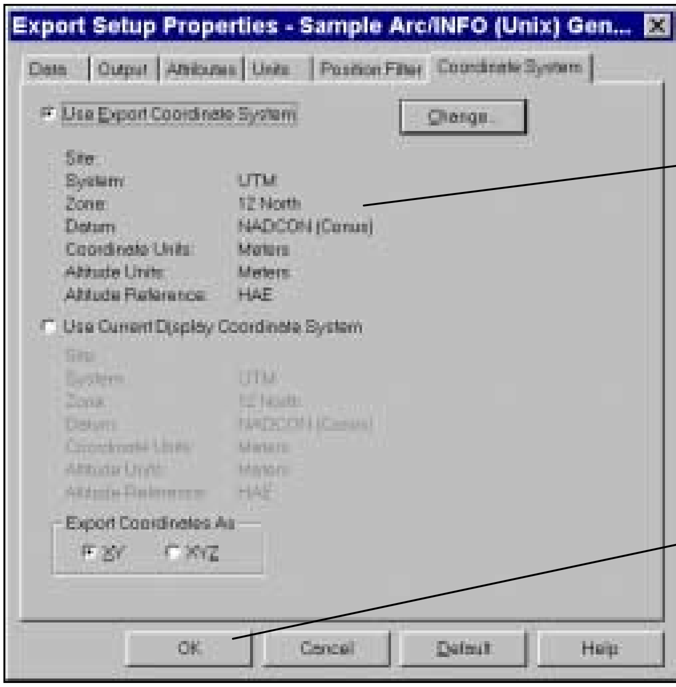
Filter By GPS Position Info should include:

- Min Satellites = 3D (4+ SVs)
- Max PDOP = 8

In the ***Include Positions That Are*** frame, check ***all*** boxes ***except*** the one for ***Uncorrected*** positions.

Un-check the ***Include Non-GPS Positions*** box.

Although GPS receiver configuration settings should be the primary method of enforcing GPS position quality, the ***Position Filter Criteria*** shown here provide GIS personnel an opportunity to assure themselves that position quality standards are being met prior to export.

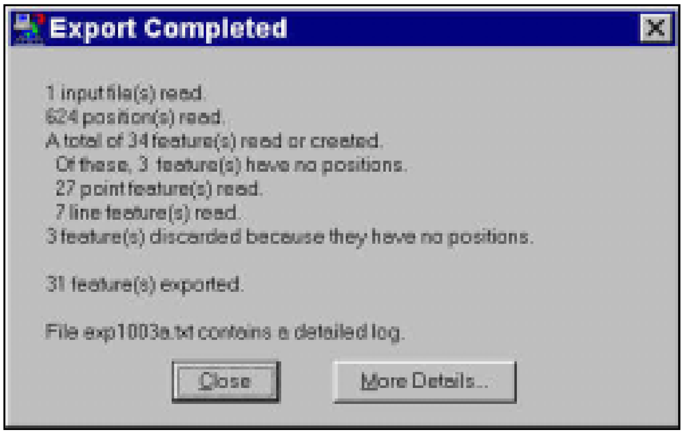


Set up the ***Coordinate System*** tab as shown at left.

It doesn't really matter whether ***Export Coordinate System*** or ***Display Coordinate System*** is selected, as long as the ***correct*** datum and coordinate system (for the GIS being exported to) are shown. **This is absolutely critical!**

Click ***OK*** to return to the ***Export*** form.

Click ***OK*** when all export ***Properties*** are set as desired.



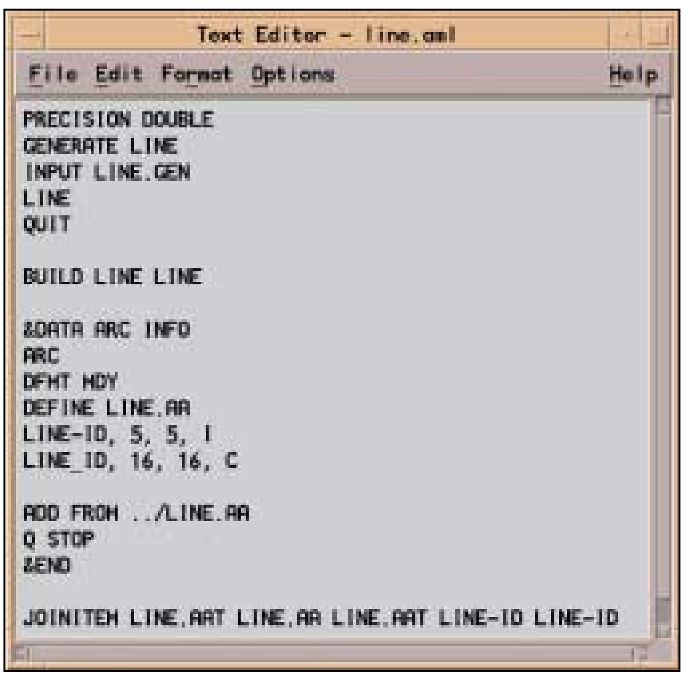
Export is complete.

Several export-related files are generated for each GPS data dictionary feature. These files are automatically directed to the ***Output Folder*** selected during the ***Export*** setup process.

These files are used in Arc/Info to convert GPS features to point, line, or polygon coverages.

These file types, and their contents, are briefly described below.

Feature	.aml files	.gen files	.aa files	.pa files	.pts files
Polygon	Converts .gen, .pa, and .pts files to an Arc/Info polygon coverage	Polygon coordinates	N/A	Polygon attributes	Label point coordinates
Line	Converts .gen and .aa files to an Arc/Info line coverage	Line coordinates	Line attributes	N/A	N/A
Point	Converts .pa and .pts files to an Arc/Info point coverage	N/A	N/A	Point attributes	Point coordinates



An example of the AML files produced by the export process is illustrated at left.

Run the AMLs (**`&run filename.aml`**) from an Arc prompt.

Data items TNODE# and FNODE# are populated with zeros because Arc's GENERATE conveys no topology. To remedy, apply the Arc command RENODE to line and polygon coverages, and then re-BUILD. RENAME coverages as desired. When satisfied that coverages have been exported satisfactorily, delete the .aml, .gen, .aa, .pa, and .pts files.

The new coverages are now ready for editing, routing, additional attribution, or incorporation into existing, corporate GIS coverages.

Many other export formats are also available, ESRI shapefile format, for instance.

PLEASE!!! – Avoid turning expensive GPS effort into taxpayer funded, one-time use, "throw-away data".

- Use NMAS-compliant data capture settings (PDOP, SNR, Elevation, etc.);
- Use a data dictionary to attribute GPS features in the field;
- Organize, document, and archive GPS work; and
- Have a GIS Coordinator incorporate GPS work into corporate GIS coverages.

Chapter 13 – Sources Of Help And Information

Sources Of Help And Information

Help on GPS topics is readily available from a variety of sources that include:

- About ten pounds of books and a quick reference guide that used to come (not so any longer) with each Trimble GPS unit. These manuals are packed with lots of good, readable information and illustrations.
- Content formerly contained in the hardcopy manuals, as well as other support notes, documentation, and free downloads, are available from Trimble's website at:

  `http://www.trimble.com/support.html`

- Trimble's Pathfinder Office software contains a tutorial dataset corresponding to a tutorial section in the PFO software manual.
- Trimble's web site contains a number of good GPS tutorials at:

  `http://www.trimble.com/gps/`

- Trimble's Pathfinder Office software has pretty good on-line help. Click ***Help – Contents…*** on the Pathfinder Office menu bar to activate on-line help, or press the ***F1*** key for context sensitive help.
- Check out the Forest Service GPS website for news and information at:

  `http://www.fs.fed.us/database/gps/`

- Seek advice or assistance from other GPS practitioners, or from Regional or Forest GPS Coordinators.
- Enter a GPS topic of interest (like "**`what is WAAS`**") into any internet search engine (like `www.google.com`) and see what comes up.

Trimble Priority Support

The End User Support Center (EUSC) does not support Trimble products and software because they are not considered "corporate" to the Forest Service. For instance, Pathfinder Office software does not come on the Forest Service software image.

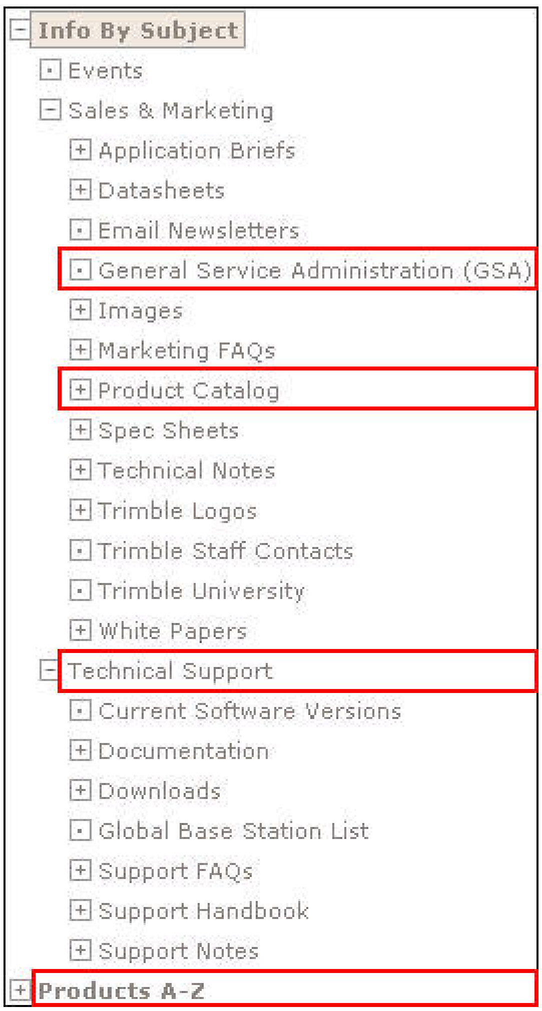
Therefore, the Forest Service has purchased a Trimble GPS Priority Support agreement. Unfortunately, this means that you can no longer contact Trimble Support directly. They will simply forward your support request on to the Regional Trimble Support Contact person. Here is how it is supposed to work.

- Spend at least 30 minutes trying to resolve the issue using:
  - Printed materials received with your Trimble GPS equipment or software;
  - Electronic Help files included with Trimble software;
  - Your "local" Trimble product vendor, CompassCom or Allen Instruments, for instance;
  - Product information from Trimble's generic web site (`http://www.trimble.com/support.html`); or
  - Product information from Trimble's more specialized federal user's web site (`http://mgispartners.trimble.com/logon.asp`). The logon and password for this site are **`"federal"`** and **`"feduser2004"`**, respectively.

- If unsuccessful, e-mail or call the Regional Trimble Support Contact with a description of the issue, and what has been done so far to resolve it. Currently, the Regional Trimble Support Contact is:
    - Carl Beyerhelm (cbeyerhelm@fs.fed.us)
    - (928) 354-2216 - Mogollon Rim District
    - (928) 527-3635 - Coconino SO
    - (928) 606-7582 - Cell phone
- If the Regional Trimble Support Contact is unable to resolve the issue, they pass it on to the folks at Priority Support, who (within 24 hours) will:
    - Get back to the Regional Trimble Support Contact with an answer; or
    - Get back to the person having the original issue with an answer.

Please try to solve any issues at the local level, but if unable to do so, do not hesitate to contact the Regional Trimble Support Contact.

Trimble's Mapping And GIS Partners Website



Trimble's Mapping and GIS Partners Website has information pertinent to their federal partners that is not available on their public website. Log on at `http://mgispartners.trimble.com/logon.asp` with username "**`federal`**" and password "**`feduser2004`**".

Areas of particular interest are those indicated at left.

- The **GSA** area contains contract information, ordering procedures, and GSA contract prices.
- The **Product Catalog** area contains schematic product diagrams and their part numbers.
- The **Technical Support** contains extensive information on many topics.
- The **Products A – Z** area arranges much of the technical support information by product, including firmware downloads and documentation for discontinued products.

Product Comparison

Trimble products can be compared to Trimble products in their class. For instance, use this link to determine the difference between TerraSync Standard and TerraSync Professional.

http://www.trimble.com/mgisprod_cmp.html

Comparisons And Evaluations Of Resource- and Recreation-Grade GPS Receivers

A comparison and discussion of GPS receiver evaluated under actual field conditions can be found at:

http://www.fs.fed.us/database/gps/gpsusfs.htm

Where To Obtain Trimble Products

Trimble does not sell its products directly to consumers. Locate a Trimble distributor at:

http://www.trimble.com/locator/sales.asp