Introduction to

Global Positioning Systems (GPS)

Maryland NRCS

August 2007

Topics

- GPS function & terminology
- GPS applications in NRCS
- Garmin GPS 76 for Data Collection

I. What is GPS?

GPS is a positioning system based on a network of satellites that continuously transmit coded information. The information transmitted from the satellites can be interpreted by receivers to precisely identify locations on earth by measuring distances from the satellites.

GPS is funded by and controlled by the U.S. Department of Defense (DOD). The system is called NAVSTAR.

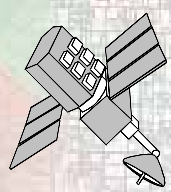
- Precisely identify locations on earth by measuring distances from the satellites

- NAVSTAR –

Navigational Satellite Timing And Ranging

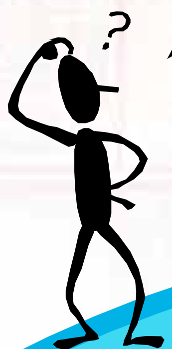
Three Components to GPS

Space Segment -the satellites orbiting the earth and transmitting timing and ranging messages



Control Segment - monitors the health and position of the satellites in the space segment and transmits correction information back up to the satellites

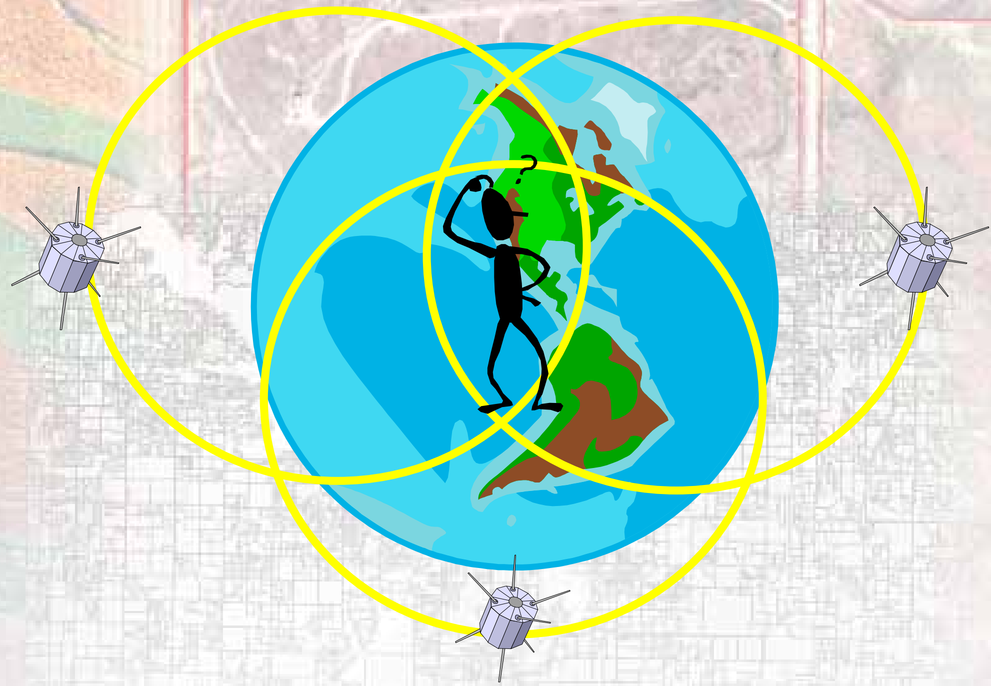
User Segment - the hand-held or other receivers used to interpret the messages broadcast from the satellites



GPS Constellation

- The nominal GPS Operational Constellation consists of roughly 24 satellites. Each satellite has a number on your GPS screen. Newer satellites have been sent up to replace older ones.
- The GPS signal communicates information about the precise position of the satellite and the precise time of the signal.
- Each satellite orbits the earth in about 12 hours. The satellite orbits repeat roughly the same ground track each day. Learn to identify the time of day when satellite coverage is best in your area and plan your field work accordingly.

2-D and 3-D Positioning



Since we exist in three dimensions, theoretically we need to get our distance from three satellites. The scenario above is theoretical because it supposes that we know exactly how far we are from the satellites. In order to get our GPS clock in synch with the satellite clocks, we need to get data from a fourth satellite to calculate the time offset and set our GPS clock to near perfect system time.

Bottom line:
You need at least 3 satellites to get a 2-Dimensional position and 4 satellites to get a 3-D position.

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Sources of Error…

that decrease the accuracy of your GPS readings

- Number and geometry of satellites visible
- Signal multi-path
- Orbital and Satellite Clock errors
- Ionosphere and troposphere delays
- Receiver clock errors

GPS position is not perfect . Some errors you have some control over. As a GPS user, you have some control over the first type of error - you can wait for the satellites to move into better geometry or plan your data collection for a good time of day. You cannot control multi-path error, but you do need to recognize when it may occur and pay close attention to the measurements that you are taking. Orbital and Satellite Clock errors as well as atmospheric delays are invisible to you, but you can avoid them by using differential correction. There is nothing that you can do about your receiver clock errors. GPS receivers will generally report an estimate of the accuracy of the position being reported by the unit at the time.

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DGPS

Differential Global Positioning Systems

- DGPS improves the accuracy and integrity of standard GPS
- DGPS works by placing a GPS receiver at a known location, this is called a reference station
- The reference station knows its exact location, and therefore can calculate the difference between the GPS derived positions and the true position.

The reference station calculates the errors in the GPS signals by comparing its known position to the position derived from the satellite signals. The stations actually calculate the differences between measured and actual ranges for each of the satellites visible from that station. This calculated difference is called the “differential correction” for that satellite. In real time DGPS, the correction signals are broadcast from the reference station and used immediately by the roving GPS to correct the position data being collected. There are two main sources of real time DGPS that USDA uses.

NDGPS

Nationwide Differential Global Positioning System

The Coast Guard operates a network of reference stations known as the Coast Guard Maritime Differential GPS Service as well as the developing Nationwide DGPS service.

The type of frequency that the NDGPS uses is “ground following”, meaning that it will not be blocked by most terrain features in its operating range. This means that the GPS user does not need to have a clear line of site to the DGPS transmitter. GPS users can use this signal if they have specialized receivers like the MBX-3 that is included in the USDA GPS configuration 1.

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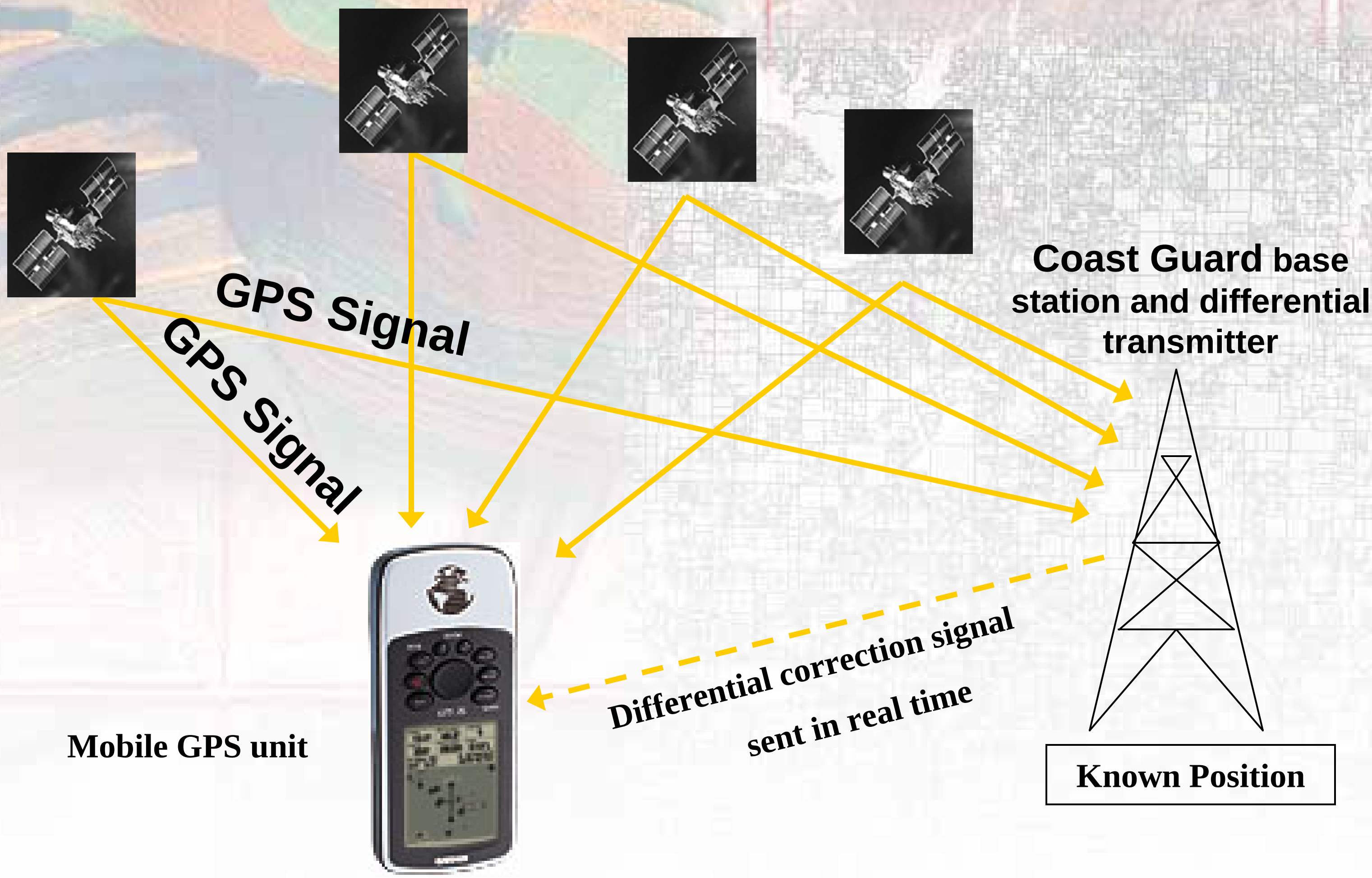
NDGPS

Nationwide Differential Global Positioning System



Wide Area Augmentation System (WAAS)

WAAS is a DGPS system implemented by the Federal Aviation Administration and designed primarily for aviation users. The system uses 25 ground reference stations to generate a nation-wide correction message. This message is then uploaded to two geo-synchronous satellites. The WAAS satellites then beam the correction message back to GPS users on the L1 frequency, the same frequency that the GPS signal is broadcast on.

The target accuracy of this system is 7 meters horizontal and vertical, testing has found it to be in the 3-5 meter range.

WAAS has some serious limitations for users on the ground because the L1 frequency is “line of sight”, meaning that it can be blocked by terrain, buildings, etc.

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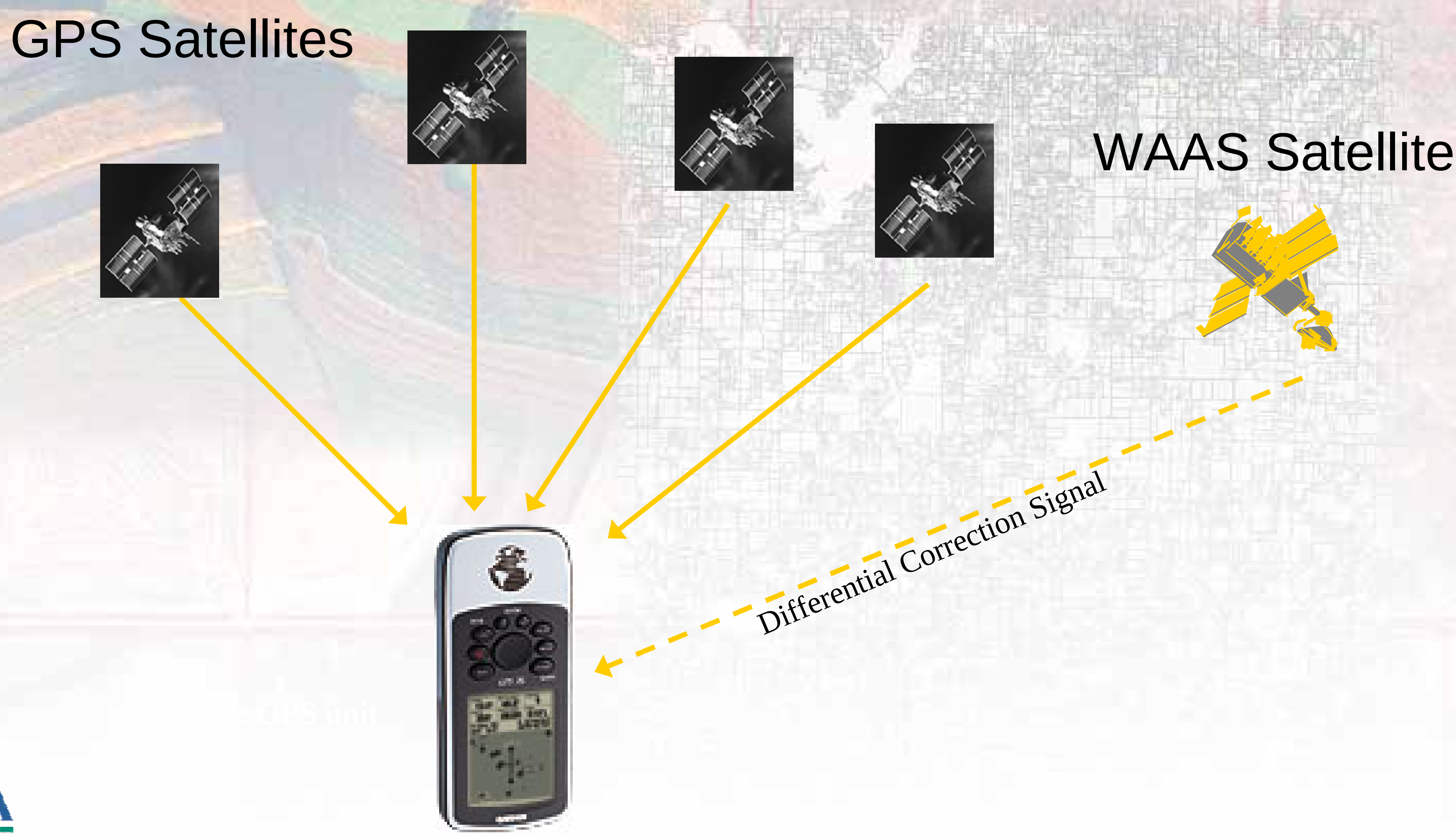
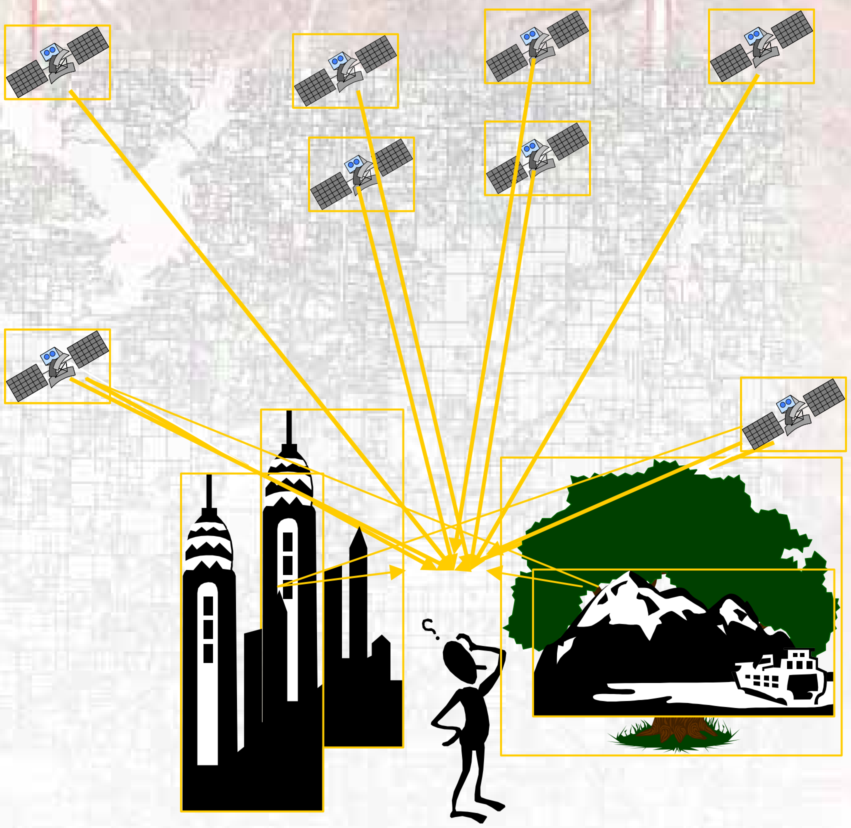
Wide Area Augmentation System (WAAS)



GPS Error NOT Addressed by DGPS

- Poor Satellite Geometry
- Poor Satellite Visibility
- Multipath Interference



GPS Error NOT Addressed by DGPS

- DGPS can eliminate some errors that were discussed in the last slide but not all of them.
- Satellites that are bunched in the sky will give a less accurate position than if those satellites were more evenly distributed in the sky.
- If the satellites are hidden by trees, buildings etc then they can not be used to determine position.
- As you gain experience, you will get an idea of where satellites are in the sky at different times of the day. This will help you to plan when to get GPS data in difficult areas.
- The signal can be bounced around by buildings and other flat reflective surfaces. This can cause some error because a bouncing signal will take longer to get to you and will therefore tell you that the satellite is farther away than it really is. This is called multipath interference and you just need to be aware that it exists.

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Accuracy varies by type of GPS unit

- Standard GPS - 15 m horizontal (50 ft)
- NDGPS - 5 m horizontal (16 ft)
- WAAS - 3 m horizontal (10 ft) in tests

II. GPS Applications in NRCS

- Determine 3-Dimensional Positions
- Measure Lengths/Distances
- Measure Areas
- Navigation
- GPS Mapping

II. GPS Applications in NRCS

GPS allows the user to obtain, record and manipulate precise positions on the face of the earth. This basic functionality can be used to accomplish the core tasks listed in the previous screen.

Determining positions means that you obtain their geographic coordinates. Lengths and areas can be measured if end points of a line or the corners of a field are obtained with a GPS.

If you know the coordinates of your destination, then the GPS can show you the distance and direction to that point.

GPS position measurement relies on very precise time measurement. Because of that, the general GPS user can tell time with near atomic clock accuracy.

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The key function of GPS…
to locate your position on the Earth

Barn Location

Latitude 39.5673 N

Longitude 115.345 W

GPS allows us to obtain, record and manipulate positions on the earth.

A waypoint gives us the coordinates for a single point location.

Waypoints and tracks give us a digital record in the form of a geospatial layer that we can print to a map (ex. planned practice, structure, resource layer)

GIS tools allow us to discern relationships and measure distances between points.

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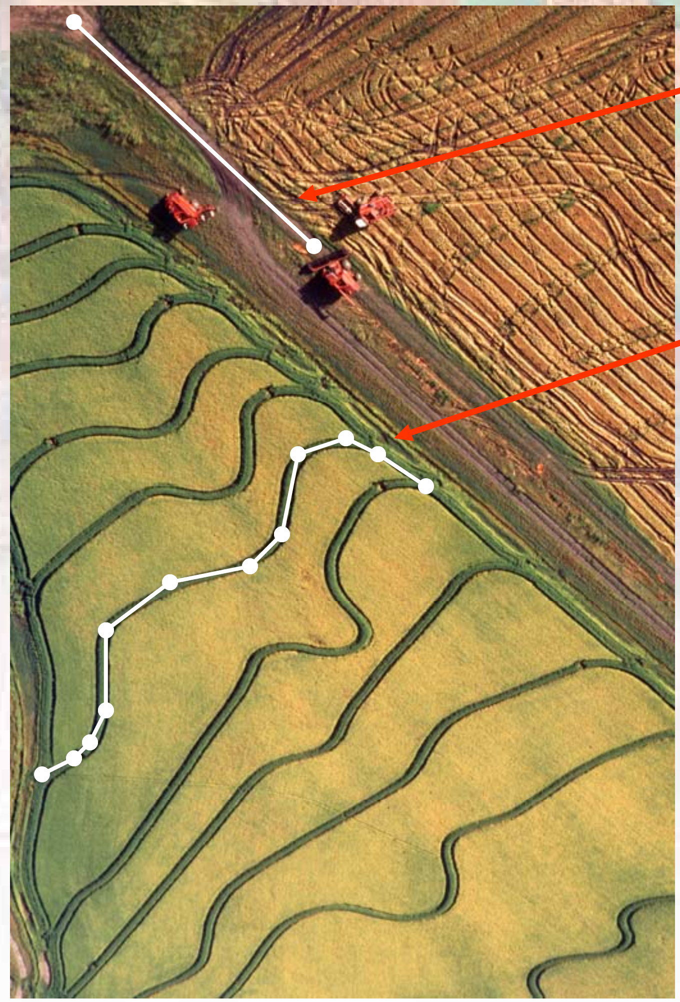
GPS can be used to measure distances



Waypoint

Point to Point Distance = 200 ft

Track

Length of Berm = 350 ft

Tracks are a collections of points collected automatically by the unit. For example, the GPS can record track points every 10 seconds as you walk the perimeter of a field. The collection method can also be set to distance, i.e. collect a point every 5 feet. Garmin also has an automated mode that takes into account speed of travel and direction changes. The length of a track is calculated as the cumulative length between each track point.

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GPS can be used to measure areas

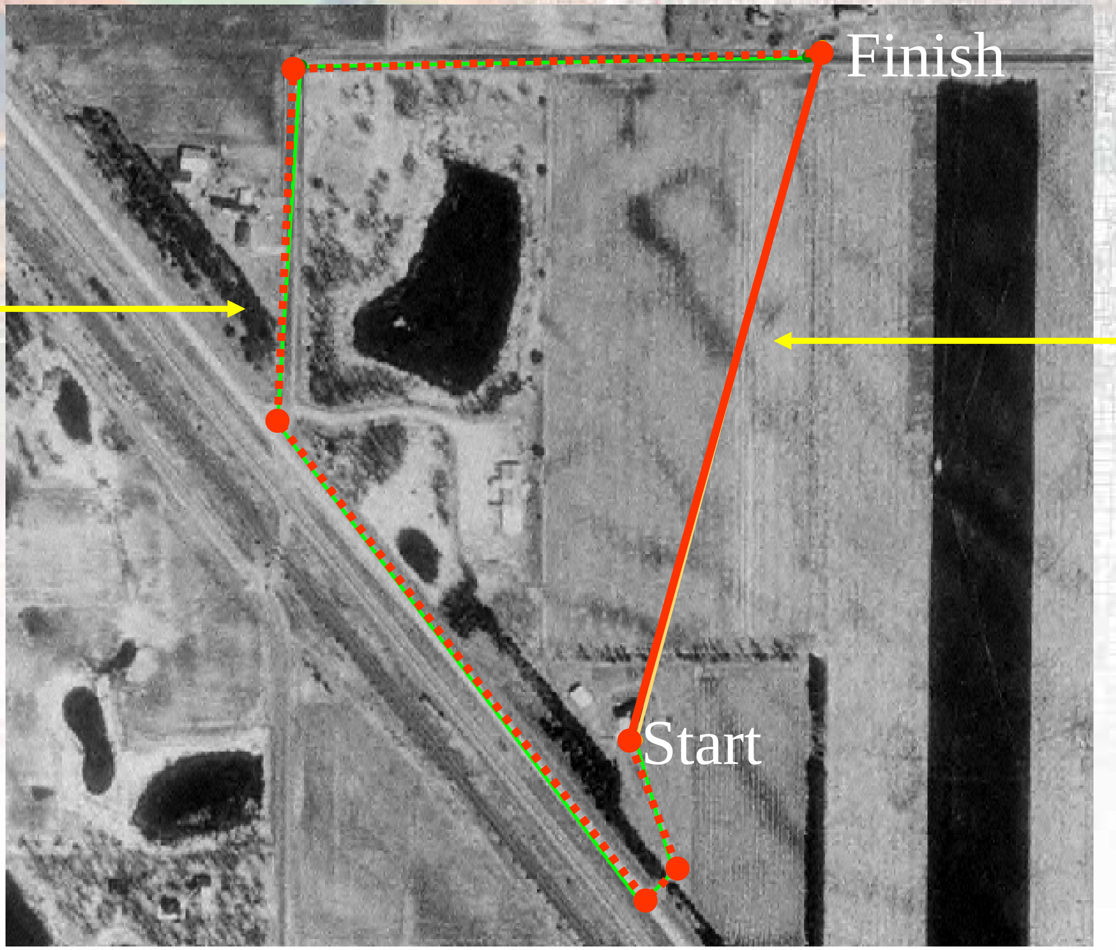
Just like lengths, areas can be measured using points or tracks.

Points can be used to define the area of regularly shaped areas that have well defined corners. A shape with curving edges, like a circular field or a field bounded by a meandering stream, will be harder to define using points that you determine in the field.

Tracks are very good at capturing curving lines as you travel around those edges. The downside is that a track will follow your every move.

Navigation with GPS

Route between two points



Straight line between two points

Routes

A route is an ordered set of waypoints that represents the path between two locations.

The solid line on the slide shows an example of the straight line between the points labeled start and the finish.

A route allows you to set intermediate waypoints on your path from A to B that take into account terrain, roads or other relevant factors.

The GPS will report the length of the entire route as well as the lengths of each of the segments between waypoints.

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GPS Mapping

GPS data can be used to map point, line and area features.

Examples of these features are:

Points - grain bins, utility poles, range monitoring sites, cultural resource areas,
Lines - roads/trails, streams, pipelines, fences
Areas - fields, wetlands, ponds

In general, and on the GPS units that USDA is acquiring, there is a method to attribute data that you collect in the field. That means that you can give unique symbols and names to the data that you collect so that you can interpret it back in the office. For example, you will be able to distinguish between points collected for a field boundary and those collected to map a grain bin.

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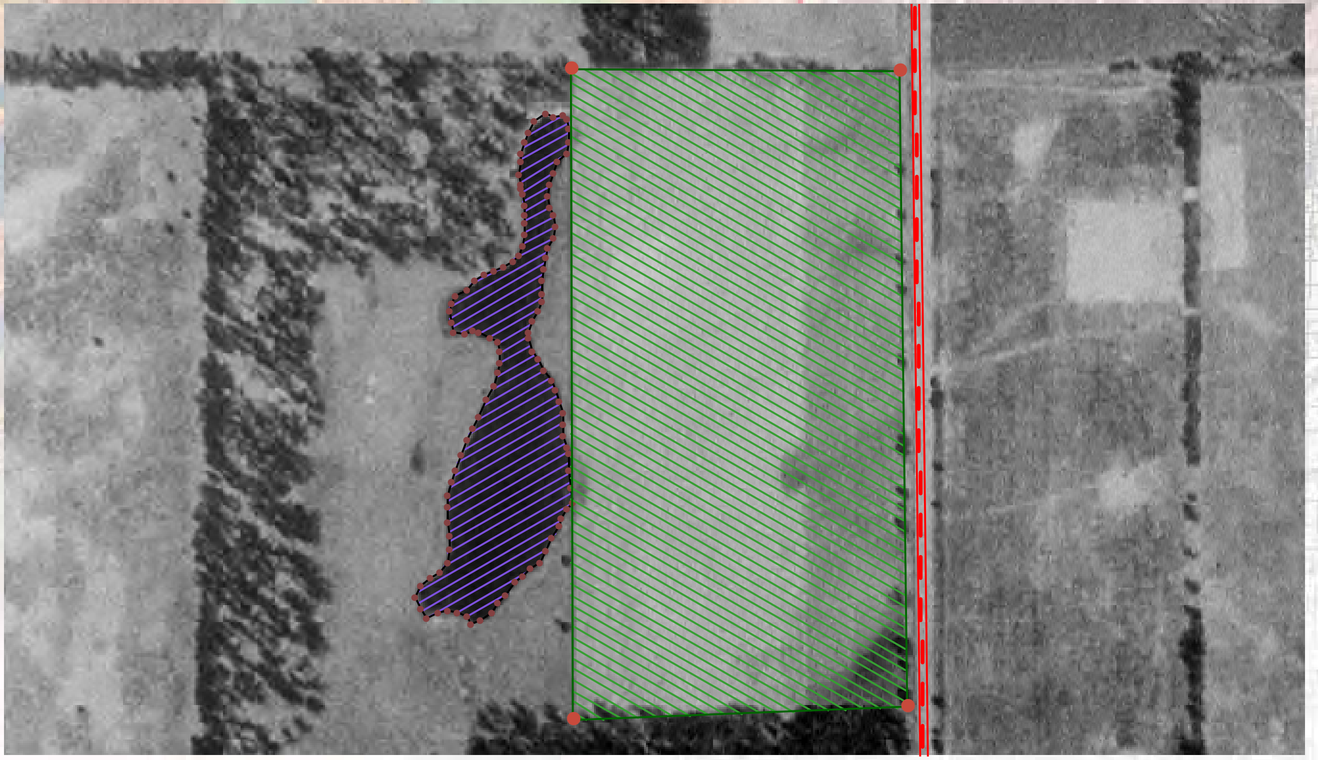
GPS Mapping



The data collected using GPS can be used to make maps of natural resources, physical infrastructure or any other geographic features.

In the slide the field is an area defined by 4 corner points, the road is a line, the lake is and area defined by a series of points.

III. Data Collection
Garmin GPSMap 76

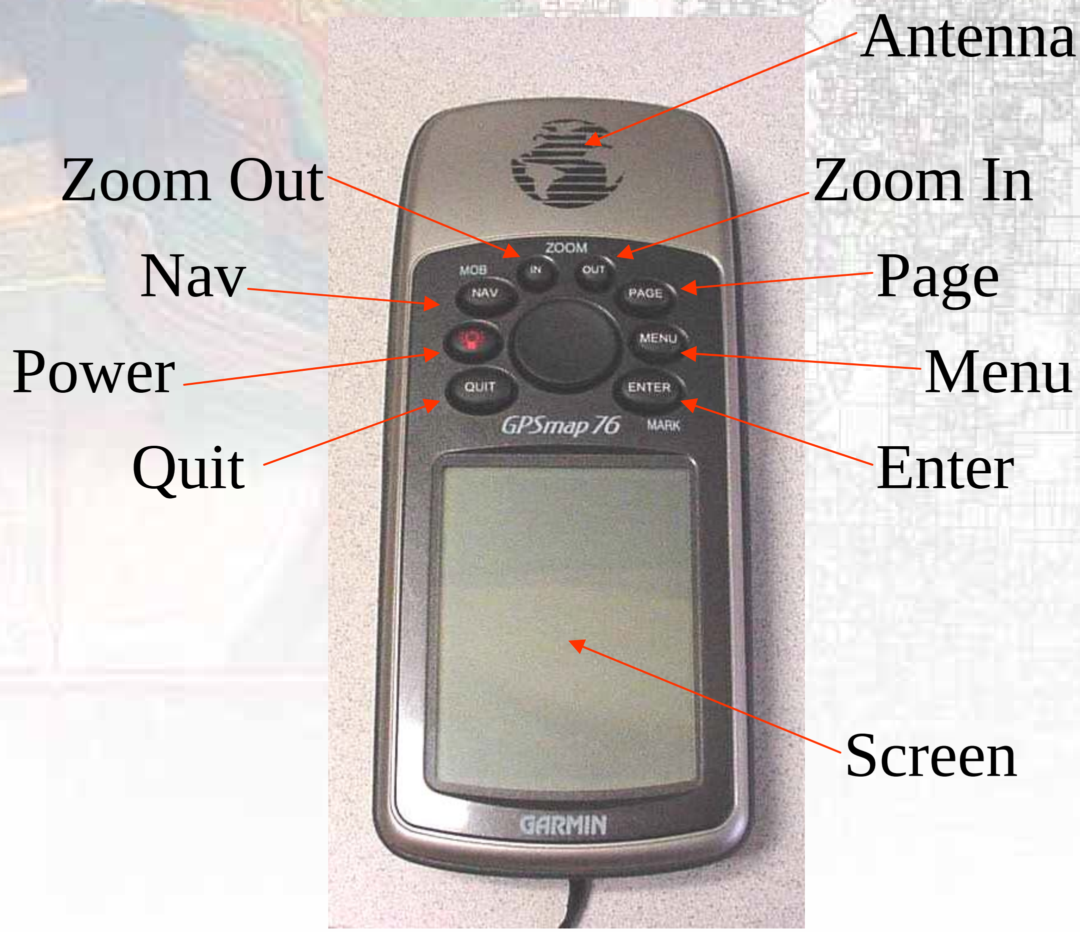
Required Accuracy Levels

USE THE DGPS BEACON TO ACHIEVE GREATEST ACCURACY

DGPS Beacon Receiver -
Accuracy should be less than or equal to 10 ft.
Use for: Certifying Conservation Practices

Stand-Alone GPS -
Accuracy should be less than or equal to 20 ft.
Use for: Basic Conservation Planning
Resource Inventories
Navigation

Layout and Button Functions of the Garmin GPSMap76



Back of the unit

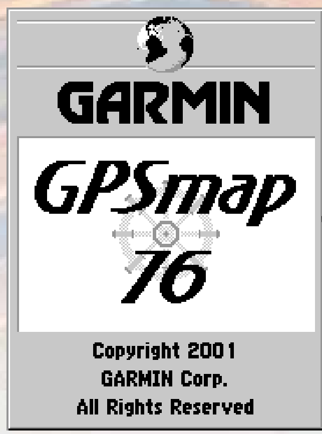
Antenna Cable Port

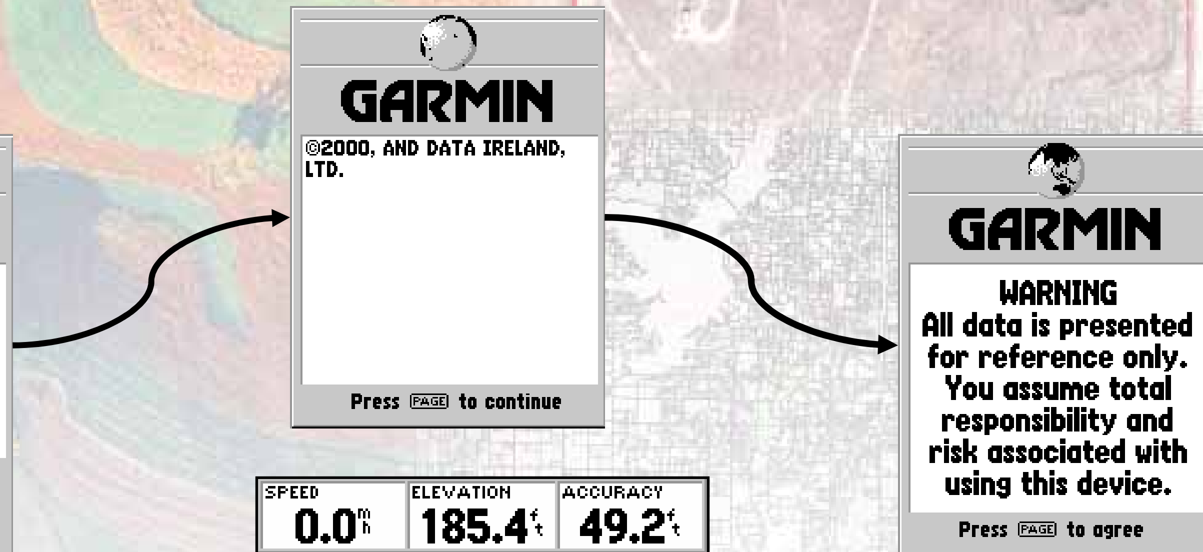
Battery Compartment

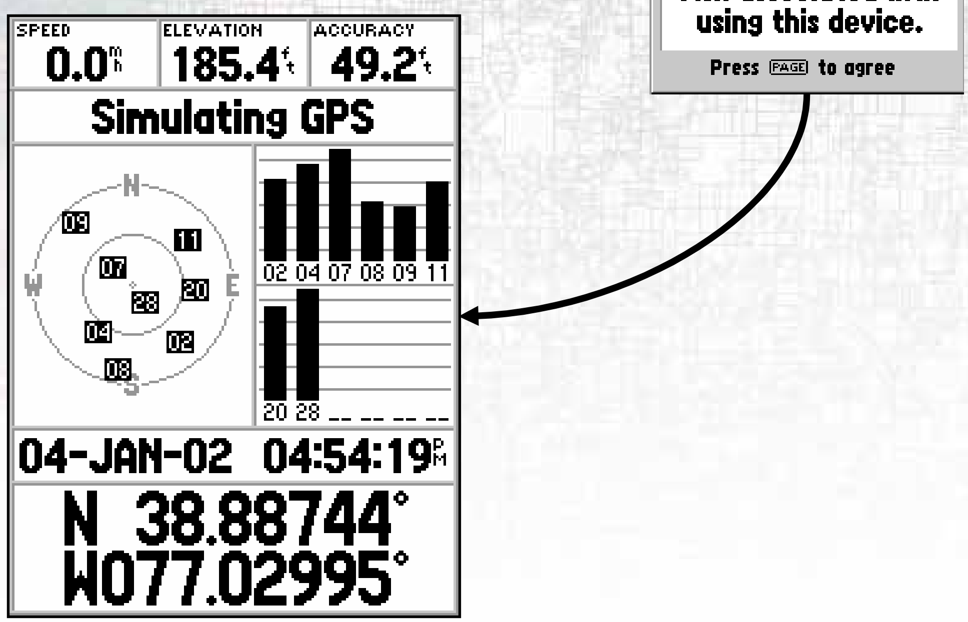
Power/Data Port

Open the battery compartment by turning the steel D-ring 1/4 turn counter-clockwise and then pulling straight away from the unit.

Turning on the Map76



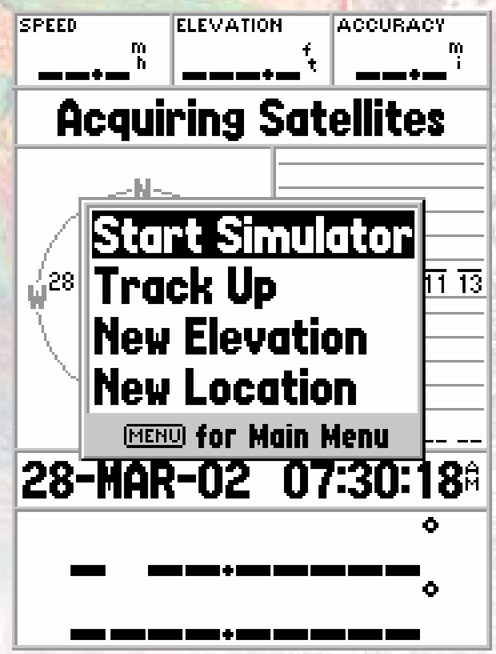




Turn on the GPS by pressing and holding the power key.

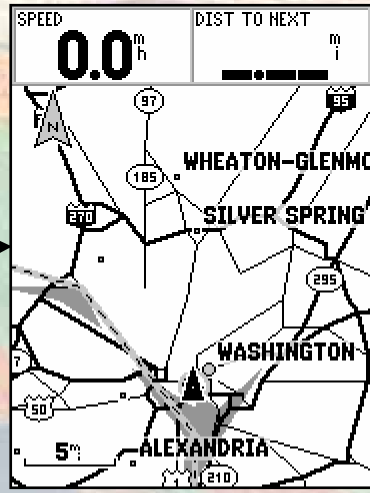
Move through the introductory screen by pressing the **Page** key.

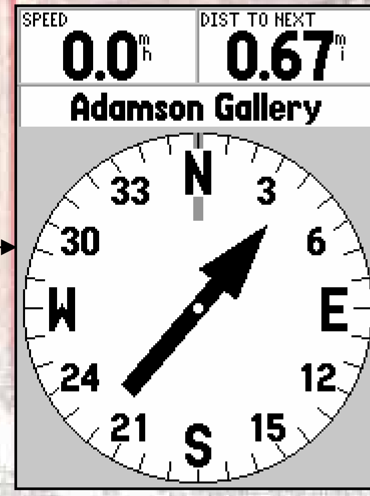
Setting the Map76 to Simulator Mode

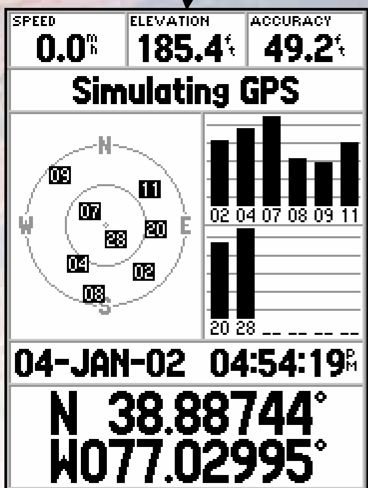


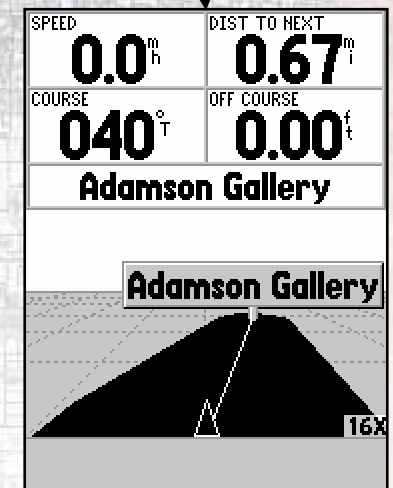
You will want to set theMap76 to simulator mode any time you have the GPS unit powered up inside. This save batteries by not powering the antenna, it also prevents you from getting messages telling you that the unit can not see any satellites.

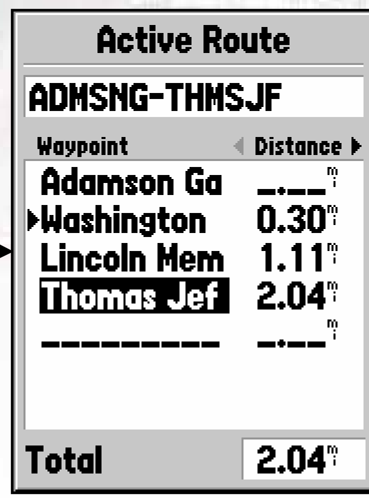
Pages on the Map76











The **Page** and **Quit** keys are used to navigate between the pages.

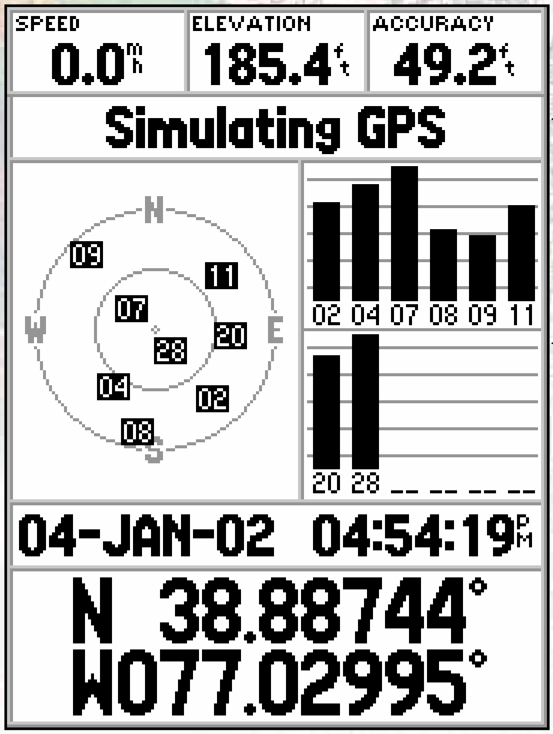
GPS Information Page

Receiver Status Message

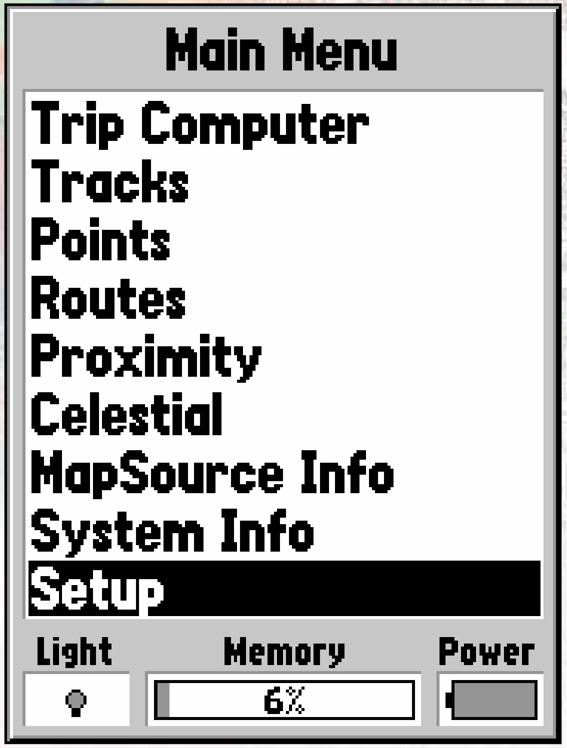
Sky Map

Satellite Strength Indicator Bars

Position

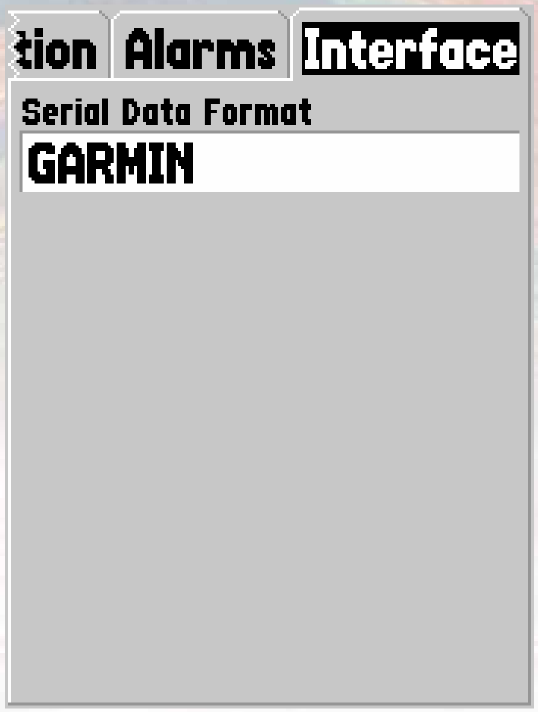


Main Menu

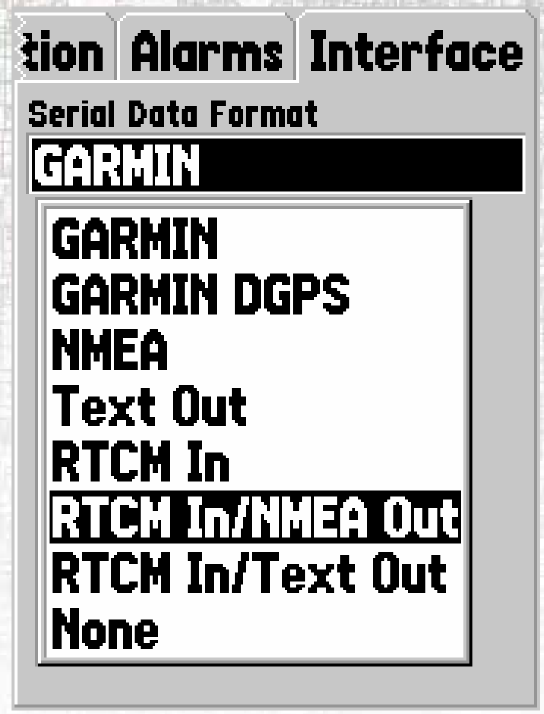

Main Menu
Trip Computer
Tracks
Points
Routes
Proximity
Celestial
MapSource Info
System Info
Setup
Light
Memory
6%
Power

Interface Setup

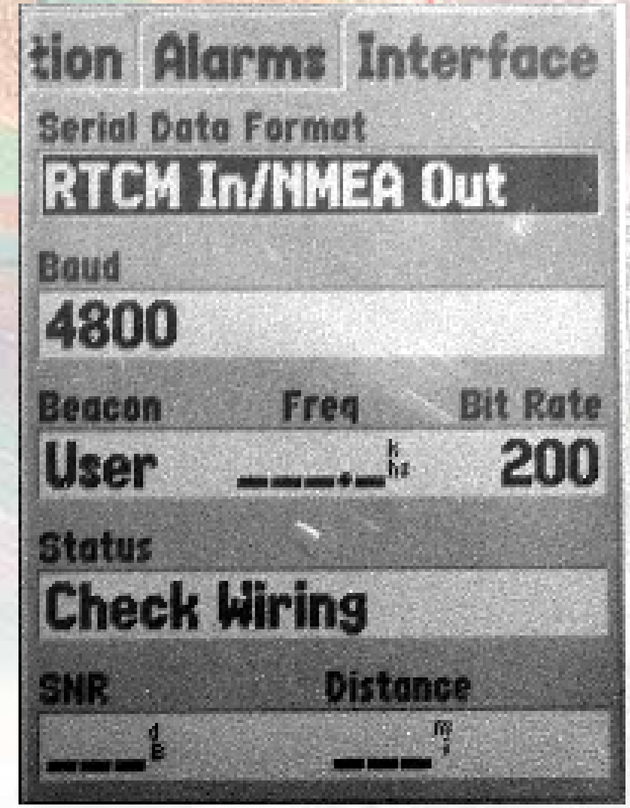
Stand-Alone GPS



Backpack - DGPS

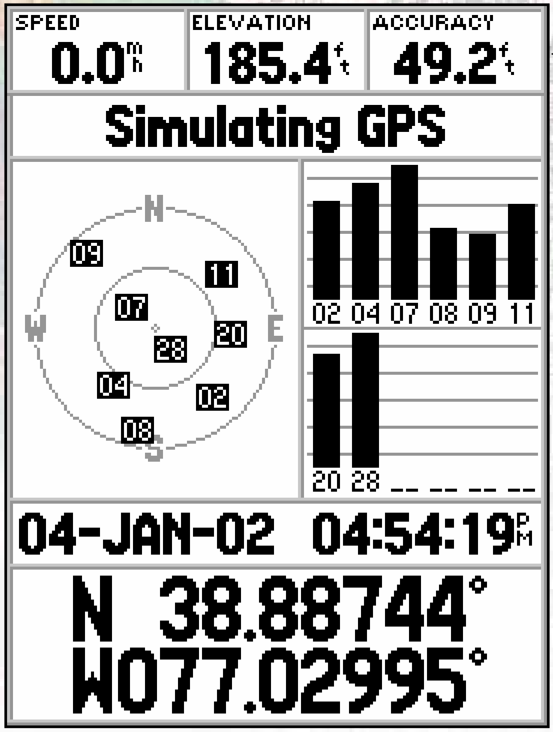


Backpack – DGPS Beacon Receiver



Set the “Beacon” field to User and then set the Frequency and bit rate for the NDGPS station that you want to use. This is often more effective and predictable than the Scan setting. Baud rate setting is a parameter of the communication between the GPS and the Beacon receiver and can not be adjusted by the user on this screen.

Note Accuracy



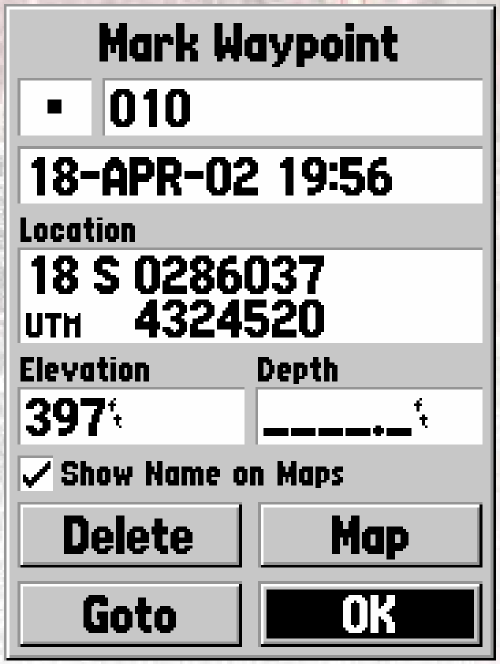
Accuracy

Mark A Waypoint

A waypoint is the coordinate definition of a position stored on the GPS.

To mark a waypoint:

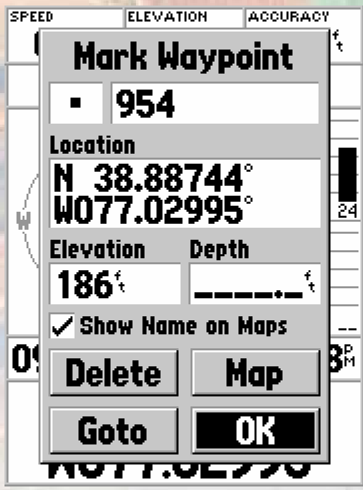
Press and hold the **Enter** key (also called the **Mark** key) until the waypoint dialog box appears on your screen. Use the **Rocker** key to highlight the name field, located on the top right of the dialog box. Press **Enter** to begin editing the waypoint name. Waypoint names can be up to 10 characters long. The characters for each field are selected one at a time using up and down on the rocker key. Press enter to accept a name for the point.

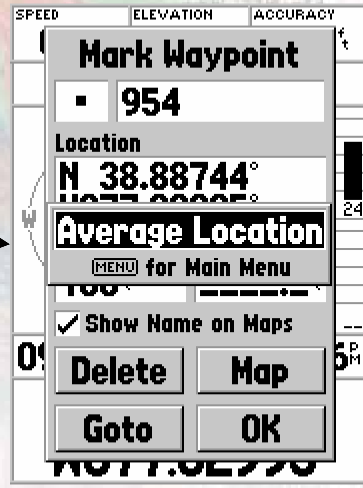


Waypoints are automatically saved when you press the **Mark** button. Pressing the **Quit** button before the waypoint information is edited will prevent the waypoint from staying in the memory. Otherwise, if you find that you have created a waypoint that you do not want, select the delete button on the waypoint screen and press enter. The GPS unit will ask you for a confirmation before it deletes the waypoint.

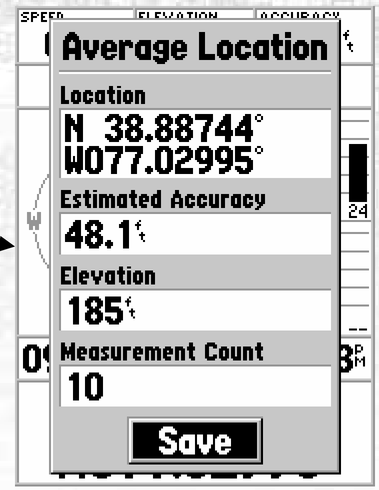
Using the Averaging Function

The averaging function can be used to reduce the inaccuracy of waypoints. To use averaging, start marking a point like you would normally. Before naming the point or accepting it, press the **Menu** key. Press **Enter** to accept "Average Location."





Keep the GPS antenna in the same place!



Once the accuracy has stabilized, press **Enter** to return to the waypoint page. Highlight "OK" and press **Enter** to save the waypoint.

The End