

Global Positioning Systems (GPS) and Geographic Information System (GIS) *a “hands-on” approach*

The University of Mississippi
Geoinformatics Center (UMGC)



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During this course we will be working together to help you [1] understand the basic principles underlying global positioning systems (GPS) and [2] learn to use a typical GPS unit.

We hope that you will return to your work with a solid foundation in this technology and the tools to further develop your ability to use GPS.

We encourage your full participation and welcome your questions at any time.

This workbook is yours to use during the course and keep as a reference.

Course Objectives

Upon completion of this course, you will be able to:

- Understand GPS technology
- Understand coordinate systems and datums
- Collect geographic coordinates
- Navigate to specific locations
- Transfer coordinates collected in the field to a personal computer.
- Import data into ArcView 3.2
- Add attribute information to data points

Agenda

DAY 1:

8:00 – 8:15	Welcome, Introductions, Expectations
8:15 – 8:45	Review of GIS Theory and ArcView
8:45 – 9:15	Creating Themes in ArcView and adding/displaying attributes
9:15 – 9:30	Break
9:30 – 10:00	Map projections and coordinate/datum systems
10:00 – 10:45	GPS Theory and Applications (Short history and FAQ included)
10:45 – 12:00	Introduction to the GPS receiver and hands-on
12:00 – 1:30	Lunch and collection of data points
1:30 – 2:00	Hardware installations and software alternatives for data retrieval
2:00 – 2:45	Data download and import into ArcView
2:45 – 3:15	Adding/displaying attributes to data points
3:15 – 3:30	Break (Maybe collect more data)
3:30 – 4:00	Adding other data themes (images, roads, digital elevation models, landuse, political boundaries etc.)
4:00 – 4:30	Creating map layout and printing output
4:30 – 4:45	Creating points to upload to the GPS for navigation
4:45 – 5:00	Demonstration of other GPS units available
5:00	Closing Thoughts

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Chapter 1 - GLOSSARY

Arc/INFO	Fully-functional GIS software capable of calculating topology and creating new geospatial data.
Almanac Data	Initial satellite data the GPS needs in order to calculate its present position. The almanac data updates the clock and satellite configurations, synchronizing the GPS with the satellite constellation.
ArcView	Software developed to allow non-specialists to use data developed in Arc/INFO.
Attribute	Descriptive information about an element in a GIS data layer, such as the name and length of a stream, the concentration of lead in well #57, etc.
Base Station	A GPS unit permanently installed at a known location that is used to differentially correct the position error of the GPS signals.
Coordinate System	A system of expressing the location of features. An example is Latitude/Longitude.
Cover Type	Term used to identify the vegetation community in an area according to a particular classification system.
Coverage	A geospatial data layer in Arc/INFO containing information about a set of features with characteristics in common, such as streams, roads, refuge boundaries, etc.
Data Dictionary	A description of the fields (items) that describe a feature in an attribute table, including a list of the possible values and codes used in each field.
Datum	A set of characteristics that define a coordinate system, and a set of control points whose geometric relationships are known, either through measurement or calculation. All datums are based upon a spheroid, which approximates the shape of the earth. Examples include North American Datum (NAD) 1927 and NAD83.
Differential Correction	See Post-processing.

DOP	Dilution of Precision; a method of describing the current accuracy of a GPS unit based on satellite configuration. PDOP is Position Dilution of Precision, a factor that includes both horizontal and vertical accuracy, while HDOP (Horizontal Dilution of Precision) only describes horizontal accuracy. PDOP values should be 6 or less.
Feature	A single geospatial data element, e.g., a stream, a road, a county, a well, etc.
Field	The columns in a database or spreadsheet.
GIS	A computer-based system designed for the collection, storage, and analysis of phenomena where geographic (spatial) location is an important characteristic or is crucial to analysis.
GPS	Global Positioning System; a satellite-based system capable of determining the x,y,z coordinates of one's location on the earth.
Ground Truth	To visit a site to verify data derived from remote sensing.
HDOP	Horizontal Dilution of Precision - a calculated likelihood of horizontal error based on the present position of the satellites being tracked; higher numbers indicate larger errors.
Land cover	See Cover type.
Landsat	A series of satellites that acquires images of the earth. The data have 30 meter resolution with 7 Thematic Mapper bands.
Layer	See Theme.
Line or Arc	A spatial feature that is defined by a beginning point (node) and ending point (node). An arc contains additional points called vertices that change the direction of the line between the nodes.

Map Projection	A mathematical system that represents the spherical surface of the earth on a flat (planar) surface, like a map. Examples include Universal Transverse Mercator (UTM) and the Albers Equal-Area Projection. Latitude/Longitude is not a map projection, it is a spherical coordinate system.
Metadata	Information describing the contents and development history of a data set. Data Documentation. “Data about data.”
NAVSTAR	Navigation Satellite Timing and Ranging - the space-based satellite system used for global, continuous, all-weather calculation of time, position and velocity.
NWI	National Wetlands Inventory. A Fish and Wildlife Service program responsible for classifying and mapping wetlands throughout the United States.
PDOP	Position Dilution of Precision - a calculated likelihood of position error based on the present position of the satellites being tracked; includes horizontal and vertical error. PDOP values should be 6 or less.
Point	A spatial feature with neither length or area.
Polygon	A vector-based feature in which an area is defined by the series of lines comprising its boundary and a label point.
Post Processing	Correcting field position data collected by a portable unit not able to use the PPS signal by acquiring nearby base station data for the same time period and using a computer program to differentially calculate the actual positions.
PPS	Precise Positioning Service - encoded GPS information broadcast from satellites that contains corrections to remove the intentional errors of Selective Availability.
Scale	A value, usually represented as a ratio or a fraction, identifying the relationship between the dimensions of the map and the dimensions of the earth. The scale at which data are entered into a GIS is a very important consideration for performing analyses and producing maps because it determines the level of detail contained within the data.

Solution	The geographic coordinates of a location calculated by a GPS receiver.
Spatial Data	Geographical data that store the geometric locations of features on the earth.
Spoofing	The attempt to imitate the GPS satellite signals by an unfriendly party.
SPS	Standard Positioning Service - GPS information broadcast in the clear, available to anyone, but with built-in errors making the signal accurate to only +/- 100 meters. A receiver that collects only the deliberately degraded signal from the satellites with no internal correction is said to use the Standard Positioning Service.
Theme	A collection of geographic objects (e.g., rivers, telephone poles, vegetation communities) with a common subject.
Topology	The relationships between spatial features.
UTM	Universal Transverse Mercator; a map projection system that uses the intersection of Northing (north-south) and Easting (east-west) lines to describe a position on the globe.
Vector	A data format in which the spatial data elements are represented as points, lines, or polygons and are referenced to a spatial location.
Vegetation Classification	A system for characterizing the species compositions or habitat types of homogenous plant communities.
Waypoint	GPS term used to describe a single position solution. Waypoints can be collected singly for point-source data or automatically for mapping roads, trails or boundaries.

Chapter 2 - Datums, Coordinate Systems, Map Projections

Session Objectives: At the conclusion of this session, you will:

- Understand how the selection of datum and coordinate system affects the results of your data collection.

The following is excerpted material developed by Peter H. Dana from the Department of Geography, University of Texas at Austin. It is part of a work in progress from "The Geographer's Craft". The author has generously permitted use of these materials for study, research, and education.

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The complete materials may be viewed at the following world wide web address:

<http://www.utexas.edu/depts/grg/gcraft/notes/coordsys/coordsys.html>

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Source: This module was developed by Pat Carroll and Hope Malcom. Additions by Lance Yarbrough.

Geodetic Datum Overview

Introduction

This overview of coordinate systems for georeferencing provides a brief description of local and global systems for use in precise positioning, navigation, and geographic information systems for the location of points in space. There are many different coordinate systems, based on a variety of geodetic datums, units, projections, and reference systems in use today. As an example, here is the position of one of the thousands of geodetic control points in the United States, the star in the hand of the Goddess of Liberty atop the Capitol building in Austin, Texas.

The Austin Capitol Dome Liberty Star Horizontal Control Station (The star in the hand of the Goddess of Liberty)			
Datum	Coordinate System	Coordinates	Units
NAD-83	Geodetic Latitude, Longitude	30:16:28.82 N, 97:44:25.19 W	deg:min:sec
NAD-27	Geodetic Latitude, Longitude	30:16:28.03 N, 97:44:24.09 W	deg:min:sec
WGS-72	Geodetic Latitude, Longitude	30:16:28.68 N, 97:44:25.75 W	deg:min:sec
NAD-83	UTM Easting, Northing, Zone	621160.98, 3349893.53 14 R	meters
NAD-27	UTM Easting, Northing, Zone	621193.18, 3349688.21	meters
NAD-83	Military Grid Reference System	14RPU2116149894	meters
NAD-27	Military Grid Reference System	14RPJ2119349688	meters
NAD-83	State Plane, TX C 4203 Easting, Northing	949465.059, 3070309.475	meters
NAD-27	State Plane, TX C 4203 Easting, Northing	2818560.55, 230591.76	feet
NAD-83	State Plane, TX SC 4204 Easting, Northing	721201.977, 4271229.432	meters
NAD-27	State Plane, TX SC 4204 Easting, Northing	2397741.25, 889749.98	feet
WGS-72	World Geographic Reference System	FJHA4416	deg. and min.
	VOR-DME Bearing, Distance, VOR ID	230.46, 2.271, 114.6 Ch.93 AUS	deg,nmi,id
	Loran-C GRI 7980 W, X, Y, Z TDs	10998.9,24795.0,47040.8,63902.3	microsec.
	U.S. Postal Zip Code (5-digits)	78705	

One Location Described by Different Coordinate Systems
Peter H. Dana 9/9/94

Geodetic datums define the reference systems that describe the size and shape of the earth. Hundreds of different datums have been used to frame position descriptions since the first estimates of the earth's size were made by Aristotle. Datums have evolved from those describing a spherical earth to ellipsoidal models derived from years of satellite measurements. Modern geodetic datums range from flat-earth models used for plane surveying to complex models used for international applications which completely describe the size, shape, orientation, gravity field, and angular velocity of the earth. While cartography, surveying, navigation, and astronomy all make use of geodetic datums, the science of geodesy is the central discipline for the topic. Referencing geodetic coordinates to the wrong datum can result in position errors of hundreds of meters. Different nations and agencies use different datums as the basis for coordinate systems used to identify positions in geographic information systems, precise positioning systems, and navigation systems. The diversity of datums in use

today and the technological advancements that have made possible global positioning measurements with sub-meter accuracies requires careful datum selection and careful conversion between coordinates in different datums.

The Figure of the Earth

Geodetic datums and the coordinate reference systems based on them were developed to describe geographic positions for surveying, mapping, and navigation. Through a long history, the "figure of the earth" was refined from flat-earth models to spherical models of sufficient accuracy to allow global exploration, navigation and mapping. True geodetic datums were employed only after the late 1700s when measurements showed that the earth was ellipsoidal in shape.

Geometric Earth Models

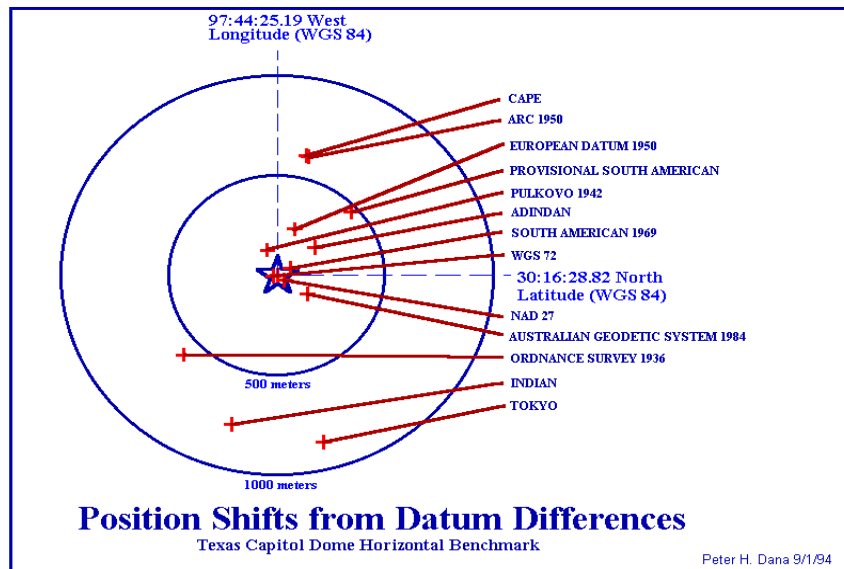
Early ideas of the figure of the earth resulted in descriptions of the earth as an oyster (the Babylonians before 3000 B.C.), a rectangular box, a circular disk, a cylindrical column, a spherical ball, and a very round pear (Columbus in the last years of his life). Flat earth models are still used for plane surveying, over distances short enough so that earth curvature is insignificant (less than 10 km). Spherical earth models represent the shape of the earth with a sphere of a specified radius. Spherical earth models are often used for short range navigation (VOR-DME) and for global distance approximations. Spherical models fail to model the actual shape of the earth. The slight flattening of the earth at the poles results in about a twenty kilometer difference at the poles between an average spherical radius and the measured polar radius of the earth. Ellipsoidal earth models are required for accurate range and bearing calculations over long distances. Loran-C, and GPS navigation receivers use ellipsoidal earth models to compute position and waypoint information. Ellipsoidal models define an ellipsoid with an equatorial radius and a polar radius. The best of these models can represent the shape of the earth over the smoothed, averaged sea-surface to within about one-hundred meters.

Datums in Use

Hundreds of geodetic datums are in use around the world. The Global Positioning System is based on the World Geodetic System 1984 (WGS-84). Parameters for simple XYZ conversion between many datums and WGS-84 are published by the Defense mapping Agency.

Datum Shifts

Coordinate values resulting from interpreting latitude, longitude, and height values based on one datum as though they were based in another datum can cause position errors in three dimensions of up to one kilometer.

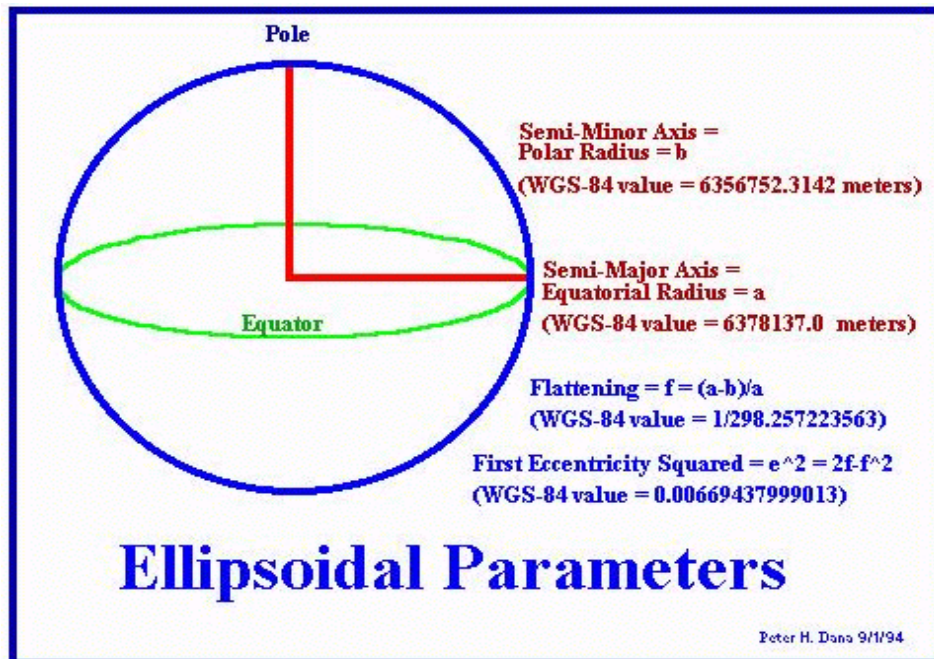


Datum Conversions

Datum conversions are accomplished by various methods. Complete datum conversion is based on seven parameter transformations that include three translation parameters, three rotation parameters and a scale parameter. Simple three parameter conversion between latitude, longitude, and height in different datums can be accomplished by conversion through Earth-Centered, Earth Fixed XYZ Cartesian coordinates in one reference datum and three origin offsets that approximate differences in rotation, translation and scale.

Reference Ellipsoids

Ellipsoidal earth models are required for accurate range and bearing calculations over long distances. Loran-C, and GPS navigation receivers use ellipsoidal earth models to compute position and waypoint information. Ellipsoidal models define an ellipsoid with an equatorial radius and a polar radius. The best of these models can represent the shape of the earth over the smoothed, averaged sea-surface to within about one-hundred meters. Reference ellipsoids are defined by semi-major (equatorial radius) and semi-minor (polar radius) axes. Other reference ellipsoid parameters such as flattening, and eccentricity are computed from these two terms. Many reference ellipsoids are in use by different nations and agencies.

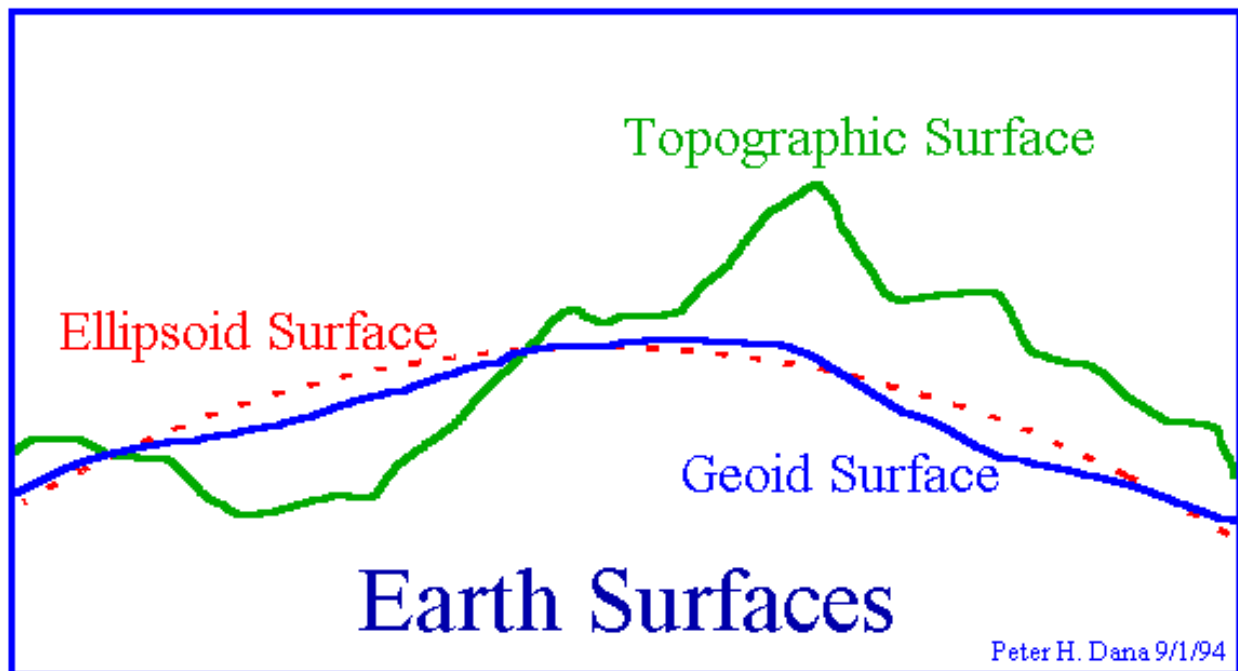


Earth Surfaces

The earth has a highly irregular and constantly changing surface. Models of the surface of the earth are used in navigation, surveying, and mapping. Topographic and sea-level models attempt to model the physical variations of the surface, while gravity models and geoids are used to represent local variations in gravity that change the local definition of a level surface.

The topographical surface of the earth is the actual surface of the land and sea at some moment in time. Aircraft navigators have a special interest in maintaining a positive

height vector above this surface. Sea level is the average (methods and temporal spans vary) surface of the oceans. Tidal forces and gravity differences from location to location cause even this smoothed surface to vary over the globe by hundreds of meters. Gravity models attempt to describe in detail the variations in the gravity field. The importance of this effort is related to the idea of leveling. Plane and geodetic surveying uses the idea of a plane perpendicular to the gravity surface of the earth, the direction perpendicular to a plumb bob pointing toward the center of mass of the earth. Local variations in gravity, caused by variations in the earth's core and surface materials, cause this gravity surface to be irregular.



Geoid models attempt to represent the surface of the entire earth over both land and ocean as though the surface resulted from gravity alone. Bomford described this surface as the surface that would exist if the sea was admitted under the land portion of the earth by small frictionless channels. The WGS-84 Geoid defines geoid heights for the entire earth. The U. S. Defense Mapping Agency publishes a ten by ten degree grid of geoid heights for the WGS-84 geoid.

Map Projections

Introduction

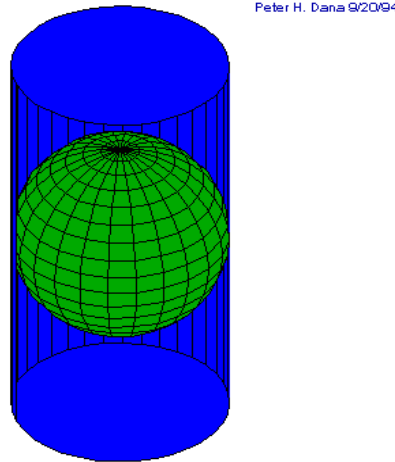
Map projections are attempts to portray the surface of the earth or a portion of the earth on a flat surface. Some distortions of conformality, distance, direction, scale, and area always result from this process. Some projections minimize distortions in some of these properties at the expense of maximizing errors in others. Some projection are attempts to only moderately distort all of these properties.

- Conformality** When the scale of a map at any point on the map is the same in any direction, the projection is conformal. Meridians (lines of longitude) and parallels (lines of latitude) intersect at right angles. Shape is preserved locally on conformal maps.
- Distance** A map is equidistant when it portrays distances from the center of the projection to any other place on the map.
- Direction** A map preserves direction when azimuths (angles from a point on a line to another point) are portrayed correctly in all directions.
- Scale** Scale is the relationship between a distance portrayed on a map and the same distance on the Earth.
- Area** When a map portrays areas over the entire map so that all mapped areas have the same proportional relationship to the areas on the Earth that they represent, the map is an equal-area map.

Four General Classes of Map Projections:

1. **Cylindrical** projections result from projecting a spherical surface onto a cylinder.

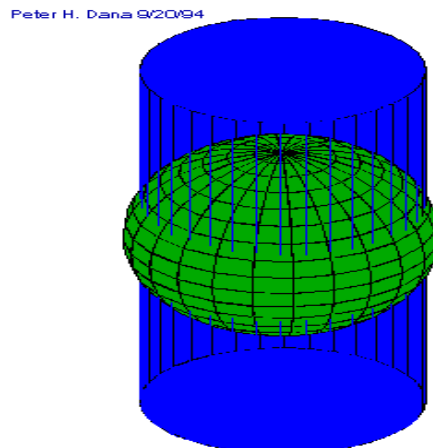
When the cylinder is tangent to the sphere contact is along a great circle (the circle formed on the surface of the Earth by a plane passing through the center of the Earth).



Cylindrical Projection Surface

In the secant case, the cylinder touches the sphere along two lines, both small circles (a circle formed on the surface of the Earth by a plane not passing through the center of the Earth).

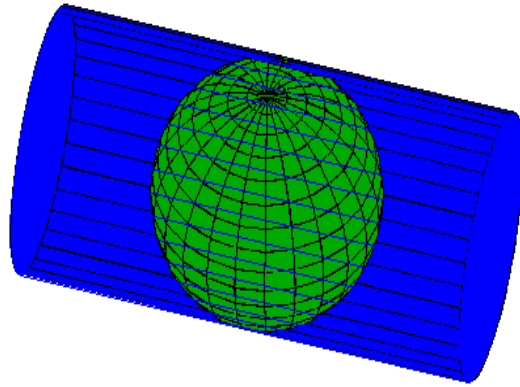
When the cylinder upon which the sphere is projected is at right angles to the poles, the



Secant Cylindrical Projection

cylinder and resulting projection are transverse.

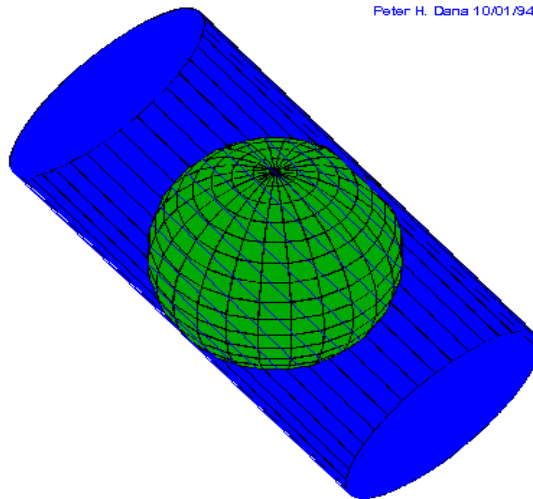
Peter H. Dana 10/01/94



Transverse Cylindrical Projection Surface

When the cylinder is at some other, non-orthogonal, angle with respect to the poles, the cylinder and resulting projection is oblique.

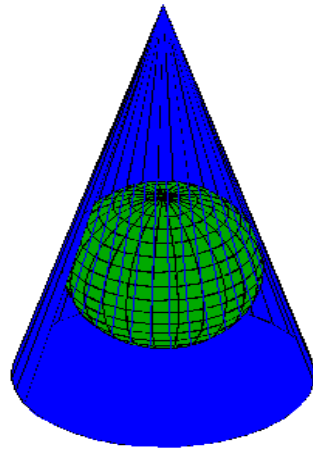
Peter H. Dana 10/01/94



Oblique Cylindrical Projection Surface

2. **Conic** projections result from projecting a spherical surface onto a cone. When the cone is tangent to the sphere contact is along a small circle.

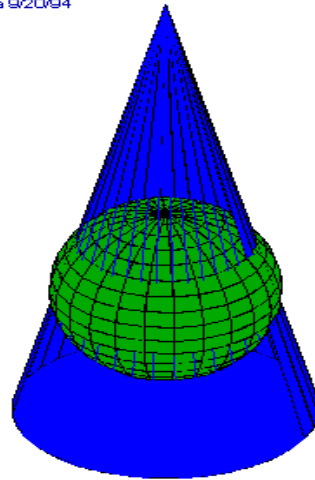
Peter H. Dana 9/20/94



Conical Projection Surface

In the secant case, the cone touches the sphere along two lines, one a great circle, the other a small circle.

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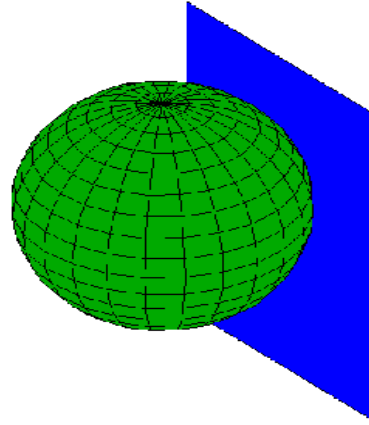


Secant Conic Projection

3. Azimuthal projections result from projecting a spherical surface onto a plane.

When the plane is tangent to the sphere contact is at a single point on the surface of the Earth.

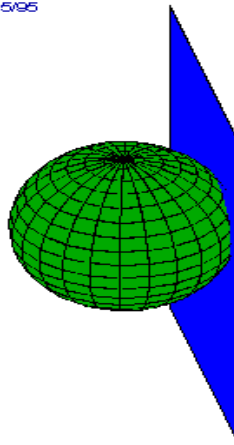
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Planar Projection Surface

In the secant case, the plane touches the sphere along a small circle if the plane does not pass through the center of the earth, when it will touch along a great circle.

Peter H. Dana 4/25/95



Secant Planar Projection

4. Miscellaneous projections include unprojected ones such as rectangular latitude and longitude grids and other examples of that do not fall into the cylindrical, conic, or azimuthal categories.

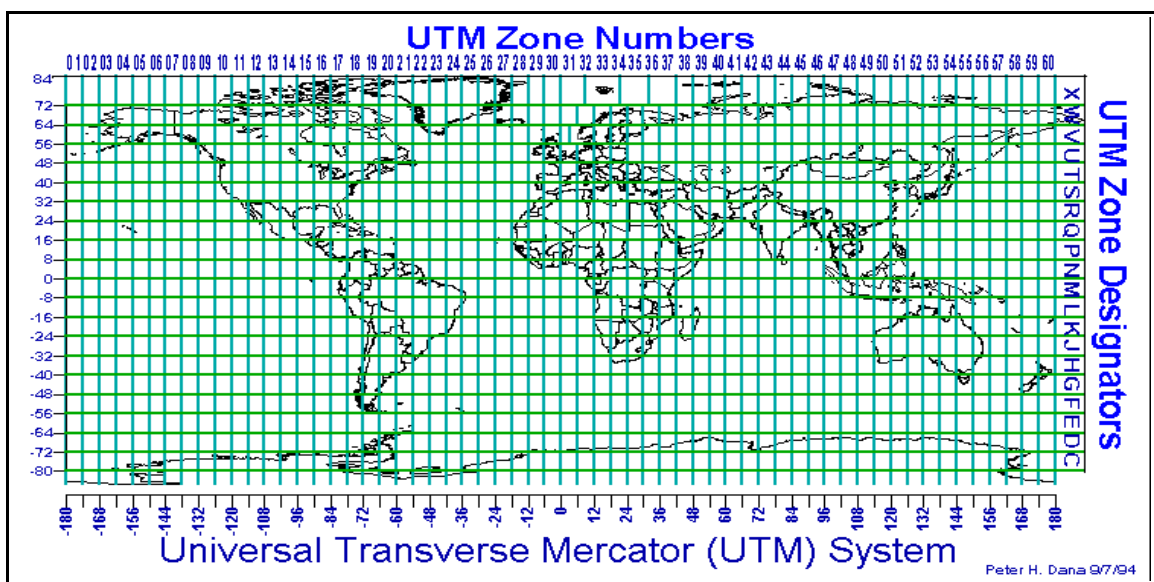
Selected Map Projections

Universal Transverse Mercator

Transverse Mercator projections result from projecting the sphere onto a cylinder tangent to a central meridian. Transverse Mercator maps are often used to portray areas with larger north-south than east-west extent. Distortion of scale, distance, direction and area increase away from the central meridian. Many national grid systems are based on the Transverse Mercator projection.

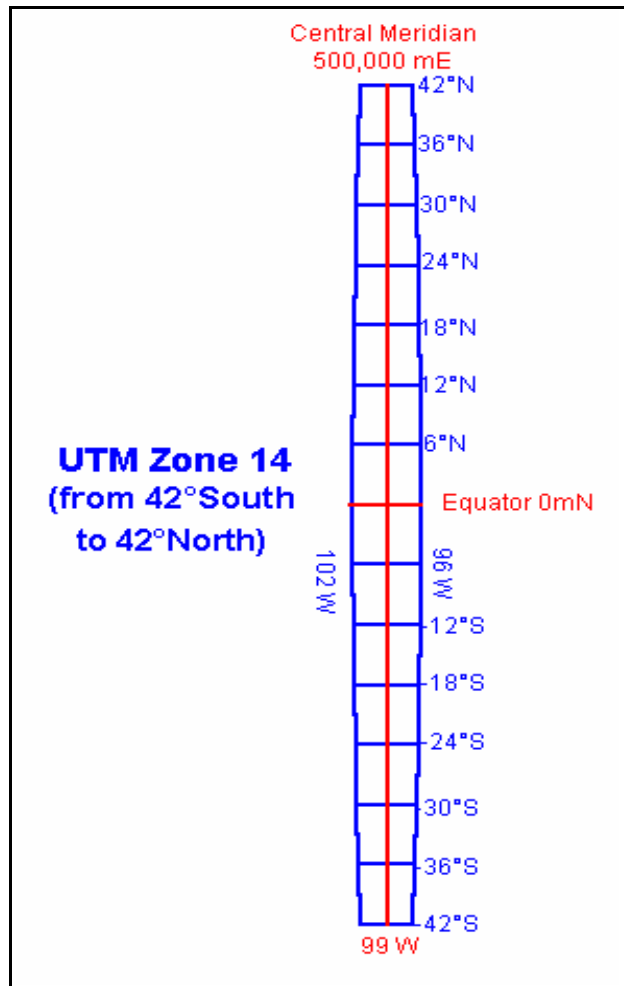
The Universal Transverse Mercator (UTM) projection is used to define horizontal positions world-wide by dividing the surface of the Earth into 6 degree zones, each mapped by the Transverse Mercator projection with a central meridian in the center of the zone. UTM zone numbers designate 6 degree longitudinal strips extending from 80 degrees South latitude to 84 degrees North latitude.

Eastings are measured from the central meridian (with a 500km false easting to insure positive coordinates). Northings are measured from the equator (with a 10,000km false northing for positions south of the equator).



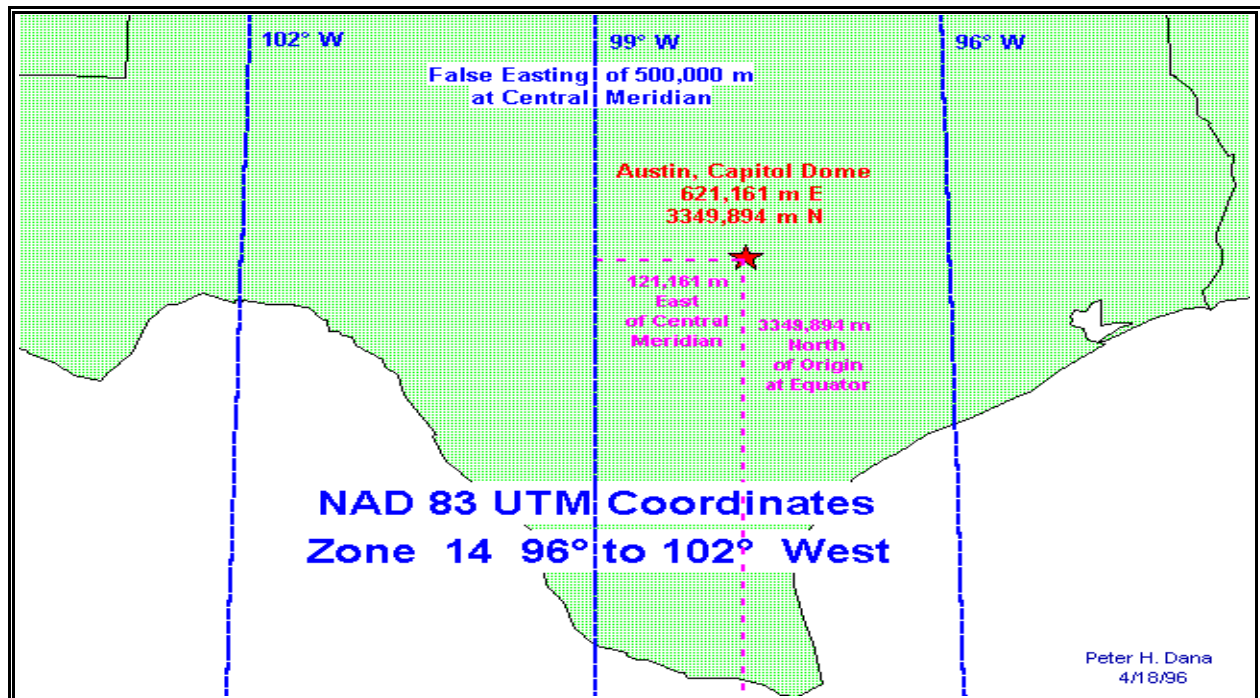
To the right:

Each zone has a central meridian. Zone 14, for example, has a central meridian of 96 degrees west longitude.



Below:

Eastings are measured from the central meridian (with a 500km false easting to insure positive coordinates). Northings are measured from the equator.

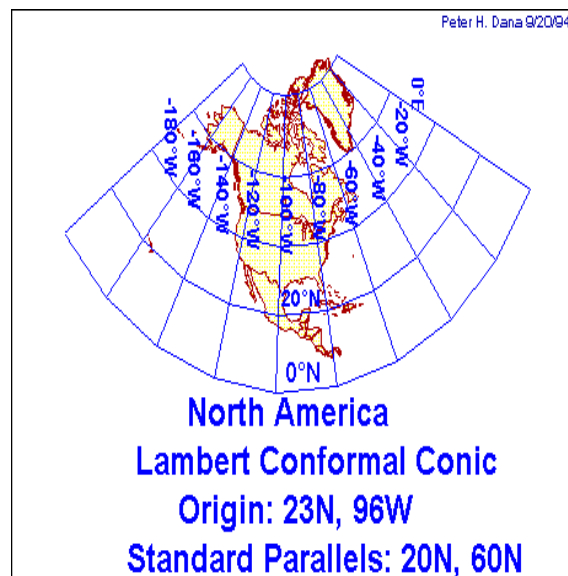


Albers Equal Area Conic

A conic projection that distorts scale and distance except along standard parallels. Areas are proportional and directions are true in limited areas. Used in the United States and other large countries with a larger east-west than north-south extent.

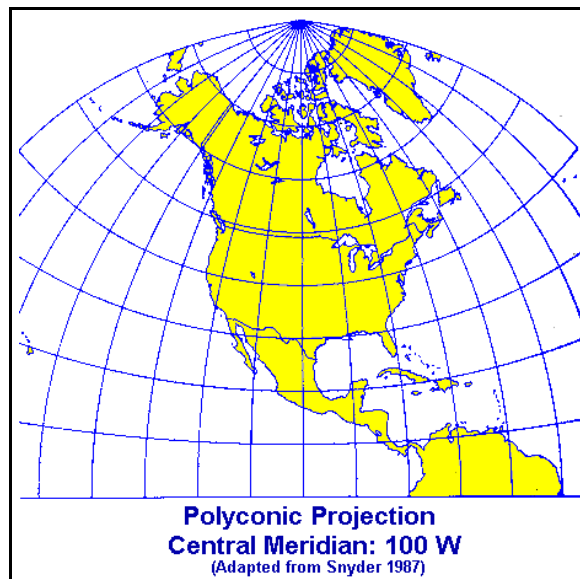
Lambert Conformal Conic

Area, and shape are distorted away from standard parallels. Directions are true in limited areas. Used for maps of North America.



Polyconic

The polyconic projection was used for most of the earlier USGS topographic quadrangles. The projection is based on an infinite number of cones tangent to an infinite number of parallels. The central meridian is straight. Other meridians are complex curves. The parallels are non-concentric circles. Scale is true along each parallel and along the central meridian.



Mississippi Transverse Mercator (MSTM)

The MARIS Technical Center (MTC) and the Mississippi Department of Transportation (MDOT) jointly developed a map projection for Mississippi called the Mississippi Transverse Mercator (MSTM) Projection. When viewing geographic data on a statewide level, the MSTM projection alleviates the multiple-zone conflict inherent in UTM and State Plane systems. The problem with both of these systems is that each divides the state into an east and west zone that cannot be digitally displayed together.

The MSTM projection is a customized Transverse Mercator projection designed to more evenly distribute convergence and scale-factor, and is based on the North American Datum of 1983 (NAD83). The projection parameters of the MSTM projection are as follows:

Scale Factor: 0.9998335

Central Meridian: -89° 45' 00"

Central Latitude: 32° 30' 00"

False Northing: 1,300,000 meters

False Easting: 500,000 meters

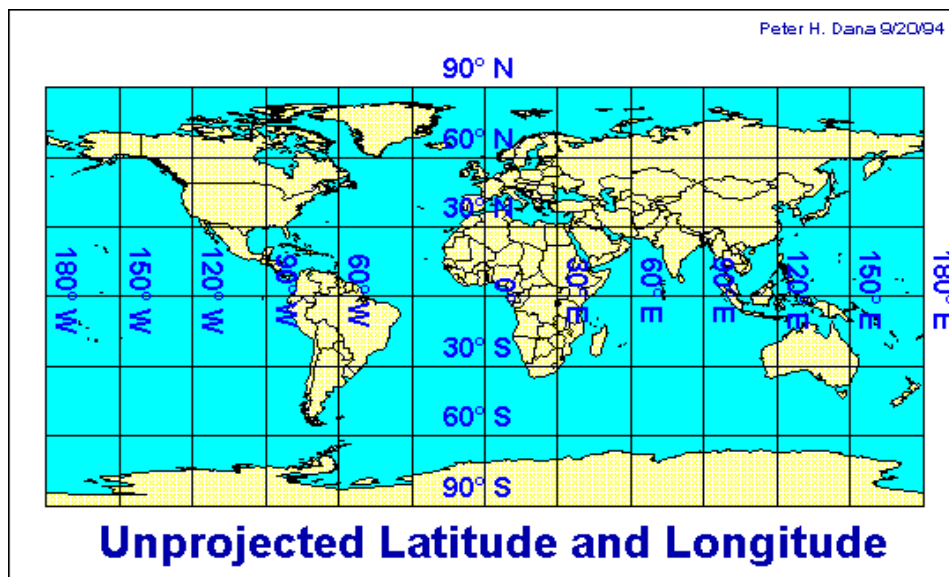
Projection Units: meters

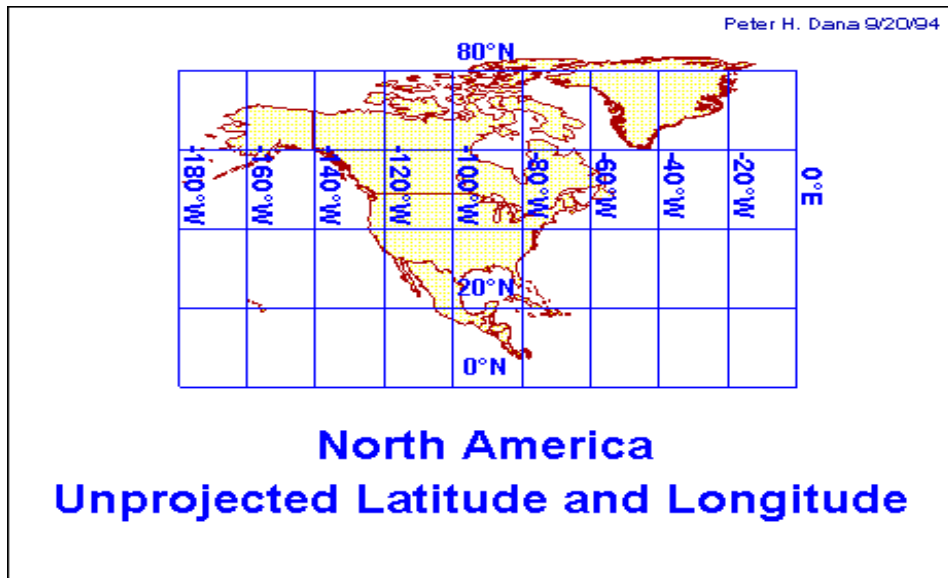
Spheroid: GRS80

Datum: NAD83

Unprojected Maps

Unprojected maps include those that are formed by considering longitude and latitude as a simple rectangular coordinate system. Scale, distance, area, and shape are all distorted with the distortion increasing toward the poles.





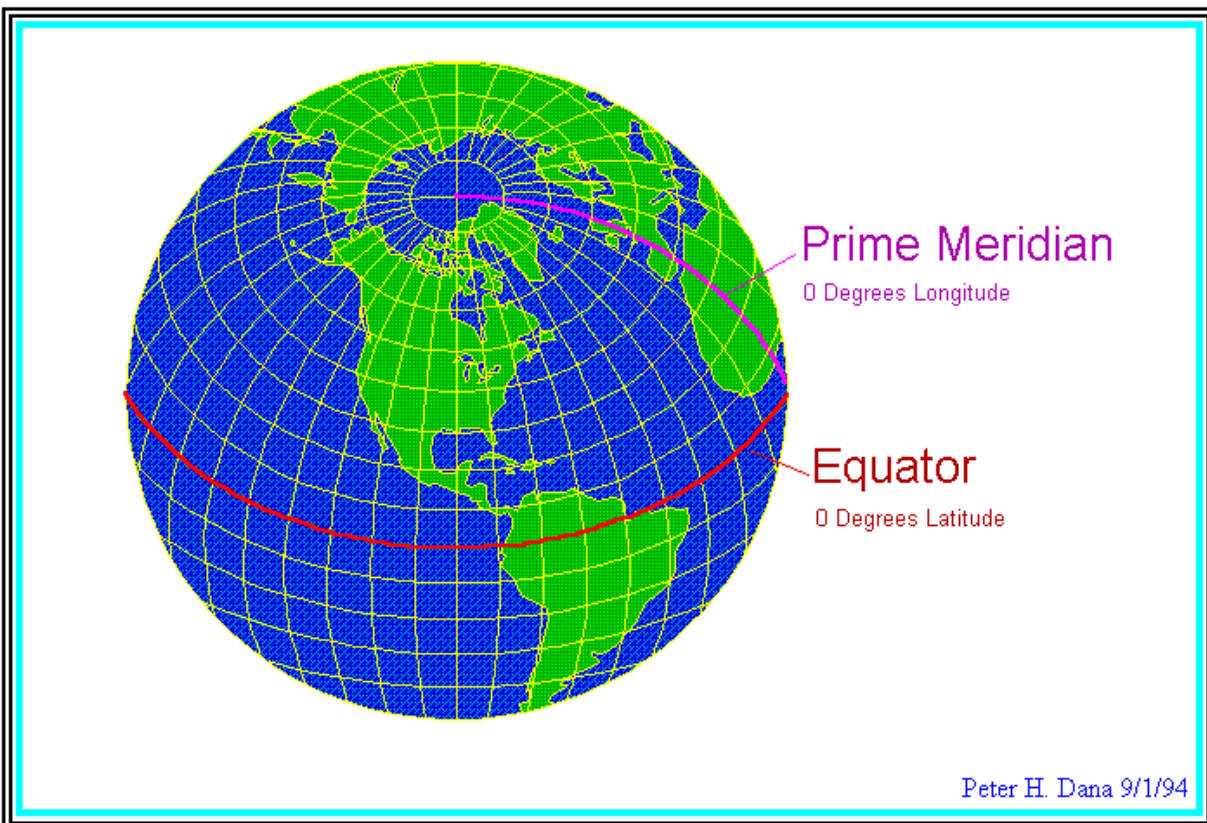
Coordinate Systems

Introduction

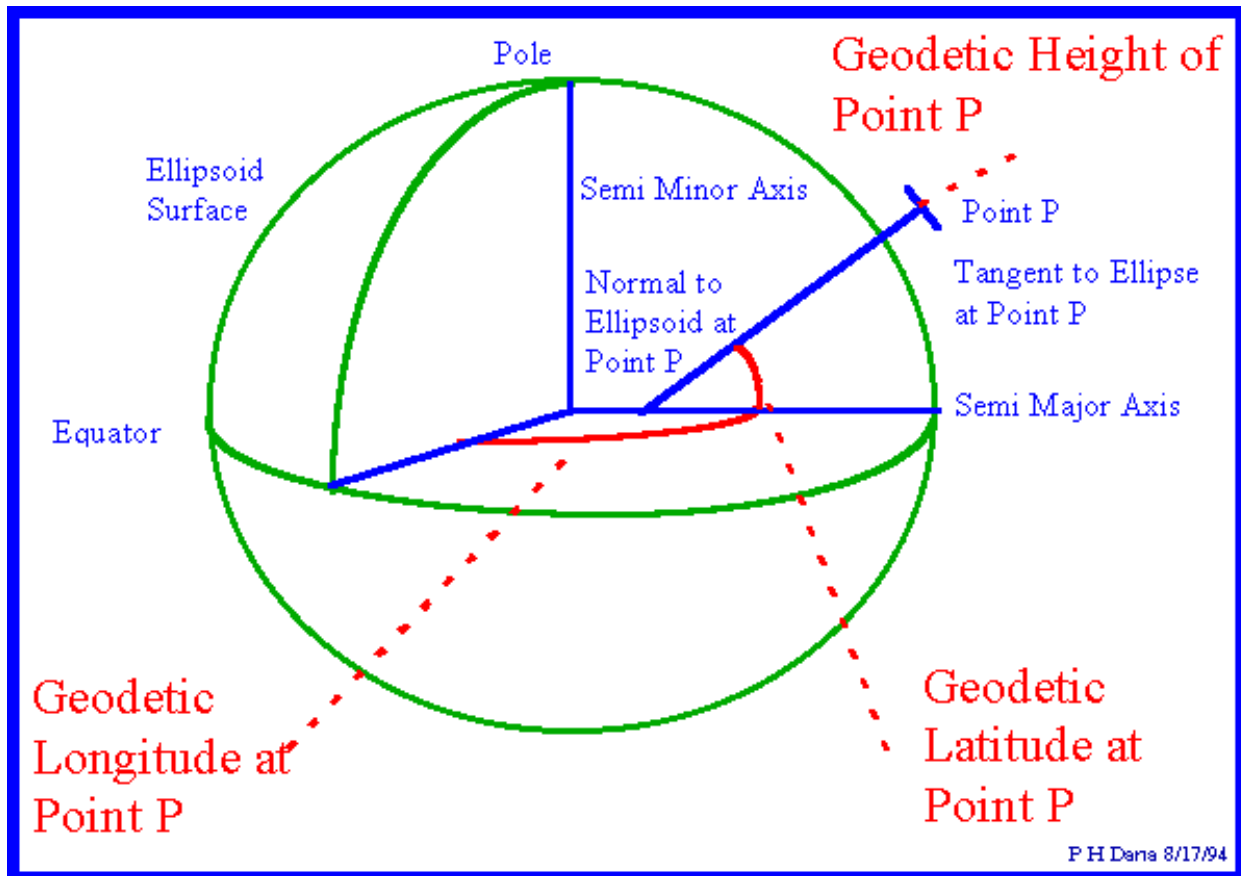
Coordinate systems to specify locations on the surface of the earth have been used for centuries. In western geodesy the equator, the tropics of Cancer and Capricorn, and then lines of latitude and longitude were used to locate positions on the earth. Eastern cartographers like Phei Hsiu used other rectangular grid systems as early as 270 A. D. Various units of length and angular distance have been used over history. The meter is related to both linear and angular distance, having been defined in the late 18th century as one ten-millionth of the distance from the pole to the equator.

Latitude, Longitude, and Height

The most commonly used coordinate system today is the latitude, longitude, and height system. The Prime Meridian and the Equator are the reference planes used to define latitude and longitude.



The geodetic latitude (there are many other defined latitudes) of a point is the angle from the equatorial plane to the vertical direction of a line normal to the reference ellipsoid. The geodetic longitude of a point is the angle between a reference plane and a plane passing through the point, both planes being perpendicular to the equatorial plane. The geodetic height at a point is the distance from the reference ellipsoid to the point in a direction normal to the ellipsoid.



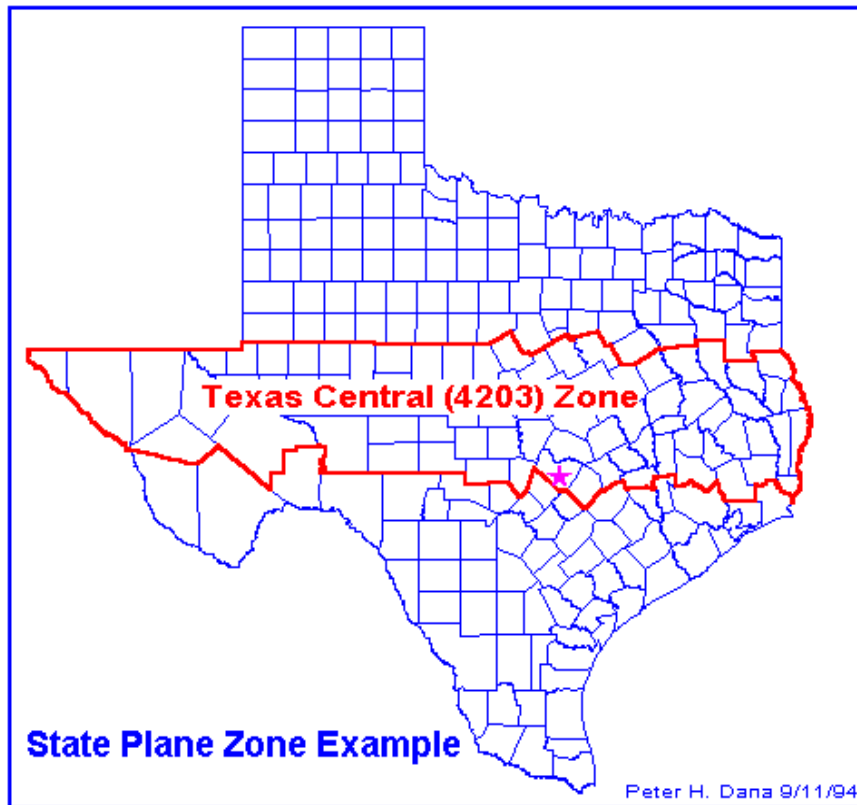
State Plane Coordinates

In the United States, the State Plane System was developed in the 1930s and was based on the North American Datum 1927 (NAD27). NAD 27 coordinates are based on the foot. While the NAD-27 State Plane System has been superseded by the NAD-83 System, maps in NAD-27 coordinates (in feet) are still in use.

Most USGS 7.5 Minute Quadrangles use several coordinate system grids including latitude and longitude,

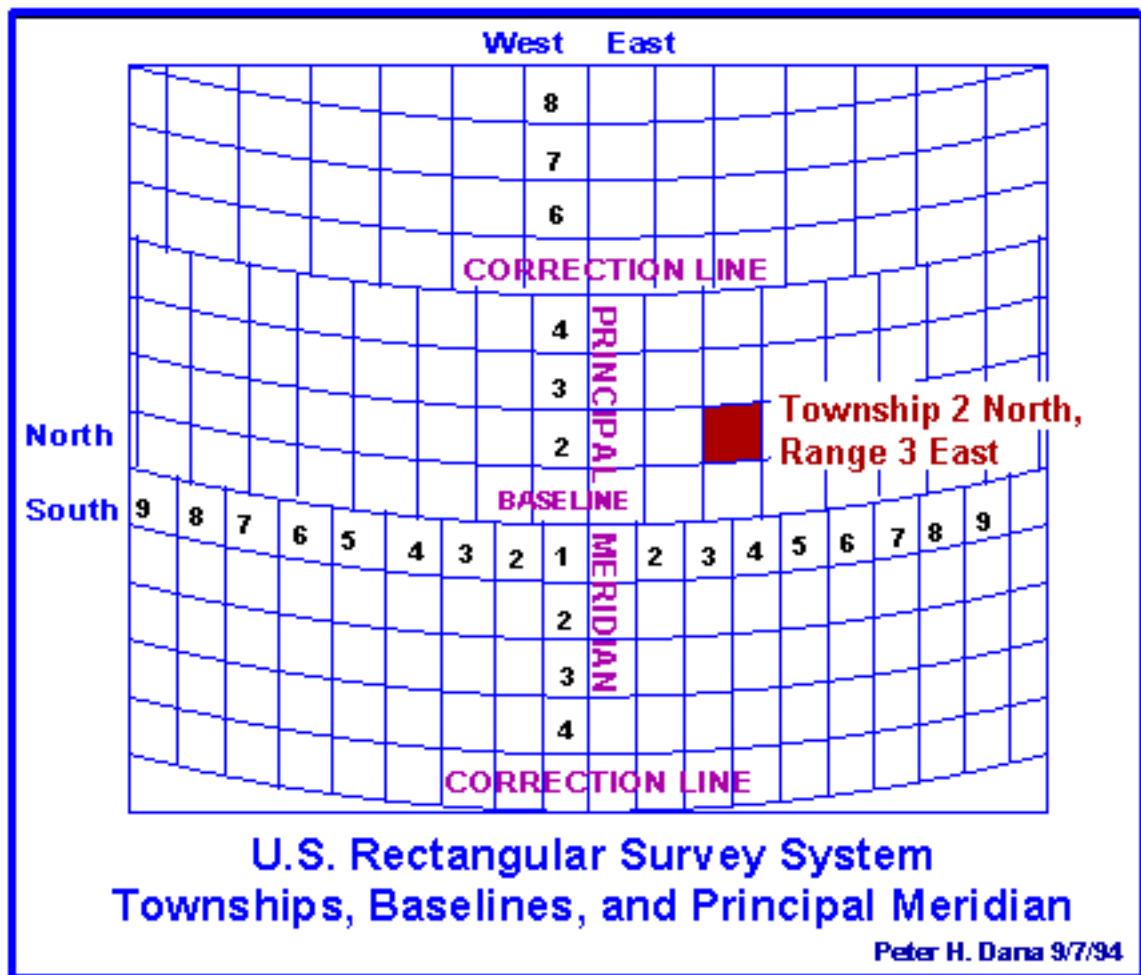
UTM kilometer tic marks, and applicable State Plane coordinates. The State Plane System 1983 is based on the North American Datum 1983 (NAD83). NAD 83 coordinates are based on the meter.

State plane systems were developed in order to provide local reference systems that were tied to a national datum. Some smaller states use a single state plane zone. Larger states are divided into several zones. State plane zone boundaries often follow county boundaries. Lambert Conformal Conic projections are used for rectangular zones with a larger east-west than north-south extent. Transverse Mercator projections are used to define zones with a larger north-south extent. One State Plane zone in Alaska uses an oblique Mercator projection for a thin diagonal area.

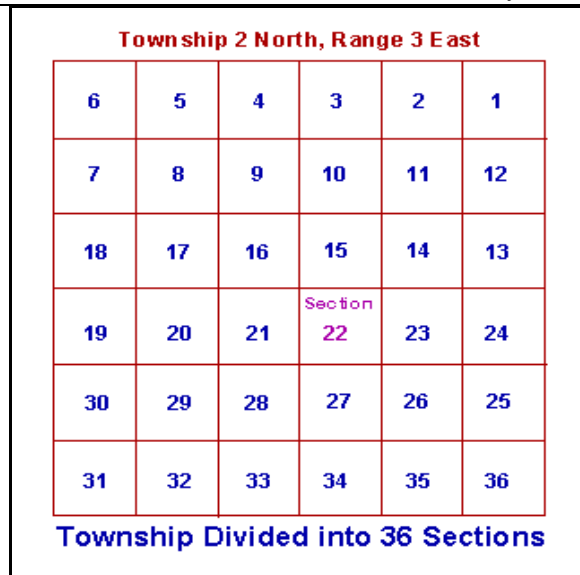


Public Land Rectangular Surveys

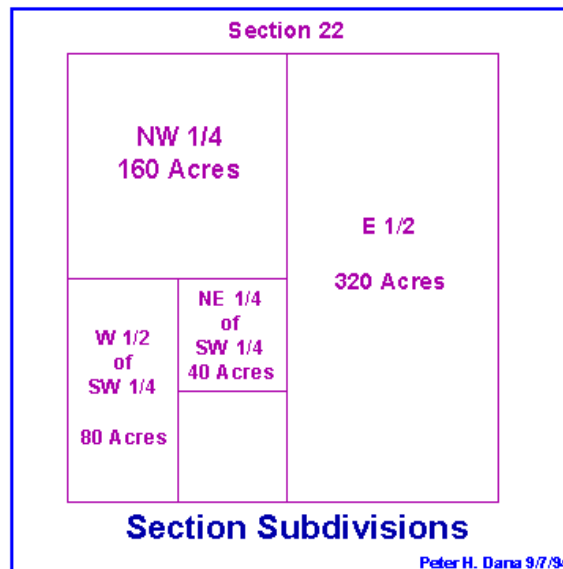
Public Land Rectangular Surveys have been used since the 1790s to identify public lands in the United States. The system is based on principal meridians and baselines. Townships, approximately six miles square, are numbered with reference to baseline and principal meridian. Ranges are the distances and directions from baseline and meridian expressed in numbers of townships. Every four townships a new baseline is established so that orthogonal meridians can remain north-oriented.



Sections, approximately one mile square, are numbered from 1 to 36 within a township:



Sections are divided into **quarter sections**. Quarter sections are divided into 40-acre, quarter-quarter sections. Quarter-quarter sections are sometimes divided into 10-acre areas.



Fractional units of section quarters, designated as numbered lots, often result from irregular claim boundaries, rivers, lakes, etc. Abbreviations are used for Township (T or Tps), Ranges (R or Rs), Sections(sec or secs), and directions (N, E, S, W, NE, etc.).

Black Hills Meridian

T. 3 S., R. 1 E.,

sec. 8., SE1/4;

sec. 21;

sec. 28, E1/2, N1/2NW1/4, and NE1/4SW1/4;

sec. 31, lots 2 and 4, NW1/4NE1/4, NE1/4NW1/4, and SE1/4;

sec. 34, W1/2NE1/4, W1/2, W1/2SE1/4, and W1/2SE1/4.

Land Description based on Public Land Rectangular Survey

Metes and Bounds

Metes and Bounds identify the boundaries of land parcels by describing lengths and directions of lines. Lines are described with respect to natural or artificial monuments and baselines defined by these monuments. The metes and bounds survey is based on a point of beginning, an established monument. Line lengths are measured along a horizontal level plane. Directions are bearing angles measured with respect to a previous line in the survey.

A right of way 40 ft. wide, the center line of which is described as follows:

Beginning at station No.1, on the boundary between the United States Military Reservation and Land Court application 1000 (amended), from which the azimuth and distance to United States Military Reservation Monument No. 80 is 182°36'40", 6.55 ft.

From station No. 1, by azimuths and distances,

109°55'48", 444.2 ft. to station No. 2;

159°44'10", 183.8 ft. to station No. 3;

209°07'56", 208.3 ft. to station No. 4;

139°02'05", 414.6 ft. to station No. 5;

173°38'45", 325.5 ft. to station No. 6;

201°43'50", 505.9 ft. to station No. 7;

156°57'40", 435.1 ft. to station No. 8;

186°41'20", 477.9 ft. to station No. 9;

165°16'45", 345.4 ft. to station No. 10;

187°43'20", 1092.1 ft. to station R 1, at the southern intersection of the center of the Honolulu-Waialua road with the Military Reservation boundary between monuments No. 79 and No.80, and being determined by the following azimuths and distances;

To monument No. 79, 351°53'12", 2179.0 ft.;

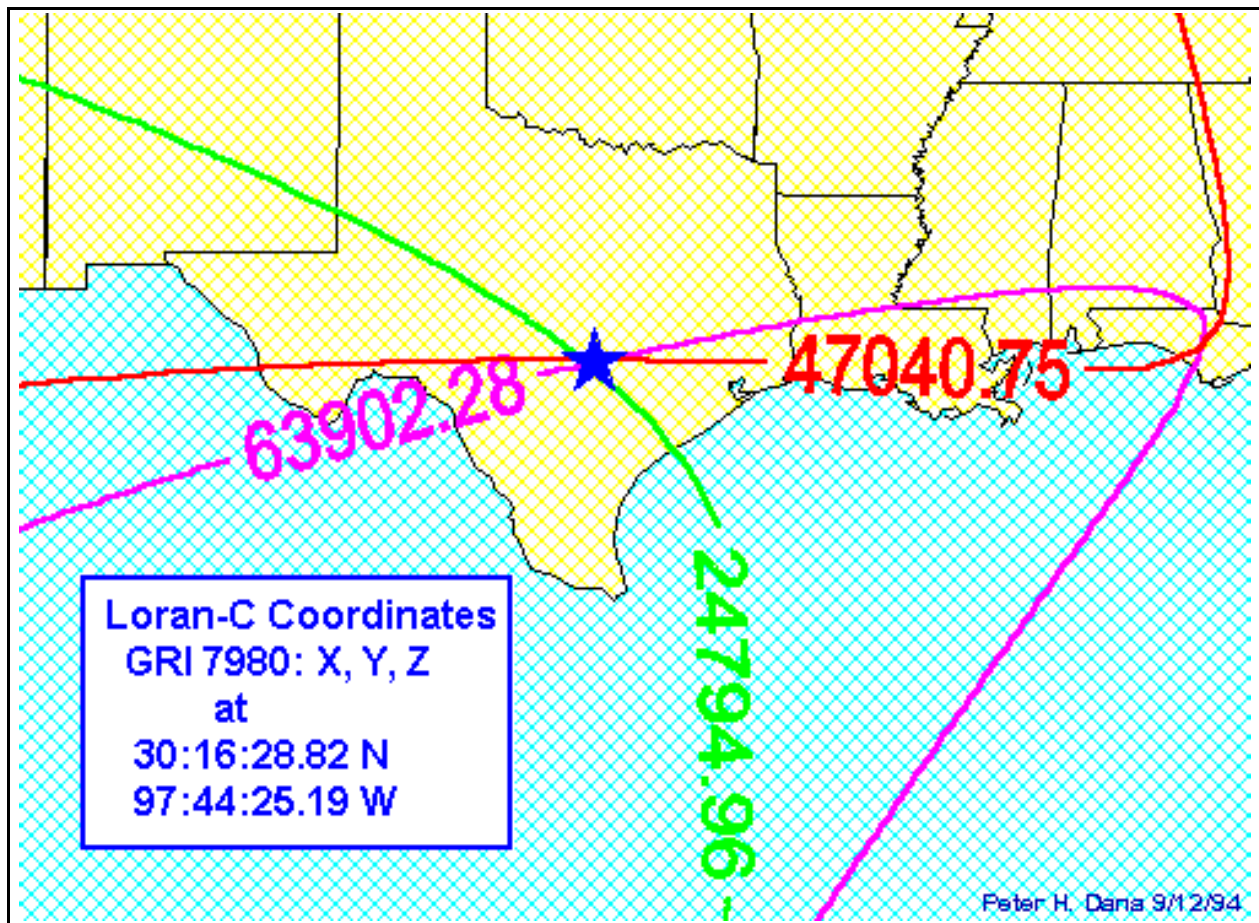
To monument No. 80, 171°53'12", 3930.2 ft.;

Example of Metes and Bounds Description

(Specifications for Descriptions of Tracts of Land for Use in Land Orders and Proclamations, U. S. Dept., of the Interior 1976)

Navigation System Coordinates

Navigation systems can define locations by referencing measurements of electronic signals. Loran-C time-differences can identify positions with an accuracy of one-quarter of a mile.



Navigational buoys, and other aids to navigation can be used as visual reference points, bearings to visual references can identify locations with varying accuracies.

References:

Muehrcke, Phillip C. 1986. Map use: reading, analysis, interpretation. Madison, WI: JP Publications.

Snyder, John P. 1987. Map projections: a working manual. USGS Professional Paper 1395. Washington, DC: United States Government Printing Office.

Chapter 3 - GPS Theory and Applications

Session Objectives: At the conclusion of this session, you will be able to:

- Describe the NAVSTAR satellite system
- Define “Solution”
- Identify how many satellites are required for a 2- or 3-d solution
- Describe “Selective Availability” and its effect on GPS solutions

Source: This module was originally developed primarily by Hope Malcom using materials developed by Carol Lowenberg of the National Biological Service Environmental Management Technical Center. Modifications have been made by Greg Easson and Lance Yarbrough of The University of Mississippi Geoinformatics Center.

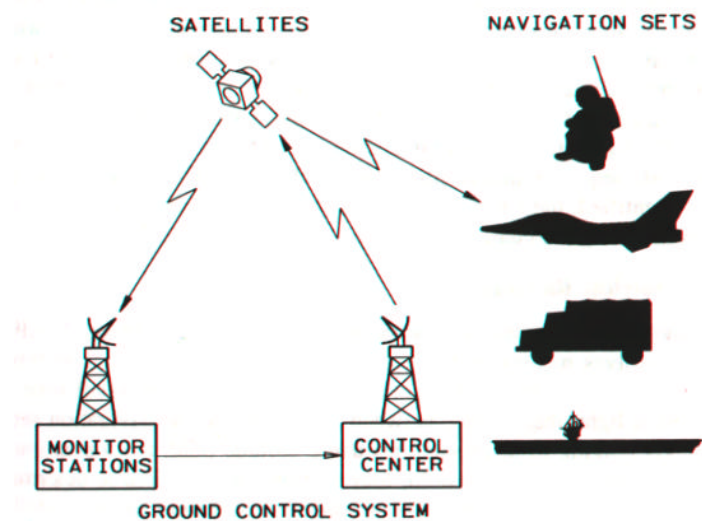
Introduction

Here's how GPS works in five logical steps:

1. The basis of GPS is "triangulation" from satellites.
2. To "triangulate," a GPS receiver measures distance using the travel time of radio signals.
3. To measure travel time, GPS needs very accurate timing which it achieves with some tricks.
4. Along with distance, you need to know exactly where the satellites are in space. High orbits and careful monitoring are the secret.
5. Finally you must correct for any delays the signal experiences as it travels through the atmosphere.

Background

The Global Positioning System (GPS) is a space-based radio positioning system designed to provide suitably equipped users with highly accurate positioning, velocity, and time data. The Global Positioning System is comprised of three major segments: Space, Control, and User.



The Space Segment consists of a constellation of GPS satellites in semi-synchronous orbits around the earth. Each satellite broadcasts radio-frequency (RF) ranging codes and a navigation data message. The Control Segment consists of a Master Control Station (MCS) and a number of monitoring stations located around the world. The MCS is responsible for tracking, monitoring, and managing the satellite constellation and for updating the navigation data messages. The User Segment consists of a variety of radio navigation receivers specifically designed to receive, decode and process the GPS satellite ranging codes and navigation data messages.

Currently the Space Segment is comprised of twenty one operational satellites, and up to three additional satellites which are orbiting spares. The satellites orbit the earth in six orbital planes, with three or four operational satellites in each plane. All orbital planes are inclined in relation to the equator, and the satellites orbit at an altitude of 20,200 Km (10,900 miles). It takes approximately 12 hours for a satellite to complete its orbit.



To view these satellites using a computer model, you can visit the NASA J-Track website at:

<http://liftoff.msfc.nasa.gov/RealTime/JTrack/>

We recommend the 3-D version of the applet.

Timing IS Everything

The GPS satellites and receivers use time to calculate your spatial location. To illustrate this point, lets use the basic equation:

$$\text{Distance to satellite} = \text{Speed of light} \times \text{Time}$$

The rates are known to the GPS equipment and the time is measured using accurate clocks. The GPS unit then performs the above calculation for each of the satellite singles it is receiving. A minimum of 3 satellites are required to triangulate a point in 3- Dimensional space. With 3 satellites, two points can be triangulated with one point being able to be disregard ridicules solutions (i.e. inside the Earth) . A fourth satellite is required to further narrow the solutions and provide an elevation.

Receiver Accuracy

A variety of GPS receivers are available that utilize the radio signals sent from these satellites. The accuracy of a specific model of receiver is determined by:

- A.** The receiver's ability to receive specific radio signals being sent from the satellites.
- B.** How the receiver uses the signals it is receiving.
- C.** The software program used to calculate the location of the receiver.
- D.** The amount of internal "noise" of a particular receiver.

Selective Availability

As hard as it may be to believe, the same government that spent \$12 billion to develop the most accurate navigation system in the world intentionally degraded its accuracy. The military degraded the satellite signals to reduce the accuracy of civilian receivers to approximately $\pm 100\text{m}$. This signal degradation is called Selective Availability (SA).

SA functions by the broadcasting of a false time message. All GPS receivers require three or more satellites to calculate a position. The receiver uses the radio broadcasts from the satellites to triangulate the receiver's position on the earth. When false messages are sent by a satellite, the receiver will calculate false positions on the earth.

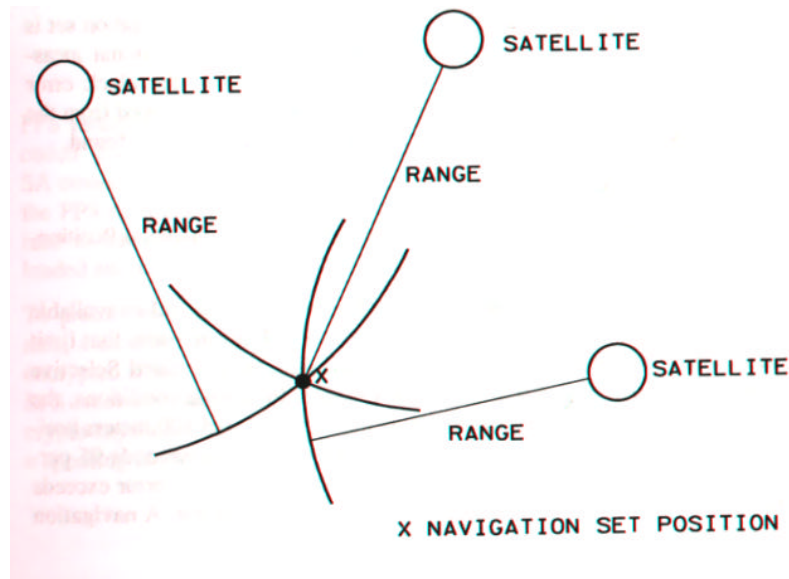
Compensating for Selective Availability using a single non-military receiver is not feasible. This is because the amount, type (northing, easting, and vertical), and direction of Selective Availability errors are constantly changing.

Selective Availability (SA) was deactivated in May 1, 2000. This was a surprise to the industry because it was not expected until 2006. This deactivation has caused a boom in the market. However, during war or other situations, the military can turn back on the SA function.

Position Triangulation (Solution Calculation)

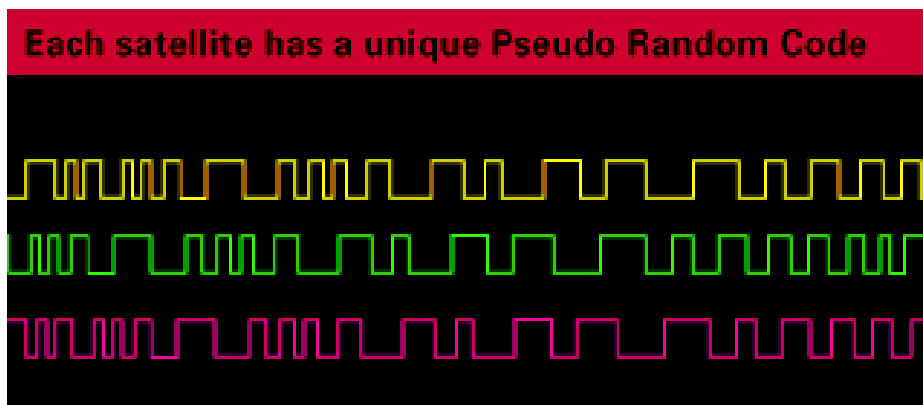
Triangulation algorithms used by GPS receivers utilize the amount of time a radio signal takes to travel between each satellite and the receiver, and the location of each satellite to calculate the receiver's position. Therefore if the satellites are constantly moving and changing positions in relation to each other, the receiver is constantly using new variables to calculate each position fix (solution). Since all input variables in the equation are always changing, it is difficult to locate and compensate for a corrupted source (or sources).

Many hand-held receivers calculate a number of individual position fixes, then use a mean value to represent the location of the unknown position. In the absence of Selective Availability, a plot of the individual position calculations would be a cluster of points centered around the actual point. When the effects of Selective Availability are added to the calculations, the result is a graph of positional calculations that tend to wander.



A Random Code?

The Pseudo Random Code (PRC, shown above) is a fundamental part of GPS. Physically it's just a very complicated digital code, or in other words, a complicated sequence of "on" and "off" pulses as shown here:



The signal is so complicated that it almost looks like random electrical noise. Hence the name "Pseudo-Random."

There are several good reasons for that complexity: First, the complex pattern helps make sure that the receiver doesn't accidentally sync up to some other signal. The patterns are so complex that it's highly unlikely that a stray signal will have exactly the same shape.

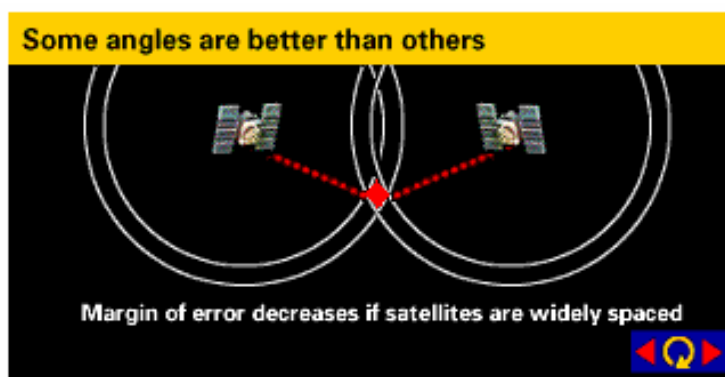
Since each satellite has its own unique Pseudo-Random Code this complexity also guarantees that the receiver won't accidentally pick up another satellite's signal. So all the satellites can use the same frequency without jamming each other. And it makes it more difficult for a hostile force to jam the system. In fact the Pseudo Random Code gives the DoD a way to control access to the system.

But there's another reason for the complexity of the Pseudo Random Code, a reason that's crucial to making GPS economical. The codes make it possible to use "information theory" to "amplify" the GPS signal. And that's why GPS receivers don't need big satellite dishes to receive the GPS signals.

Geometric Dilution of Precision

Basic geometry itself can magnify these other errors with a principle called "Geometric Dilution of Precision" or GDOP. It sounds complicated but the principle is quite simple.

There are usually more satellites available than a receiver needs to fix a position, so the receiver picks a few and ignores the rest. If it picks satellites that are close together in the sky the, intersecting circles that define a position will cross at very shallow angles. That increases the gray area or error margin around a position. If it picks satellites that are widely separated the circles intersect at almost right angles and that minimizes the error region. Good receivers determine which satellites will give the lowest GDOP



Differential Correction (Post-Processing)

Editorial Note: The Garmin® eTrex GPS receiver used in this workshop does not have the differential correction capabilities. However, many high-level systems have this feature and new users of GPS should be aware of these features.

One way a GPS user could compensate for Selective Availability, was through differential correction. Differential correction compensates for Selective Availability by adding a constant variable into positional calculations. The constant is a second receiver operating during the same period of time, using the same satellites, at a known location. Differential correction can be used improve the accuracy of data, even with SA turned on.

If data recorded by the GPS unit will be differentially corrected through post processing, the following requirements need to be filled:

1. There must be at least two GPS receivers in the field operating at the same time.
2. One receiver must be placed at a location with known coordinates. Errors in positioning the receiver (base station) will results in errors in the differential calculations.
3. The receiver at the known location needs to be programmed to collect data in base station format.
4. The two receivers must record data from the same set of satellites at the same time.
5. The base station data need to be in a data format that is compatible with the “roving” unit’s data.

Differential processing then uses data collected at the known location to correct data collected at an unknown location. The known location's coordinates are entered into a computer, then the individual position calculations made by the base station are compared to the base's actual location. The software program can then be used to link the base station file to a file from an unknown location. Individual position calculations within the files are linked together by their collection time and the satellites used to make the calculation. Locational errors calculated for the base station are then applied to and positional errors (including SA) are removed from data collected at the unknown location.

The Global Positioning System: The Role of Atomic Clocks

Where am I? The question seems simple; the answer, historically, has proved not to be. For centuries, navigators and explorers have searched the heavens for a system that would enable them to locate their position on the globe with the accuracy necessary to avoid tragedy and to reach their intended destinations. On June 26, 1993, however, the answer became as simple as the question. On that date, the U.S. Air Force launched the 24th satellite into orbit, completing a network of 24 satellites known as the Global Positioning System, or GPS. With a GPS receiver that costs less than a few hundred dollars you can instantly learn your location on the planet--your latitude, longitude, and even altitude--to within a few hundred feet.

This incredible new technology was made possible by a combination of scientific and engineering advances, particularly development of the world's most accurate timepieces: atomic clocks that are precise to within a billionth of a second. The clocks were created by physicists seeking answers to questions about the nature of the universe, with no conception that their technology would some day lead to a global system of navigation.

Today, GPS is saving lives, helping society in countless other ways, and generating 100,000 jobs in a multi-billion-dollar industry. The following article, adapted in part from an account by physicist Daniel Kleppner, describes how basic research into the nature of time and ways to measure time accurately contributed to development of GPS. It provides a dramatic example of how science works and how basic research leads to technologies that were virtually unimaginable at the time the research was done.

This article was adapted by Gary Taubes from an article written by MIT scientist Daniel Kleppner for Beyond Discovery TM: The Path from Research to Human Benefit, a project of the National Academy of Sciences. The Academy, located in Washington, D.C., is a society of distinguished scholars engaged in scientific and engineering research and dedicated to the use of science and technology for the public welfare. For more than a century, it has provided independent, objective scientific advice to the nation.

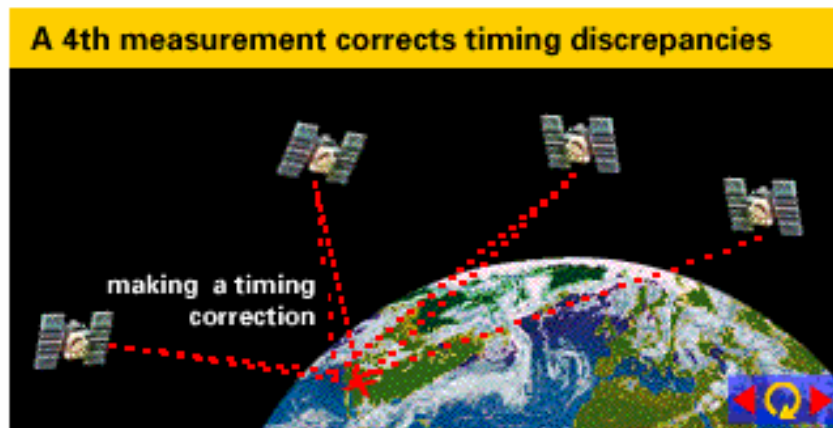
Extra Measurement Cures Timing Offset

If our receiver's clocks were perfect, then all our satellite ranges would intersect at a single point (which is our position). But with imperfect clocks, a fourth measurement, done as a cross-check, will NOT intersect with the first three.

So the receiver's computer says "Uh-oh! there is a discrepancy in my measurements. I must not be perfectly synced with universal time." Since any offset from universal time will affect all of our measurements, the receiver looks for a single correction factor that it can subtract from all its timing measurements that would cause them all to intersect at a single point.

That correction brings the receiver's clock back into sync with universal time then you have got atomic accuracy time right in the palm of your hand. Once it has that correction it applies to all the rest of its measurements and now we've got precise positioning.

One consequence of this principle is that any decent GPS receiver will need to have at least four channels so that it can make the four measurements simultaneously.



With the pseudo-random code as a rock solid timing sync pulse, and this extra measurement trick to get us perfectly synced to universal time, we have got everything we need to measure our distance to a satellite in space.

But for the triangulation to work we not only need to know distance, we also need to know exactly where the satellites are.

The Possible Errors

1. Ephemeris errors - Ephemeris (or orbital) data is constantly being transmitted by the satellites. Receivers maintain an "almanac" of this data for all satellites and they update
2. The earth's ionosphere and atmosphere cause delays in the GPS signal that translate into position errors.
3. Bouncing of signal from objects.
4. Some errors can be factored out using mathematics and modeling.
5. The configuration of the satellites in the sky can magnify other errors.

How GPS works

Summary of GPS Error Sources

Typical Error in Meters	(per satellite)	
	Standard GPS	Differential GPS
Satellite Clocks	1.5	0
Orbit Errors	2.5	0
Ionosphere	5.0	0.4
Troposphere	0.5	0.2
Receiver Noise	0.3	0.3
Multipath	0.6	0.6
SA	30	0
Typical Position Accuracy		
Horizontal	50	1.3
Vertical	78	2.0
3-D	93	2.8

Chapter 4 - Getting to Know the Garmin® eTrex

Session Objectives: At the conclusion of this session, you will be able to understand:

- Features of the Garmin® eTrex
- Setting up the eTrex for data collection
- Collect waypoints
- Data collection organization and note taking

Source: This module was developed primarily by Lance Yarbrough

The Garmin® eTrex GPS Receiver

Introduction and Disclaimer

The Garmin® eTrex GPS receiver has been selected for use in this workshop. It has been selected for the following reasons:

- Ease of use
- Unit's size and weight
- Cost of unit
- Availability of unit

The Garmin™ eTrex GPS unit can be purchased in the sporting goods department of any major store or you can purchase the unit on-line by visiting the Garmin™ website at www.garmin.com.

The UMGC does not endorse the Garmin™ GPS units or any other brand. The GPS unit selected is the basic model offered by the mentioned company is used to demonstrate GPS. It is expected that the attendee of this workshop will use the fundamentals learned and evaluate and purchase a GPS unit that meet their standards and needs.



Chapter 5 - Hardware installation and software alternatives for data retrieval

Session Objectives: At the conclusion of this session, you will be able to:

- Connect Garmin® eTrex GPS to computer COM port
- Use software supplied by UMGC to retrieve data sorted on GPS
- Update GPS software from web site
- Evaluate and select software alternatives to fit requirements

Hardware

Introduction

The Garmin® eTrex has a 3-contact PC interface cable that connects to the RS232 serial port connector on the back of your computer. This product can be purchased at some outlet stores or on Garmin's website (<http://www.garmin.com/products/etrex/>). It costs approximately \$40.



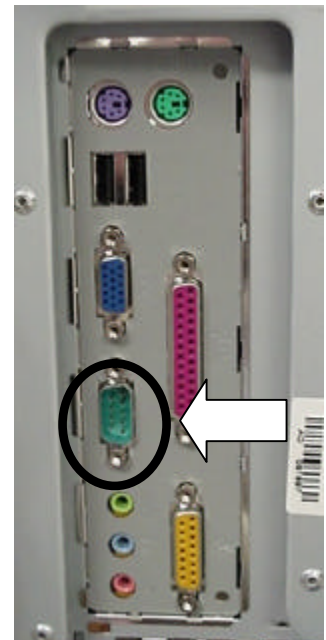
Nearly all GPS receivers have an interface method for the upload/download of data. Depending of the model type, an operator can download GPS data to a software or upload a route they would like to follow.

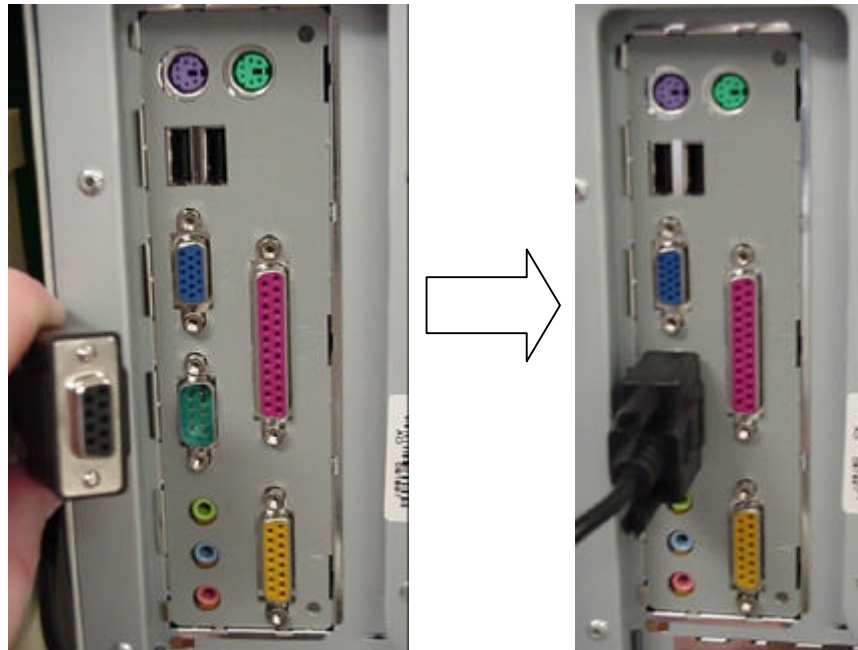
There are available GPS receivers that connect directly to a laptop computer or external data collector. What ever you chose, be sure it fits well with the purpose of your GPS (e.g. 30-data point should not require a 30,000 point data collector). It also should be noted that bare wire ends are available for direct connection applications.

Installing the interface cable

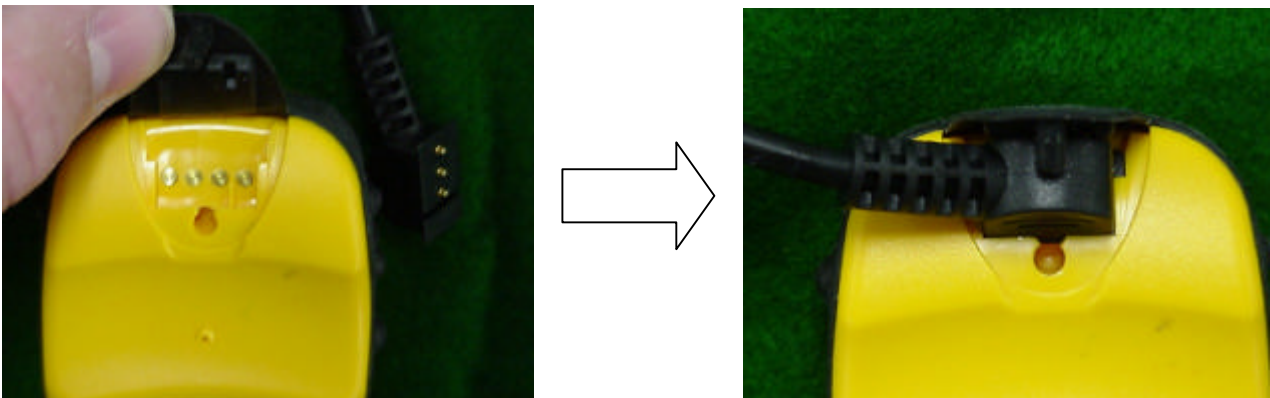
Connecting the PC interface cable can be done with the computer on or off. If extensive movement of the computer is required, it is recommended to properly shutdown the computer BEFORE connecting the interface cable.

At the back (on some newer models, on the front), there is a RS232 serial COM port. It is a 15-pin connector like the one shown on the right. On this computer, there are two RS232 serial COM port, a female and a male. For our application, we will need the male connection. Be sure the interface cable fits ports on the computer you will be using in your projects.





After connecting the PC interface cable to the computer, you now need to connect the cable to the GPS receiver. For the Garmin® eTrex, the connectors are found under the black rubber flap on the back of the device. Note that there is only one direction the interface can be connected.



Software

Introduction

There are MANY software options available for downloading GPS data. The Garmin® is one of the more popular GPS bands and many programs support it. For this workshop, we will use a free download program that provides access to you Garmin® eTrex GPS receiver. The *g7towin* software was created by C.R. Henderson. The current version is A.00.77 as of 23 July 2001. The software is continually updated and is available at:

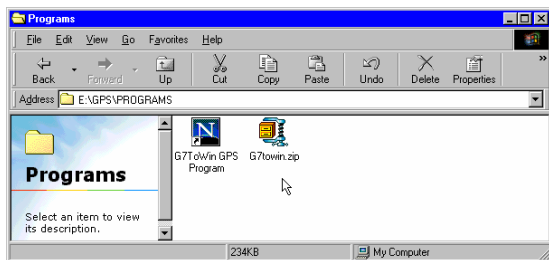
<http://members.home.net/crh24/gps/g7towin/g7towin.htm>

There are many options that are free and many more that you must pay for. If you are planning to use a more sophisticated GPS than a handheld, the GPS manufacturer may provide a “mission planning” software. These software packages allow you to “plan” the data gathering before to go to the field. For example, if you are planning to record the spatial location of fire hydrants, you may want to also record attributes such as number of taps, height and condition of hydrant. You can then upload the “plan” to the GPS receiver and be certain that the proper attributes will be recorded.

You can also create you own custom interface software. In applications requiring real-time data collection or specific data input, a custom interface can be written for your specific needs.

Download and uncompressing the software

As mentioned, this workshop will use the *g7towin* software created by C.R. Henderson.



The program is already installed on the computers in the workshop, but if you visit the web site you can download the 242 kilobyte file in a Winzip® format. After unzipping (uncompressing) the file, you will find three files, two of which are text files explaining upgrades and datum conversions. The

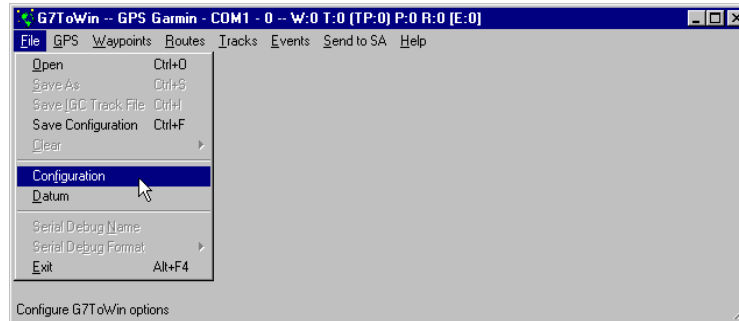
executable file (.exe) is the primary file you will use. It is recommended that you store this executable file within the same directory you are storing the GPS data. It is a small file and can easily be moved and/or compressed with your data. Unlike most Windows® programs, *g7towin* is small self-contained program.

Using the software

Now that you have obtained the *g7twin* software and installed the cable interface, you are ready to download your data. Locate the *g7twin* software icon and double-click.



One of the first item of business is to setup the configuration.

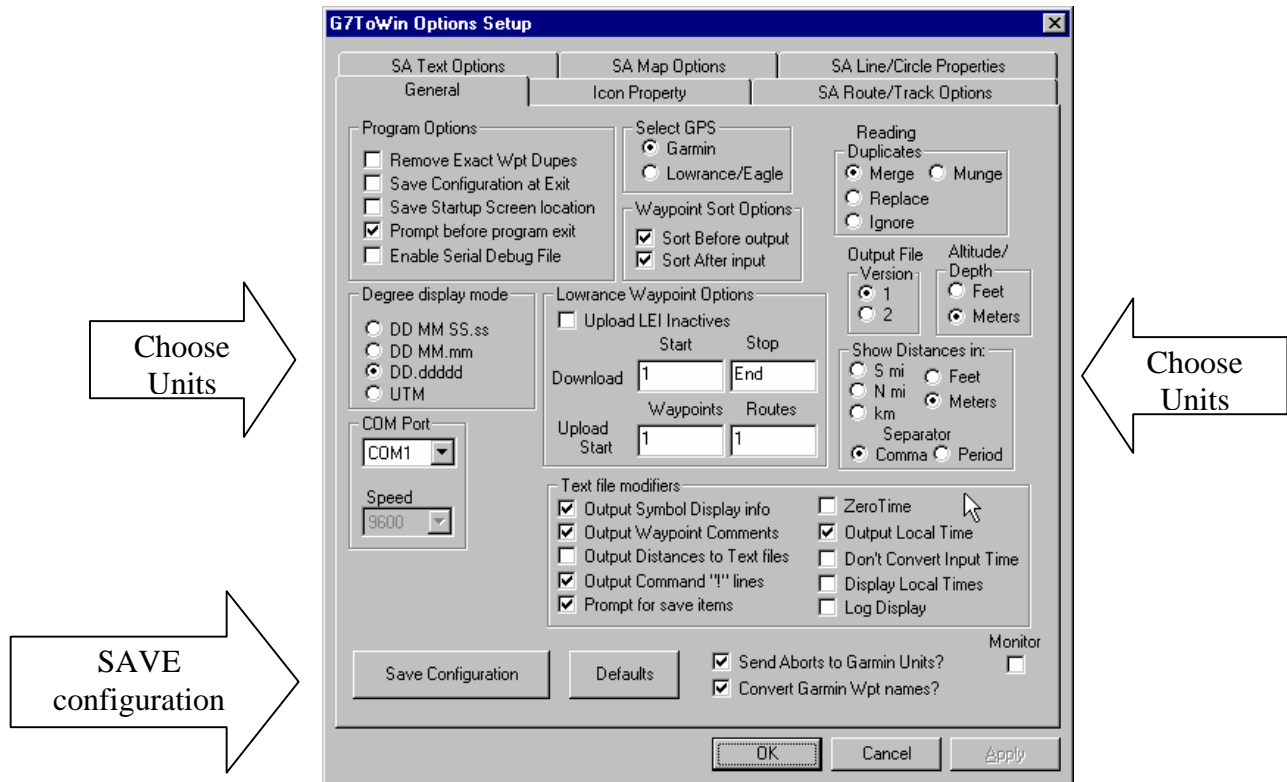


In the configuration window there are many choices. Select the units and datums that best suit your needs. For this workshop we have been using decimal degrees latitude and longitude. The *g7twin* program will automatically convert to the correct output no matter what the GPS receiver collection units were. This is NOT THE CASE with some programs so be sure you know the capabilities of your download software.

When setting the coordinate system, there are three choices:

Coordinate System	Representation	Example
degrees, minutes, seconds	DD MM SS.ss	32° 12' 34.879?
degrees, decimal minutes	DD MM.mm	32° 12.58131'
decimal degrees	DD.dd	32.2096886°
Universal Transverse Mercator	UTM	3807700.546

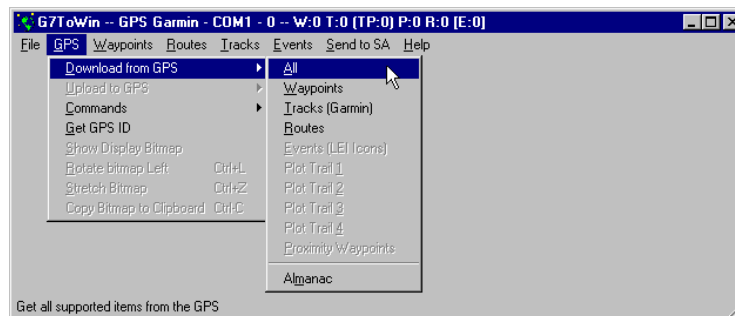
Set units and other features to desired settings.



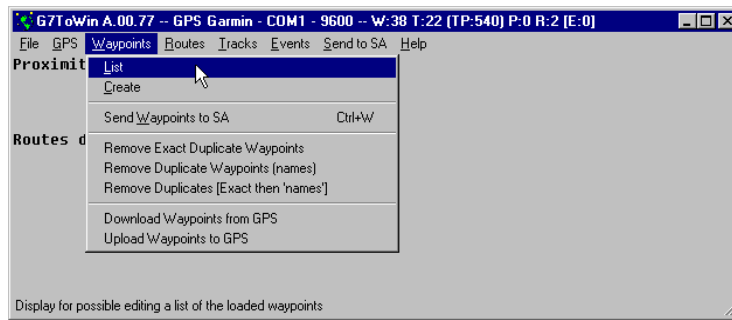
For this workshop, all the proper configurations have been set for our specific requirements. It will be up to you to select the configurations that best suit your needs. But again, there are MANY other programs available for downloading GPS data from your receiver.

For the workshop, set the datum of to be NAD83.

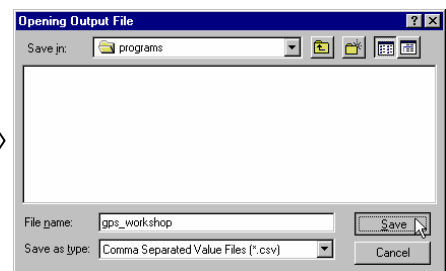
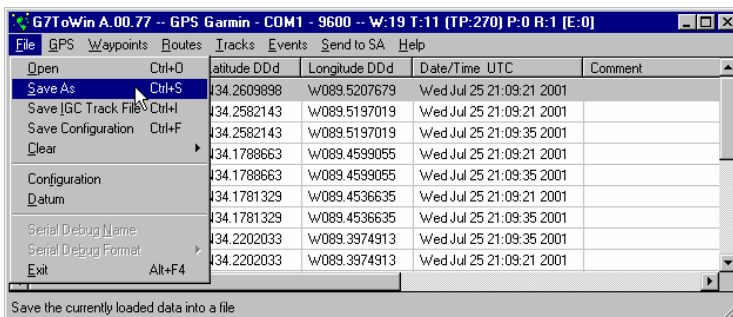
Now download all the data from the Garmin® eTrex GPS receiver. This is accomplished by selecting option below:



You are now can list and view the data using the *g7towin* program.



Let us now save all the data into a comma separated value (.csv) file format. This format can be read into any spreadsheet program and manipulated. You can also download and save specific types of data (i.e. waypoints, tracks). It may not necessary to download or view your “tracks” or the “almanac” from the Garmin® eTrex. For a specific data type, only download that data type from the GPS unit and save the file.



You have now completely downloaded the data from your Garmin® eTrex GPS receiver. In the next section, you will use a spreadsheet program to manipulate the .csv file for import into ArcView®.

N.B. With this software, you MUST enter a .csv ending on the file name. If not, sometimes Windows® will assume a .txt ending on the file and will not import correctly into Excel®.

ASCII Output Fields:

Each waypoint record consists of a single line of text, comma delimited, terminated by carriage-return/line-feed characters. Null field (blank) is used to indicate unknown or missing information. Data are case insensitive.

Field	Meaning	Notes
1	Type of data	“W” waypoints, “T” tracks, “N” Start new type
2	Color or Name	For waypoint record is the name. For track record is color of icon. Typically blank for a track record.
3	Latitude	Contain the “y” coordinate of the GPS data. For this workshop is the latitude in decimal degrees (DD).
4	Longitude	Contain the “x” coordinate of the GPS data. For this workshop is the longitude in decimal degrees (DD).
5	Month	Month in number format.
6	Day	Day in number format.
7	Year	Year in number format.
8	Hour	Hour in number format.
9	Minute	Minute in number format.
10	Second	Second in number format.
11 ¹	Comment or altitude	Comments of the waypoints or elevation in the units setup in configuration. Null value is 1e25.
12 ¹	Symbol Number or depth	Number of symbol used from waypoint or depth of point in the units in configuration. Null value is 1e25.
13	Symbol Display	Units for elevation in field 10.
14	Altitude	Elevation of waypoint in the units setup in configuration. Null value is 1e25.
15	Depth	Depth of waypoint in the units setup in configuration. Null value is 1e25

Updating the GPS software

When using a GPS, there is software that is loaded from the factor. In the case of the Garmin® xTrex, it is to version 2.10 updated on 10/20/2000. Depending on the age and model of your GPS, you may need to update the software.

First located and visit the web site of the manufacturer of your GPS. Then find out if any updates exist for the model you have. If they do exist, download the file(s) and follow the manufacture's instructions.

Do this from time to time to insure your GPS is running the latest software. Software updates can include new functionality and/or corrections to errors of previous versions. For the Garmin® eTrex, the update from version 2.09 to 2.10 included:

- Added an Advanced Skyview mode on the GPS page that displays the location in the sky of each satellite that the unit is tracking. Along with this skyview is the signal strength for each satellite.
- Allow display of speed and track when velocity is below 1.0 MPH and Selective Availability (SA) is off.
- Fixed route leg distance calculation that occurred when the unit did not have a fix.
- Fixed Dutch grid conversions and added new Dutch map datum to accompany the Dutch grid.
- The map datum list on the unit's Setup page is now displayed alphabetically.

As you can see, updating the software can provide you with greater functionality making your GPS unit easier to use.

Other software sites

The Geo Community website's GPS channel-
<http://www.geocomm.com/channel/gps/>

Topografix's Expert GPS
<http://www.expertgps.com/>

Chapter 6 - Convert ASCII Comma Separated Value File (.csv) and View the Data in ArcView 3.2

Session Objectives: At the conclusion of this session, you will be able to:

- Convert the ASCII File to a dBase file
- View the dBASE file in ArcView
- Learn of alternative methods

Source: This module was developed by Lance Yarbrough and Greg Easson.

Microsoft EXCEL®

Generic ASCII to dBASE File Conversion

Once you've uploaded all the information to your PC as an ASCII text file (.csv), you will probably want to add it to a database file or view it along with other geospatial data in a GIS application, such as ArcView. In order to do that in ArcView, for example, the file will need to be converted from the ASCII format to a database file in dBASE format (ends in .dbf). This can be done through a myriad of techniques. We're going to use the spreadsheet software called Microsoft Excel (Ver. XP) to convert the ASCII file to a .dbf file, and then view it in ArcView. The generic description of the process for converting the ASCII file to a dbf file is:

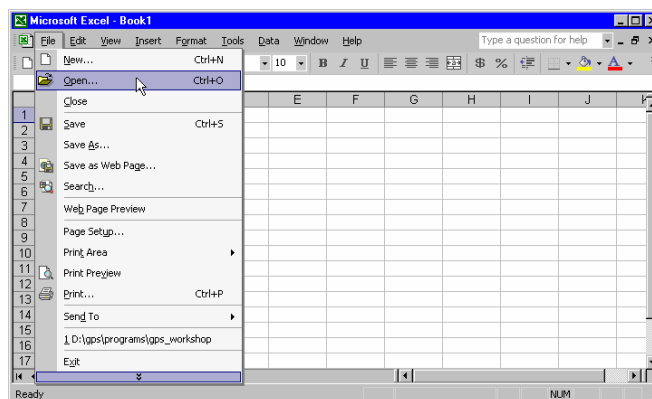
1. Import the ASCII comma separated value (.csv) into Excel
2. Manipulate the fields to properly reflect the correct data types
3. Add addition comments or information to the data
4. Export the data into a database file (.dbf)

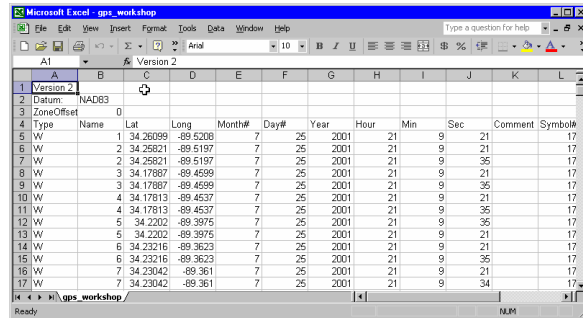
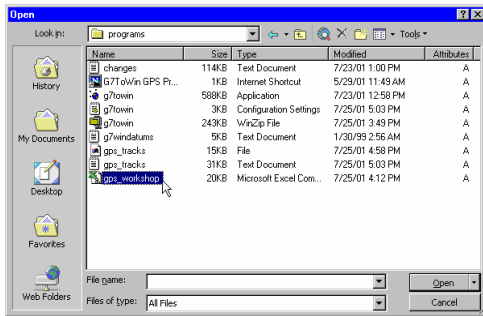
There are MANY programs that convert comma separated value files into database files. You can even write a script that will import the .csv file into ArcView. Be sure to select a method that best suits your needs.

Import into Microsoft® Excel

For these examples, Microsoft® Excel Version XP was used but any popular spreadsheet program can be used. If you are not using Excel, be sure that your program can export as a database file (.dbf).

Begin by opening Excel and using the OPEN option under the FILE menu.

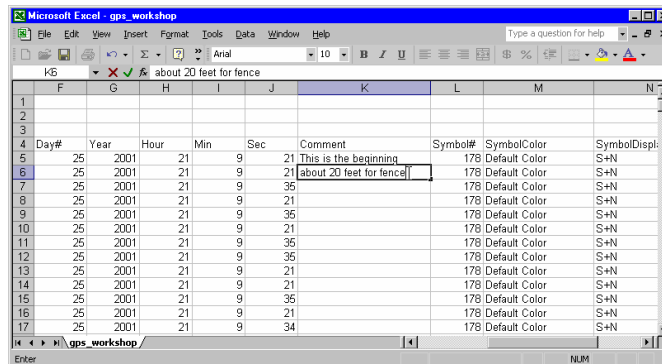




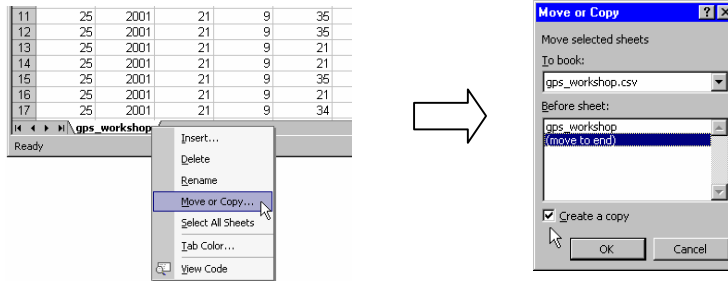
Because the file is a .csv format, Excel will automatically recognize the format and place the data into proper columns. You will have to select the delimiter for your file format with previous versions of Excel. In this case, it is a comma “,”.

Copy data cleanup

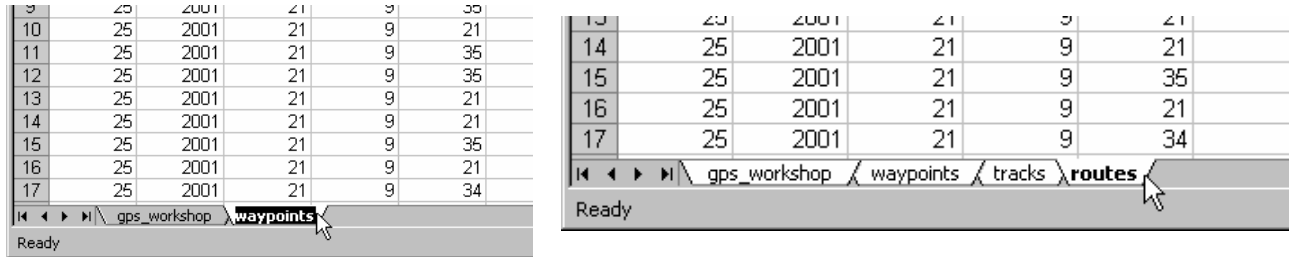
Next you will have to clean up the data file to prepare it for export into a database file. This is a good time to be sure your notebook on the project and the downloaded file are correctly referenced. Adding comments in the appropriate column may prove to be beneficial. Also be sure that your identification names for the waypoints are the same in the spreadsheet. Note the datum you are using in your notebook. We will use the NAD83 for this exercise.



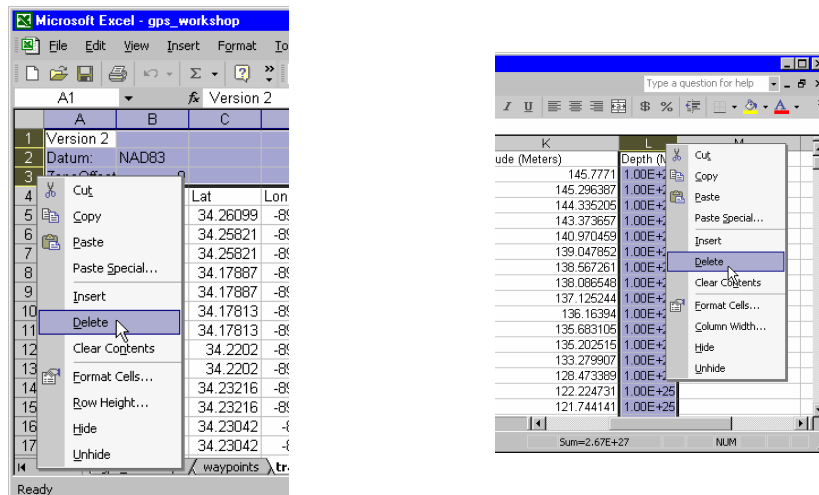
Because in this example we downloaded all the data from the Garmin®, we will now separate the data into different pages in the Excel workbook. There were three data types we downloaded, waypoints, tracks and routes. Let us make three new pages to reflect these data types.



Next you can rename the page to useful name. And do the same for each of the data types.



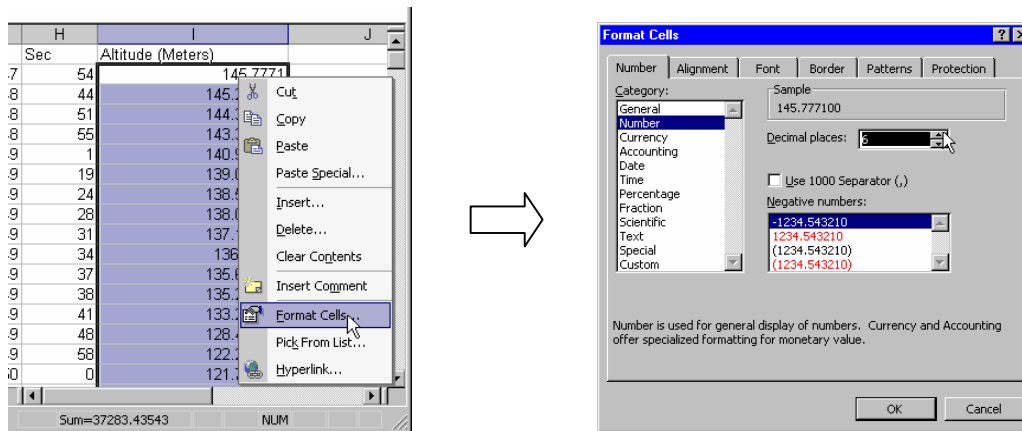
Now you can selectively delete portions of the data and NOT affect the original dataset. You will be required to delete all lines of data NOT needed on that particular page (i.e. only waypoints on the waypoint page). You will also need to prepare the page for database file export. To do this, this top line of the page will represent the header information of the database file.



Delete any rows and columns you do not need and clean up the data.

Almost done. Next format the columns to reflect the proper data types. If the data is text values, be sure the cells are “text” formatted cells. This is VERY important when exporting to a database format. Sometimes during the export process the system will truncate contents of the cells if the cells was not correctly formatted.

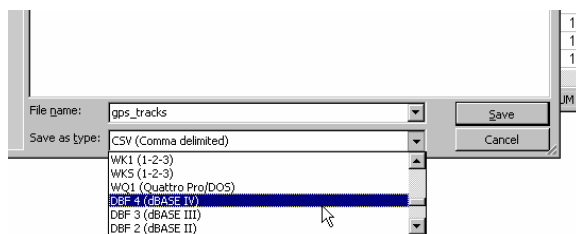
When selecting decimals places, be sure to take into account all the data vales.



Do this for the text and other numerical values. Many of the problems in importing a database file into ArcView can be traced back to mistakes made in the cell formatting. Note that the latitude and longitude columns and VERY important. If these columns get truncated, you will lose very important data!

Exporting to a database file (.dbf)

You are now ready to **SAVEAS** the Excel worksheet. Excel will not save all the worksheets from a workbook at one time. You will need to **SAVEAS** each worksheet separately into a different database file.

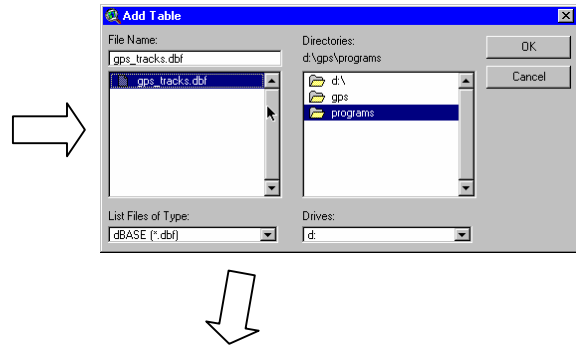
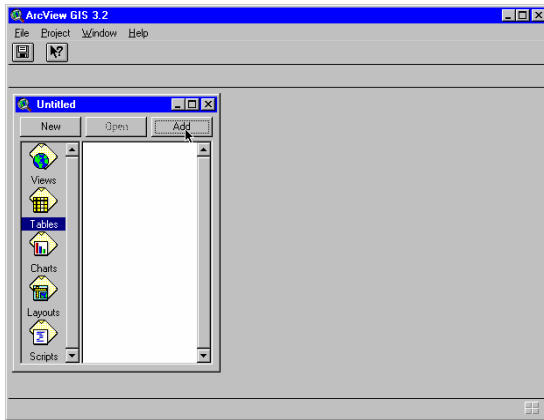


You are now ready to import the data into ArcView. You may have to come back to Excel to correct problems and then reexport. So keep Excel open just in case.

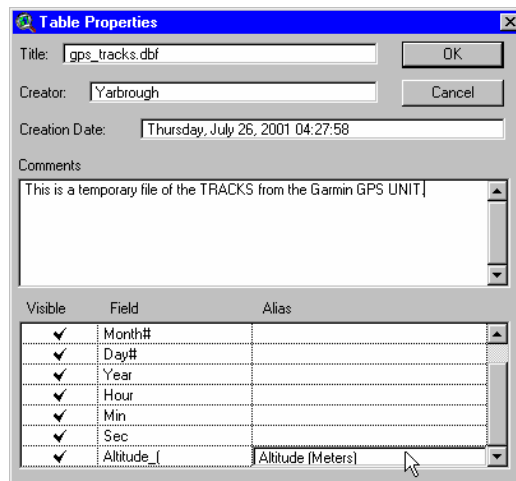
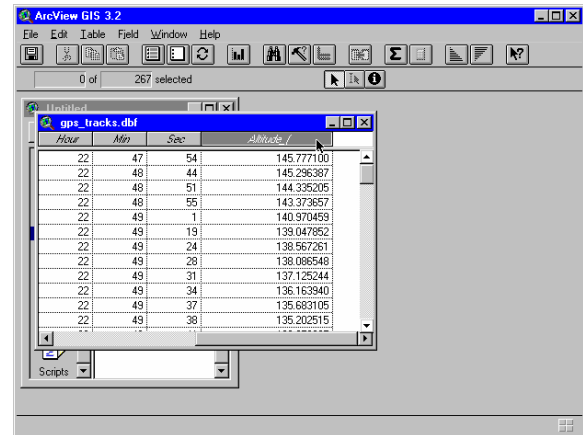
View the Data in ArcView®

Add a Table

Within ArcView, activate the Project Window and select TABLES. Next add a table.

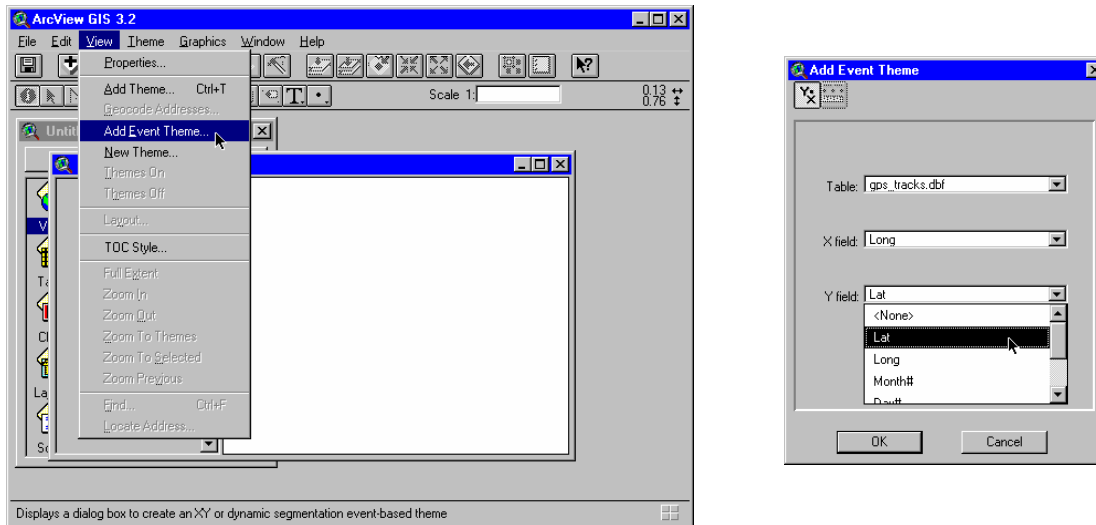


When importing a table into ArcView, be sure to inspect the new table for any import errors. As seen on the right, the field name "Altitude_" (" is a truncation of the original name of "Altitude_(meters)". ArcView limits the field name to 10 characters. You can correct this by opening the Table Properties window and create an Alias.



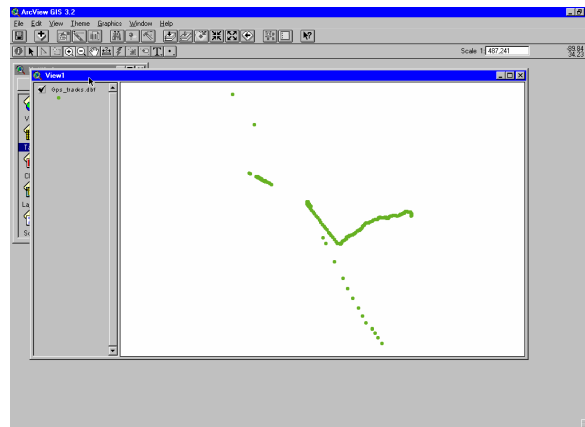
Add an event theme

Next you are ready to create a theme based on the information of the table you just imported. ArcView refers to this as an Event Theme. Checking your notebook we see that the new theme will be decimal degrees with a datum of NAD83. This is important if you are adding an Event Theme to other data. Data displayed in the same View **MUST** have the same projection.



Choose the proper fields that represent the spatial coordinates of the data. The Add Event Theme script will nearly always pre-select the correct fields but be sure to double check.

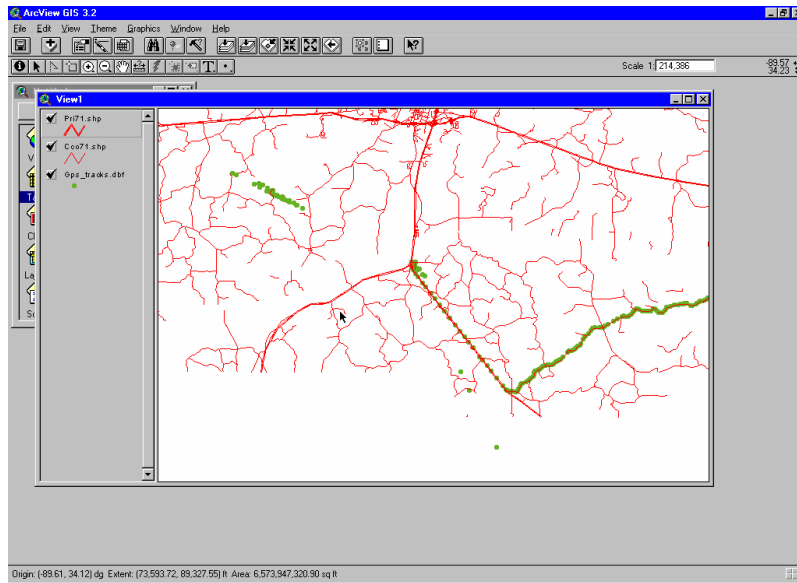
Now that you have your data displayed in the View, check it to make sure it makes sense. Compare it to other data. In the example data below, there are data points that appear to be separated from the rest of the data. They may be errors.




By adding additional data from other sources, you can evaluate your quality of data

import. In the following examples, we used track data from a trip made in a car south of Mississippi Highway 7 to the town of Paris and then proceeded down a county road.

Those separated data points are now even more erroneous by comparing them to the Lafayette county road theme downloaded from MARIS (Lat/Long).



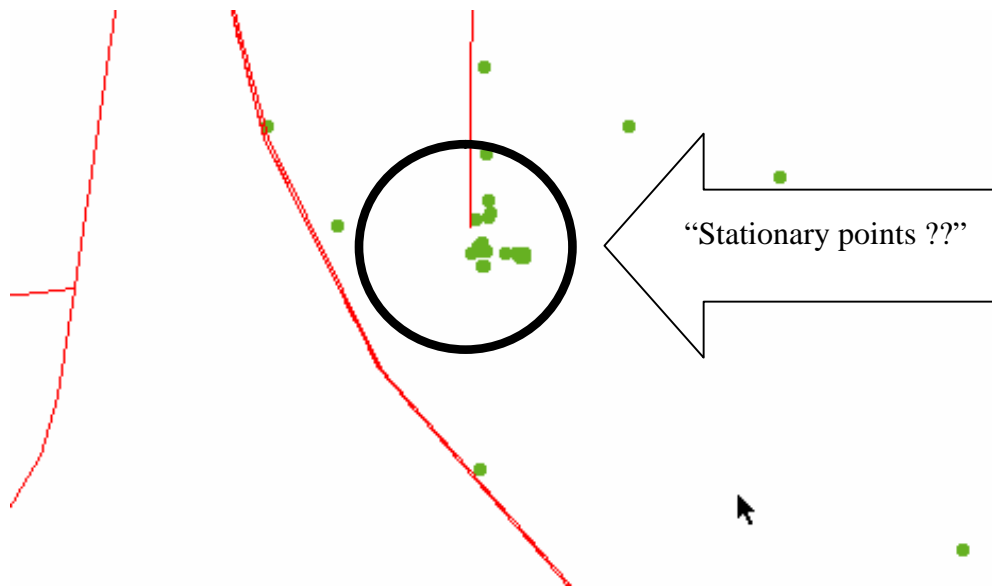
By selecting the erroneous data, we can check the table information or the  icon to check the date and time of the data point. As expected, the erroneous data has a differing time and date from the actual data collection event. The GPS was likely turned on indoors or in an area where the GPS signals could not penetrate.

<i>Day#</i>	<i>Year</i>	<i>Hour</i>	<i>Min</i>
21	2001	22	54
21	2001	22	55
21	2001	22	55
22	2001	5	35
22	2001	6	21
22	2001	6	21
22	2001	6	22
22	2001	6	22

The data points were recorded and appear in the new spatial data. You can select and delete these points before saving the new Event Theme into a shapefile format.

Now zoom into a smaller scale. The data appeared fairly accurate at larger scales but

now put it to the test by zooming in. The image below illustrates where the GPS was nearly stationary after being turned on and while waiting to acquire satellites. You can see three clusters of data points inside the circle drawn on top of the image.



The clusters are approximately 13 meters from each other. When the GPS was turned on, it took several minutes to acquire the necessary satellites to determine a solution. The cluster diameters are within the spatial error given by the Garmin® eTrex GPS receiver (4 meters). As more satellites were acquired a better solution was formulated. The more satellites the better the solution. The cluster to the top the image was the correct spatial location of the GPS receiver at the time of acquisition. Again the cluster diameter of the “stationary point” is within the published spatial error of the GPS receiver (4 meters).

Other projections

ArcView has the capability of reprojecting data using the Projection Wizard. Many popular projections and datumns are available to use. However, custom projections, such as MSTM are NOT available in ArcView. You will need to have other programs to reproject data to the MSTM projection. Contact UMGC for projection information or visit the MARIS website (<http://www.maris.state.ms.us>).

You can also create your own script to reproject the data into a custom projection. UMGC will soon have available scripts to perform this reprojection. If you have any comments or suggestions, please contact us.