AutoCAD Civil 3D 2010
Education Curriculum Instructor Guide
Unit 6: Geospatial Data

Autodesk

Lesson
2

Geodetics

Overview

Geodetics is the study of the measurement of the earth. The shape of the earth is generally an ellipsoid, but often represented as a flat surface on a map. Laying a piece of flat paper on a round globe suggests obvious problems with this type of representation. The most significant problem is distortion, suggested by folds in the paper when pressed against the globe. While geodetics is a complicated topic, this lesson addresses three major definitions in geospatial reference systems: projections, datums, and coordinate systems. Using a common "coordinate system" basically means using the same projection, datum, and coordinate system in order for data layers to correctly correlate to each other.

Utility and land development business processes are lengthy and involve many different project phases. An inherent aspect of these business processes is geospatial data transfer and leveraging throughout the entire project lifecycle. A typical project involves planners, surveyors, engineers, GIS technicians, and data analysts.

Planners extract data from a GIS for project conceptualization and preliminary design. Surveyors create base plans and existing ground surface models, and hand off pre-engineering data to engineers. Engineers create detailed design construction documents and hand off construction staking data to construction surveyors. Surveyors and engineers give post-construction "as-built" data to GIS technicians for input into a GIS. Some projects also use satellite imagery, aerial photographs, and other types of overlay data such as environmental data. GIS technicians create and manage data in a geospatial database that is in turn used by those involved with municipal/utility planning and growth management.

Land development and utility business processes must consider the use of a consistent coordinate system throughout all project phases. Data created to a locally assumed coordinate system, which is a common occurrence, needs to be transformed to a defined and common coordinate system prior to handoff to the next group involved in the process.

Objectives

After completing this lesson, students will be able to:

- Describe Cartesian and polar coordinate systems.
- Describe the principles of projections.
- Discuss horizontal and vertical datums.
- Discuss UTM and U.S. State Plane Coordinate Systems.
- Assign a coordinate system to a drawing and a data layer.
- Assemble data layers that use multiple coordinate systems.

Exercises

The following exercises are provided in a step-by-step format in this lesson:

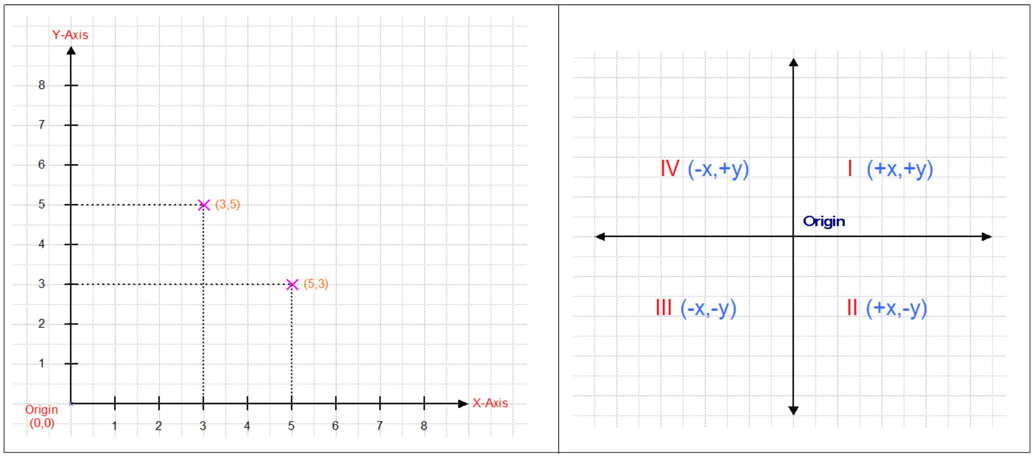
1. Assign a Coordinate System to a Drawing
2. Assign a Coordinate System to Data
3. Assemble Data from Multiple Coordinate Systems

Coordinate Systems Overview

Coordinate systems are used to spatially locate the position of points and features in either a two-dimensional or three-dimensional frame of reference. The frame of reference can be a plane, sphere, or an ellipsoid.

The most common type of coordinate system is the Cartesian, or rectangular, coordinate system, which is a two-dimensional system that is used to uniquely identify the location of a point on a planar surface. The references for measurement are two axes that are perpendicularly aligned to each other and intersect at a fixed origin. The horizontal axis (X) and the vertical axis (Y) are used to measure the location of a point on a planar surface.

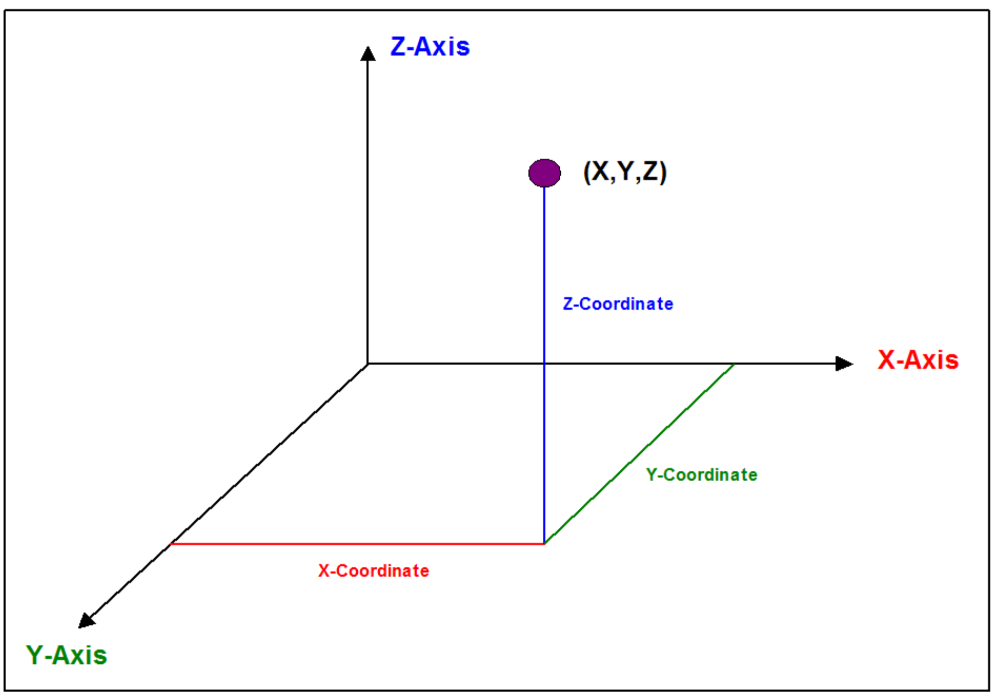
The following figure illustrates a two-dimensional Cartesian coordinate system.



A two-dimensional Cartesian coordinate system is also subdivided into four quadrants (I, II, III, and IV). The location of each quadrant is in reference to the origin of the coordinate system. In geospatial mapping, the X and Y coordinates are used to indicate horizontal, or plan, view location.

A three-dimensional coordinate system introduces a Z axis, located relative to the same origin as the X and Y axes. The Z axis is the reference of measurement for a third Z coordinate. In geospatial mapping, the Z coordinate is normally used to indicate the elevation of a point, but can represent any attribute value at the X, Y location.

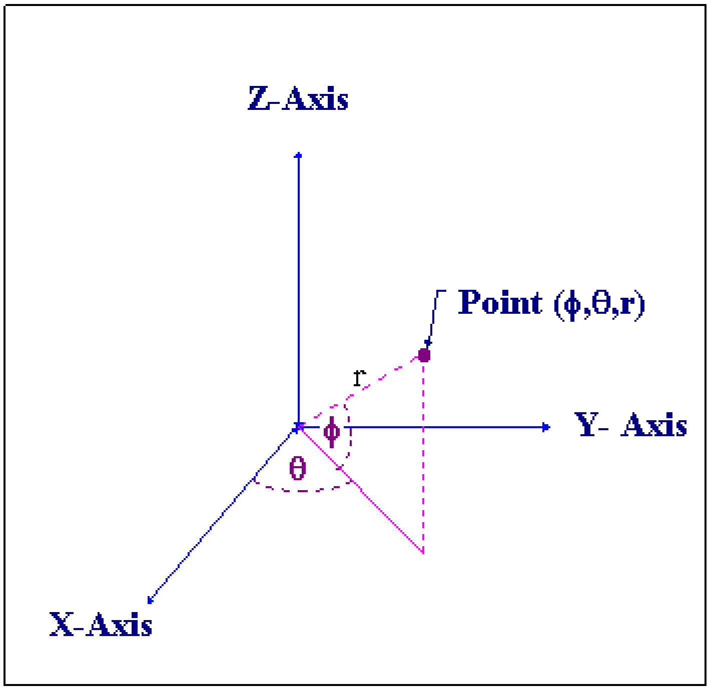
A three-dimensional coordinate system is illustrated in the following figure.



The Cartesian coordinate system is a frame of reference for locating features on planar surfaces. With a three-dimensional Cartesian coordinate system, position is indicated relative to three planes: XY, XZ, and YZ. With maps, geographic data is represented on planar surfaces.

With globes, geographic data is represented on spherical or ellipsoidal three-dimensional surfaces using a polar coordinate system.

Polar coordinate systems indicate position by using distance from the origin (also known as the pole of the coordinate system) and an angle relative to the polar axes. A polar coordinate system is illustrated in the following figure.



With a polar coordinate system, position is indicated by two angles and a distance. Latitudes and longitudes are the most commonly used polar coordinate system.

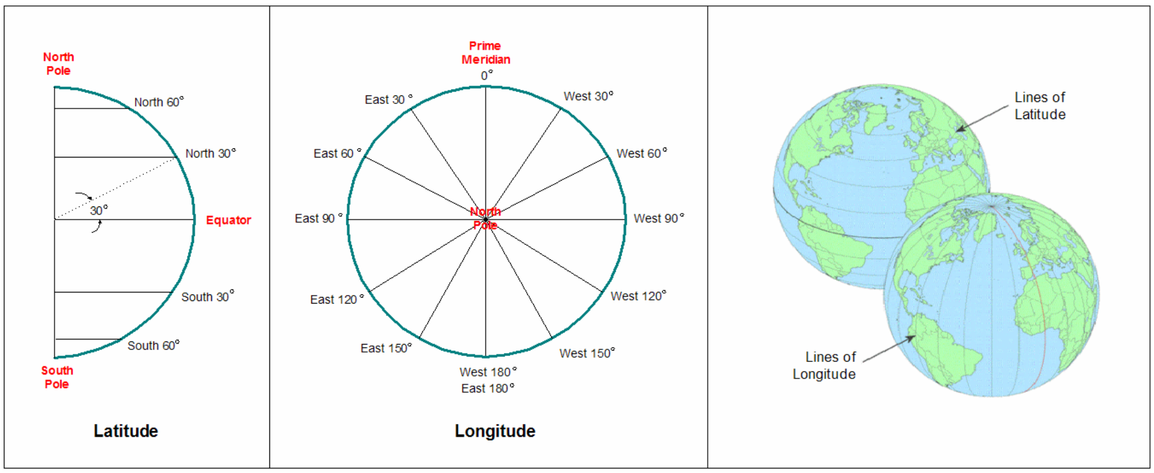
Latitude and Longitude

From a large-scale mapping and navigation perspective, using latitude and longitude is the most common method for indicating a position on the surface of the curved earth. In its most basic form, this method is a polar coordinate system that assumes the shape of the earth's surface is a perfect sphere. Lines of latitude run east-west (horizontally on a map) and indicate south and north position relative to the Equator. These lines are are also commonly known as parallels, because they are parallel and equidistant from each other.

Lines of longitude run north-south (vertically on a map) and indicate the east and west position. Vertical lines of longitude are also referred to as meridians, and intersect at the north and south poles. East-west positions are measured relative to the Prime Meridian, which is also referred to as the Greenwich Meridian.

Measurements of latitude and longitude are made in terms of angles measured from the center of the earth. The origin for a latitude position is the Equator and has a value of 0 degrees. North and south position ranges from 0 degrees to 90 degrees to the north and south of the Equator. North 90 degrees is the North Pole, and south 90 degrees is the South Pole. The distance from the pole, or the center of the earth, remains constant with a spherical polar coordinate system representing the earth's surface. Distance from the pole varies with position in ellipsoidal coordinate systems, which better represents the true shape of the earth.

The origin for longitude is the Prime Meridian and has a value of 0 degrees. East and west positions range from -180 degrees to the east and +180 degrees to the west of the Prime Meridian. The intersection of the east and west meridian lines form the International Date Line in the Pacific Ocean. Greenwich, the site of the British Royal Greenwich Observatory, was established as the site of the Prime Meridian by an international conference in 1884.



To precisely locate points on the earth's surface, degrees of longitude and latitude have been divided into minutes and seconds. Each degree has sixty minutes, and each minute has sixty seconds.

It needs to be reiterated that the latitude and longitude coordinate system is a spherical, or geographical coordinate system and is unlike the planar, or Cartesian, coordinate system. Units of measurement for a spherical coordinate system are degrees relative to the center of the earth, the Equator, and the Prime Meridian. Planar coordinate systems indicate position by using a flat surface, an origin, and two or three axes of measurement.

Units of latitude and longitude have been used for centuries by explorers and mariners and are the standard units for today's Global Positioning Satellite (GPS) navigation and data collection systems. With GPS, coordinates are transformed from spherical coordinates to planar coordinates by applying automated mapping projections. This process is referred to as a coordinate transformation.

Map Projection Overview

Cartographers have the challenging task of creating the accurate spatial representation of geographic data on flat surfaces such as computer screens and hardcopy maps. Map projections are an important means of managing distortion and achieving accurate map-making.

Map projections are the result of spatially “projecting” geographic data from the curved earth surface to a planar, or flat, projection surface. These flat projection surfaces are then used to create a number of individual maps that are commonly referred to as coordinate zones. One common analogy used to explain projection types is to place a light bulb inside a clear glass globe of the earth and let the light “project” the land area onto paper. Various methods of bending paper such as cylinders or cones result in different “projections” of the land onto the paper. The projection type used is related to the distortion error of the map and the shape of the area being mapped.

The Mercator projection is a common cylindrical projection surface that has been employed by cartographers and navigators since the early 1600s. Gerardus Mercator was a Flemish mapmaker and geographer who is best known for the map projection which bears his name.

The common map of the world uses the Mercator mapping projection. Carefully review the map in the following figure and note the distorted size of Greenland in comparison to South America.

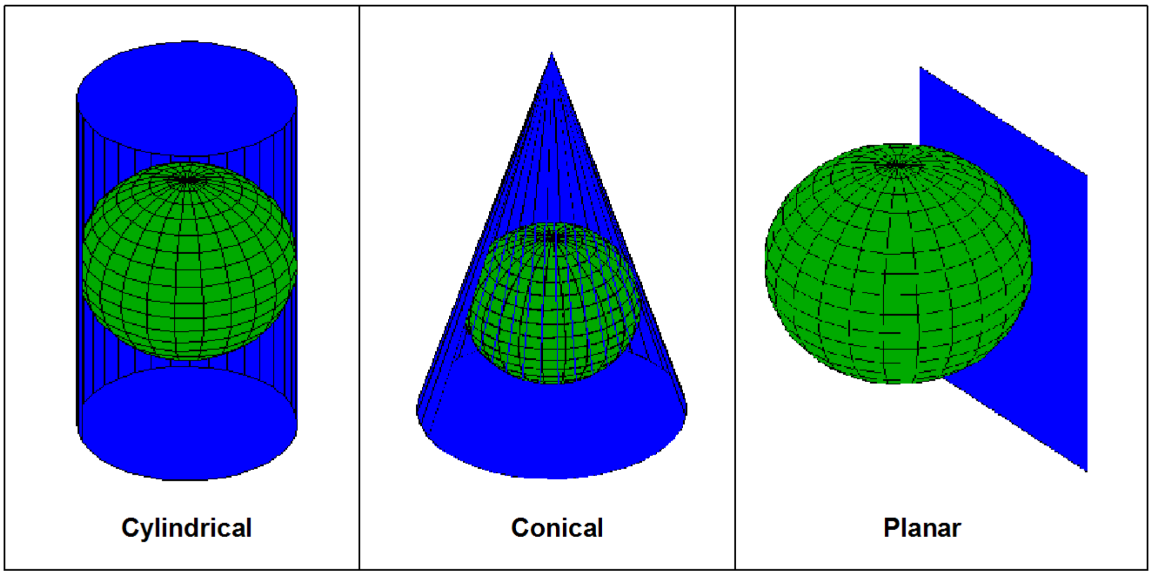
In this map, the scale of proportion relative to the curved surface of the globe is true only along the Equator. Graphical distance distortion increases rapidly as you measure distances further to the north and the south. In the figure, Greenland appears larger than South America. In reality, South America is nine times larger than Greenland.

Map Projection Surfaces

A mapping projection is used to spatially represent a curved surface data on a flat surface. A predictably accurate flat map is not possible without a mapping projection. Furthermore, the shape of the earth is not perfectly spherical. In fact the earth is more ellipsoidal in nature, with a bulge located near the Equator. This is mostly due to the centrifugal effects of a rotating earth. Depending on the application, cartographers can use either ellipsoids, of which there are many to choose from, or spheres to model the shape of the earth.

Performing a mapping projection is a two-dimensional spatial data transformation that involves moving data from a spherical or ellipsoidal frame of reference, to a planar frame of reference. The planar frame of reference is known as a projection surface. Projection surfaces are simple three-dimensional geometric shapes that are sized and oriented relative to the surface of the globe. The most common projection surfaces are cylindrical, conical, and planar. Mapping projections thus far are concerned only with the horizontal positioning coordinate pair of Northings and Eastings.

The following figure shows cylindrical, conical, and planar projection surfaces.



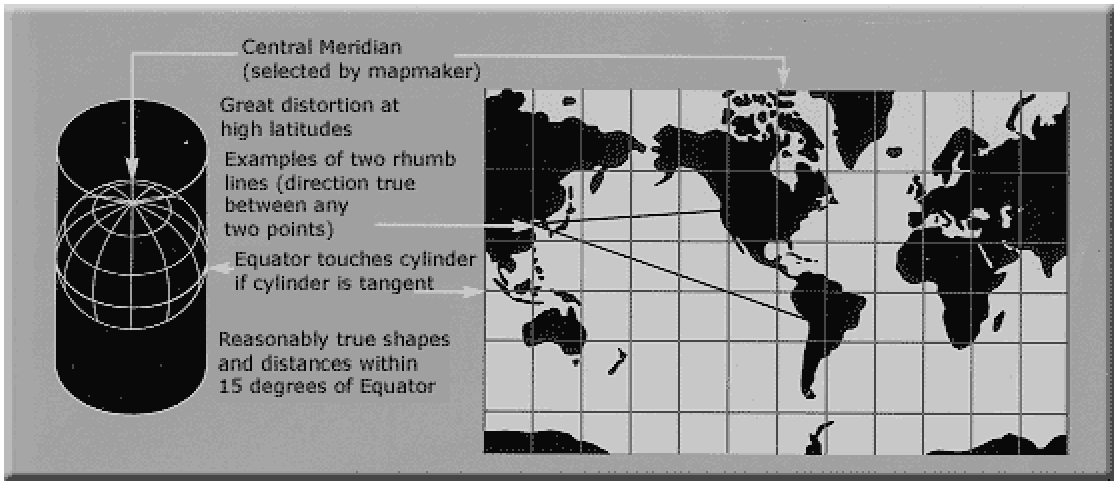
One property of a projection surface is that it can be unrolled or unfolded to a flat plane without tearing, stretching, or shrinking. The orientation of the “rolled up” projection surface relative to the globe directly affects the accuracy at different locations on the map. The locations where the projection surface intersects the globe are the most accurate. Positions become less accurate further away from the point of intersection.

Positions on the globe are then projected normal to, or perpendicular to, the projection surface. The projection surface can then be “unrolled” and subdivided to create several individual flat maps. These individual maps each represent a different zone of the projection.

Cylindrical Projections

The cylindrical projection is one of the most common mapping projections, and serves as the projection surface for the well-known Mercator projection. Mercator’s map of the world uses a cylindrical mapping projection. A cylindrical projection maps meridians (lines of longitude) to equally spaced vertical lines, and parallels (lines of latitude) to horizontal lines. A cylinder roughly the size of the earth’s surface is positioned to intersect with the surface.

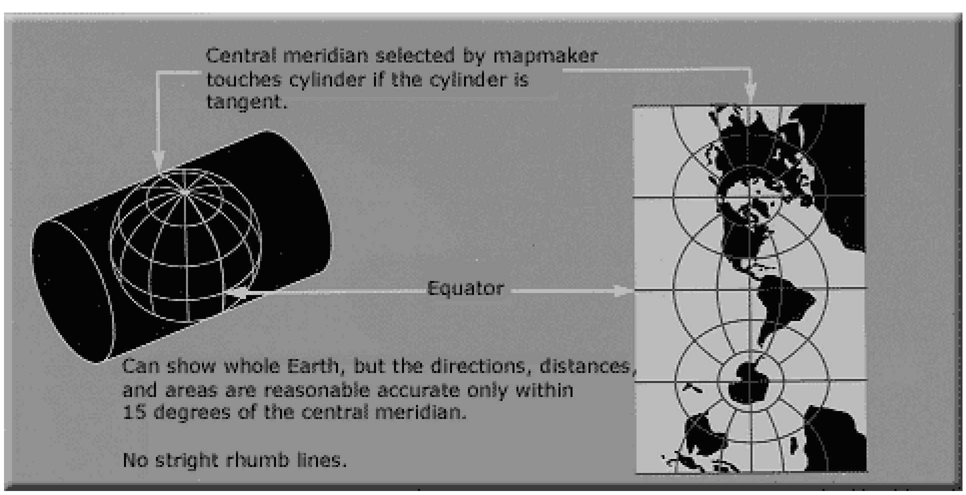
Mercator's cylindrical projection intersects the earth's surface at the Equator. The mapping of meridians to vertical lines can be visualized by imagining a cylinder (of which the axis coincides with the earth's axis of rotation) wrapped around the earth and then projecting onto the cylinder, and subsequently unfolding the cylinder. This figure illustrates the Mercator projection.



With the Mercator cylindrical projection, distances are true only along the Equator. Special scales can be used for measuring distances along the parallels further away from the Equator.

There are a number of other cylindrical projections available. The differences lie in the orientation of the cylinder with respect to the earth's surface. Remember that the areas on and near the physical intersection of the cylinder and the earth's surfaces are the most accurate.

The Transverse Mercator cylindrical projection is used for mapping areas that are mostly north-south in extent, unlike the Mercator projection which is used for mapping areas that are mostly east-west in extent. The difference between the Transverse Mercator and the Mercator projections lies in the orientation of the cylinder with respect to the rotational axis of the earth. This figure illustrates a Transverse Mercator projection.

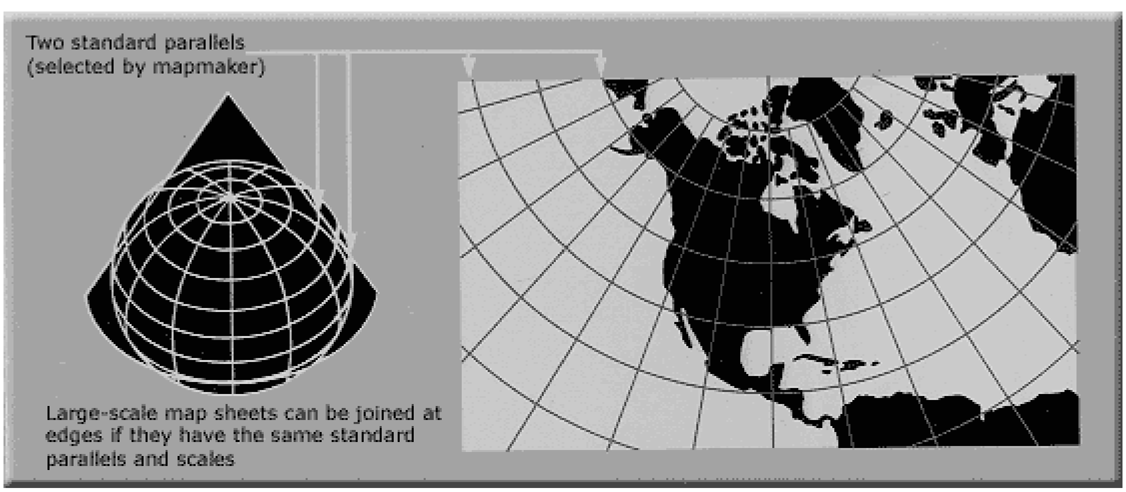


With the Transverse Mercator projection, the cylinder intersects the earth on a meridian (line of longitude) line chosen by the cartographer. The intersection with the earth runs north-south, thereby offering the greatest amount of accuracy for maps extending in the north and south directions. The Mercator projection offers accuracy in the east-west direction due to the vertical orientation of the conical projection surface.

Since the Transverse Mercator projection is very accurate in narrow zones, it has become the basis for a global coordinate system called the Universal Transverse Mercator System or UTM System. The globe is subdivided into narrow longitude zones, which are projected onto a Transverse Mercator projection. A grid is constructed on the projection, and used to locate points. The advantage of the grid system is that, since the grid is rectangular and decimal, it is far easier to use than latitude and longitude. The disadvantage is that, unlike latitude and longitude, there is no way to determine grid locations independently.

Conical Projections

A conical surface is another type of projection surface. The mapping projection for a conical surface is similar to that of a cylindrical surface, except that the projection surface is a cone as opposed to a cylinder. The Lambert Conformal Conic projection is commonly used to show a country or a region that is mainly east-west in extent. A conical projection is illustrated in the following figure.

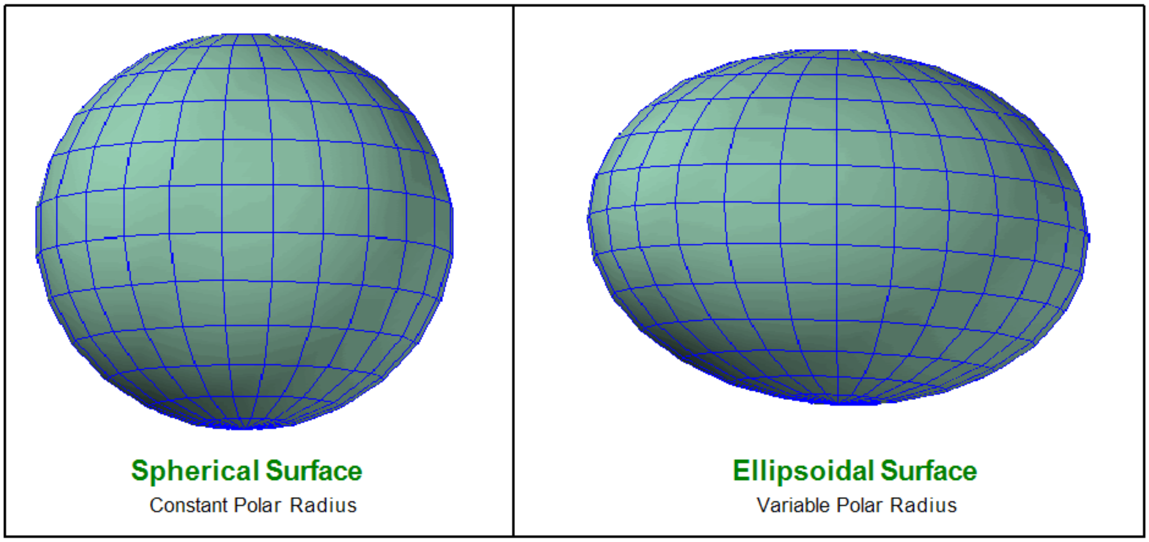


Spheroids and Ellipsoids

A mapping projection for a two-dimensional coordinate system must recognize either a spherical or ellipsoidal model of the earth. Spherical models are less accurate, but easier to work with, while ellipsoidal models are more accurate and complicated.

Selecting a model for a shape of the earth involves choosing between the advantages and disadvantages of a sphere versus an ellipsoid. Spherical models are useful for small-scale maps such as world atlases and globes, since the error at that scale is not usually noticeable or important enough to justify using the more complicated ellipsoid. The ellipsoidal model is commonly used to construct topographic maps and for other large- and medium-scale maps that need to accurately depict positions on the land surface.

Spherical and ellipsoidal surfaces are shown in the following figure.



About Horizontal Datums

A datum is a mathematically balanced model of actual measured horizontal positions on the earth. The North American Datum 1927 (NAD27) is a mathematical model that balanced more than 25,000 latitude and longitude measurements referencing the Clarke 1866 spheroid. This datum is based on ground survey information from the 1800s and has a reference point in Meades Ranch, Kansas. The North American Datum 1983 (NAD83) replaced the NAD27 Datum, balanced more than 270,000 geodetic measurements, and referenced the GRS80 (Geodetic Reference System) ellipsoid. The NAD83 Datum is based directly on ground surveys and satellite information.

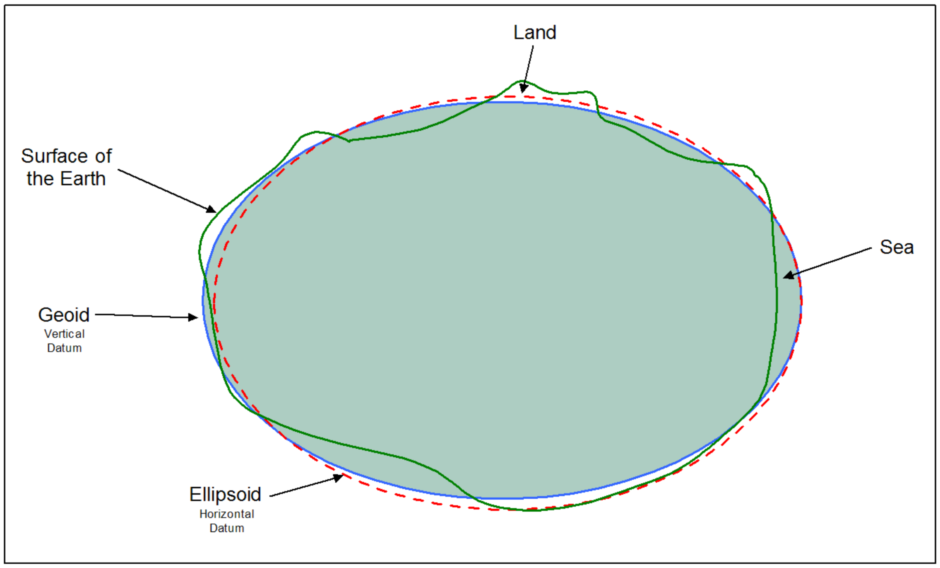
The World Geodetic System (WGS) defines a fixed global reference frame for the earth, for use in geodesy and navigation. The WGS 84 ellipsoid was introduced in 1984 and is the current reference system being used by GPS systems. The WGS84 ellipsoid is also the model for many mapping projections. The WGS 84 and NAD 83 datums are virtually identical, which means that data is compatible between the two.

About Vertical Datums: Geoids

Datums are defined to physically represent the shape of the earth. The most common datums are ellipsoidal in shape and include the NAD 83 and WGS 84 Datums. These horizontal datums are useful for calculating horizontal mapping projections, but not very useful for vertical mapping projections. Vertical or Z coordinate data is developed from a geoid.

A geoid is a surface that approximates the mean ocean surface level. It is often referred to as a close representation of the physical shape of the earth. The geoid surface is more irregular than the reference ellipsoids often used to approximate the shape of the physical earth, but considerably smoother than the earth's physical surface. Continental height elevations are derived from geoids.

The following figure shows a model of the earth with a geoid and ellipsoid overlay.



There are a number of geoid datums for vertical elevation control. In the U.S., the North American Vertical Datum 1988 (NAVD88) is commonly used. The U.S. National Geodetic Survey developed Geoid 99, which is a globally-defined geoid that enables GPS receivers to calculate correct Z values from a global vertical datum.

About Coordinate Systems

All geospatial mapping is created within a specific coordinate system, either Cartesian or polar. Geospatial data specialists, GIS mapping technicians, and cartographers have many choices to make, because there are a large number of coordinate systems available and in use. Fortunately government and industry organizations have set standards for the application and use of specific coordinate systems within their respective regions. Without coordinate system standardization, it would be difficult to overlay geospatial data layers originating from multiple sources.

The use of geospatial technologies that contribute to land development and infrastructure processes requires particular attention to coordinate systems. The concepts of the infrastructure project lifecycle and geospatial data leveraging must consider the consistent application of coordinate systems throughout all project phases. Inconsistent use of coordinate systems involves additional steps such as moving, rotating, and stretching data from one data source to overlay on data from another data source. Paying close attention to the type of coordinate system, projection, and datum for each and every data source is critical.

Cartesian coordinate systems are also called projected coordinate systems and require designation of a specific projection type and datum. For example, the Virginia State Plane South Coordinate System uses a Lambert Conformal Conic projection and is based on the NAD83 datum.

Polar coordinate systems are not projected and are sometimes referred to as geographic coordinate systems. They require designation of a datum, but no projection is applicable.

Universal Transverse Mercator Coordinate System

The Universal Transverse Mercator System (UTM) subdivides the world into 60 narrow 6-degree longitudinal zones, which are projected onto a Transverse Mercator projection. These zones lie between 80 degrees north and south latitude, and each zone has a central meridian. Coordinates are expressed in meters, and the origin of coordinates for each zone is the intersection of its central meridian and the Equator. In the north hemisphere, the origin coordinates are X = 500,000 m and Y = 0 m, while in the southern hemisphere, the origin coordinates are X = 500,000 m and Y = 10,000,000 m in order to keep all coordinates positive.

The UTM system was originated by the U.S. Department of Defense in order to map its worldwide defense efforts. Many military or defense-related installations are required to have their surveys expressed in the UTM system.

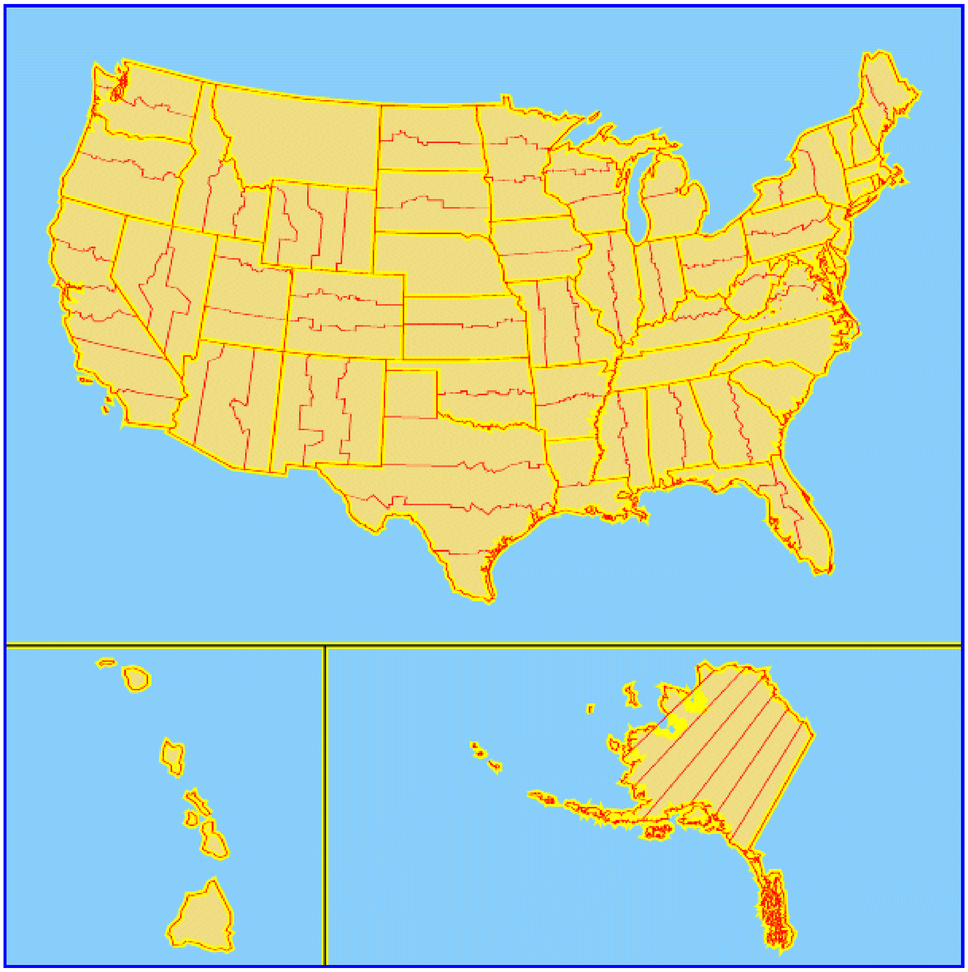
U.S. State Plane Coordinate System

The U.S. State Plane Coordinate System is a collection of distinct coordinate systems using different projections. It is a system for specifying positions of geodetic stations using planar rectangular coordinates. This coordinate system divides all fifty states of the United States, Puerto Rico, and the U.S. Virgin Islands into over 120 numbered sections. These numbered sections are individually referred to as zones. Each zone has an assigned code number that defines the projection parameters for the region.

The State Plane Coordinate System was created in the 1930s by the U.S. Coast and Geodetic Survey in order to provide a common reference system for surveyors and cartographers. The system was originally based on the NAD27 datum, but was redeveloped in the 1980s based on the NAD83 datum. It is widely used in land development and infrastructure projects.

The State Plane Coordinate System is more accurate than the Universal Transverse Mercator System because of the use of relatively small zones. The number of zones in a state is determined by the area the state covers and the allowable map distortion. The number of zones range from one for a small state such as Rhode Island, to as many as five in the state of California. While the boundaries of the UTM zone follow lines of latitude and longitude, state plane zones follow political boundaries.

The State Plane Coordinate System is shown in the following figure:



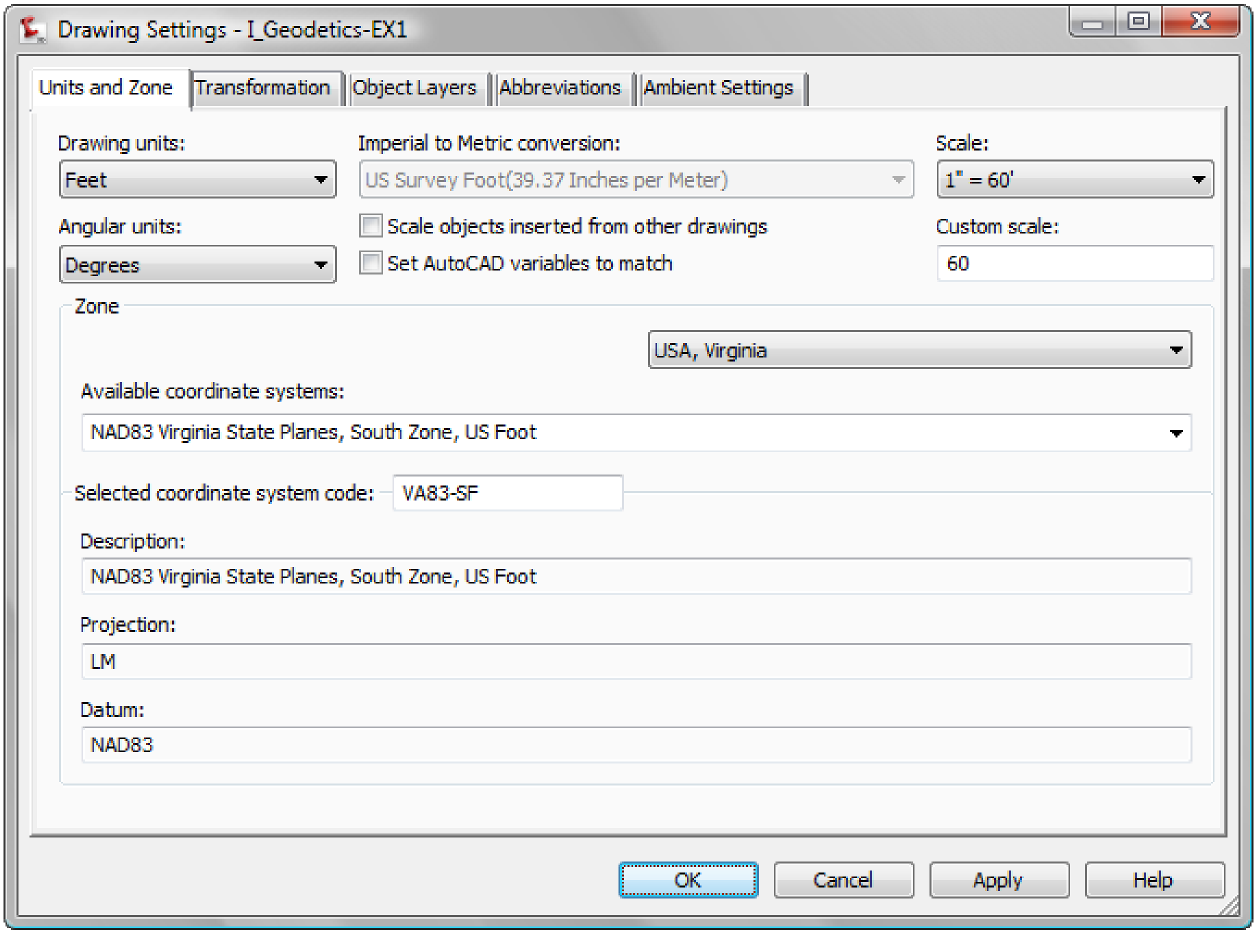
State plane zones with the long axis running north to south are mapped using a Transverse Mercator projection. Zones whose long axis runs east to west are mapped using a Lambert Conformal Conic projection.

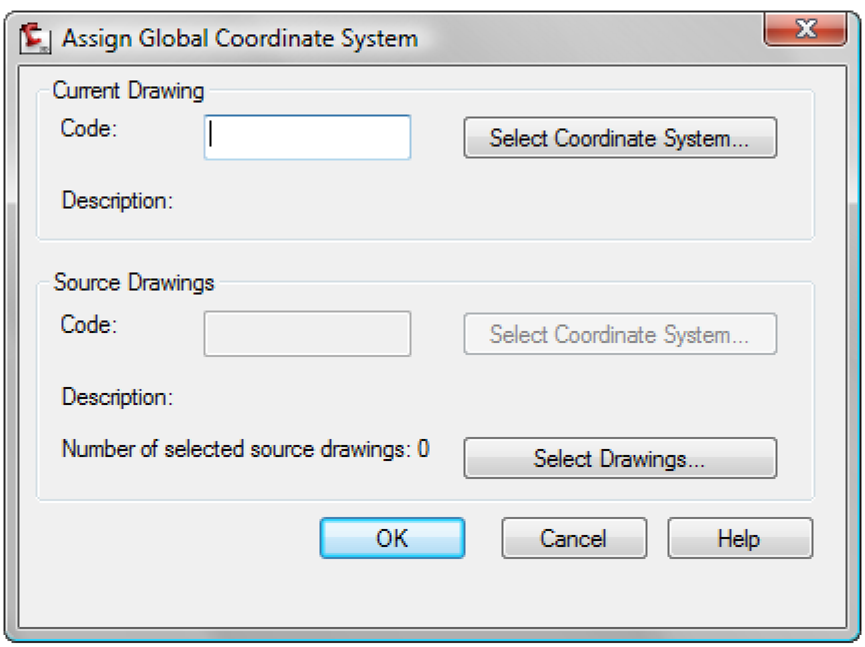
Assigning Coordinate Systems

It is important to know and understand the source coordinate system for your geospatial data layers. Assigning the wrong system to data can result in dramatic misalignment of data, which can lead to wrong conclusions.

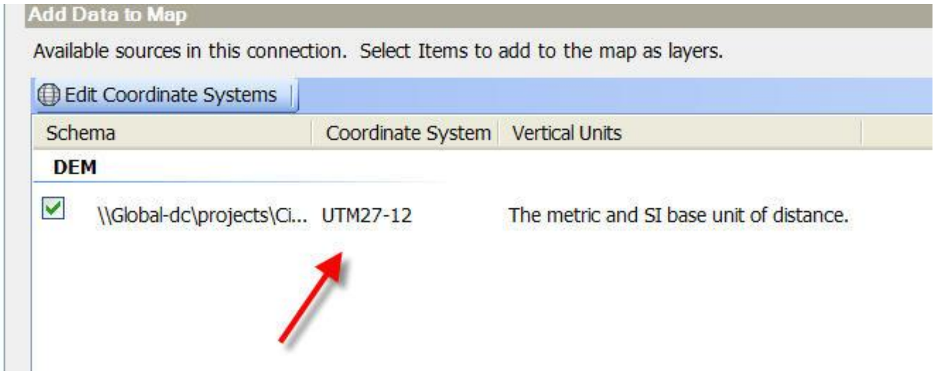
In Civil 3D, there are two steps that need to be taken to assure data alignment. First, the drawing needs to be assigned its own coordinate system. Second, the data being used or imported must have a coordinate system assigned.

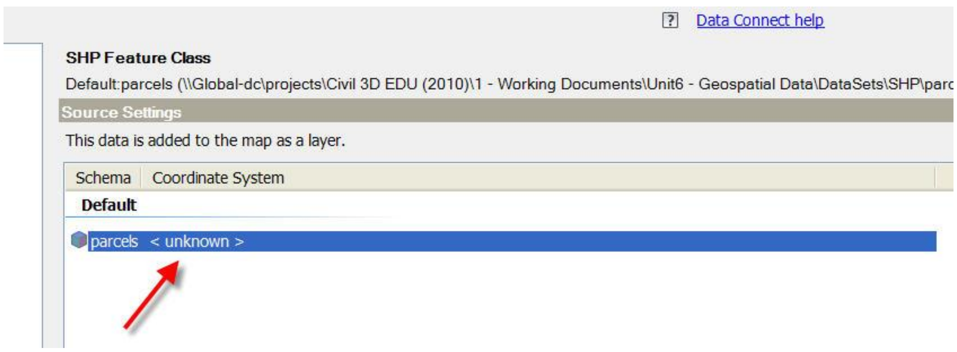
In order to assign a coordinate system to the drawing, you can either use the Drawing Settings dialog box, accessed from the Civil 3D Toolspace, or you can use the Assign Global Coordinate System dialog box.


Drawing Settings - I_Geodetics-EX1
Units and Zone
Transformation
Object Layers
Abbreviations
Ambient Settings
Drawing units:
Feet
Imperial to Metric conversion:
US Survey Foot(39.37 Inches per Meter)
Scale:
1" = 60'
Angular units:
Degrees
Scale objects inserted from other drawings
Set AutoCAD variables to match
Custom scale:
60
Zone
USA, Virginia
Available coordinate systems:
NAD83 Virginia State Planes, South Zone, US Foot
Selected coordinate system code:
VA83-SF
Description:
NAD83 Virginia State Planes, South Zone, US Foot
Projection:
LM
Datum:
NAD83
OK
Cancel
Apply
Help


Assign Global Coordinate System
Current Drawing
Code:
Select Coordinate System...
Description:
Source Drawings
Code:
Select Coordinate System...
Description:
Number of selected source drawings: 0
Select Drawings...
OK
Cancel
Help

The data's coordinate system is typically part of the data's schema and may be automatically assigned. Some data requires the user to assign the coordinate system. The following illustrations show both an automatically assigned system and one that needs user assignment.





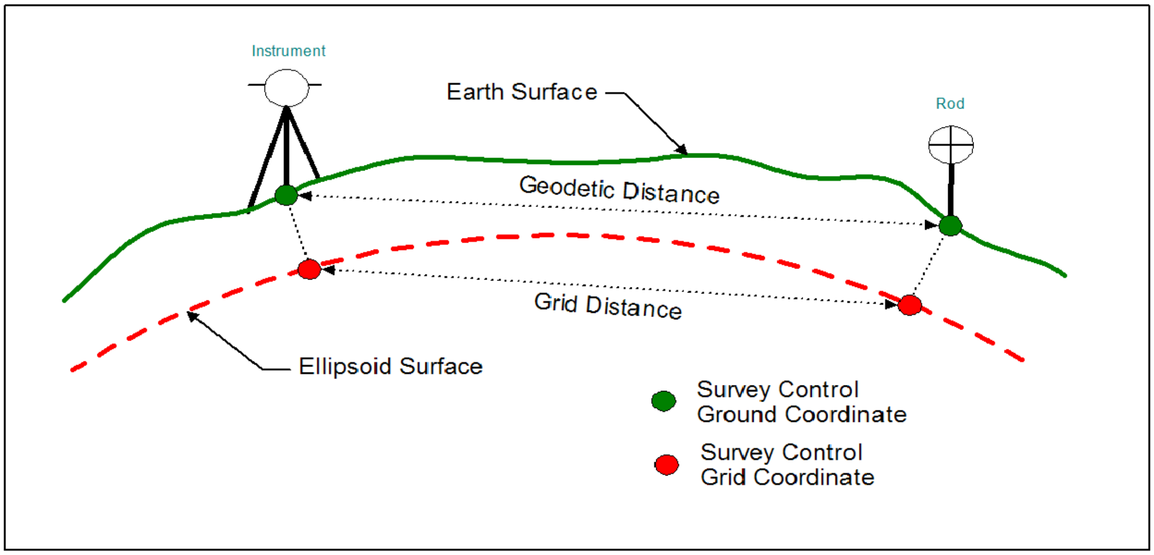
Ground and Grid Coordinates

Ground level distances and coordinates are measurements made directly on the surface of the earth. These are also referred to as geodetic measurements. Grid distances are calculations made on a map projection, or a grid surface.

Remember that UTM coordinates are based on a map projection, and that the map projection is most accurate where the projection surface intersects the ellipsoidal datum. As you move away from the intersection location, maps become less accurate. Recall that with the conical Mercator projection, distances are most accurate near the Equator. With a conical transverse Mercator projection, distances are most accurate near the meridian of intersection with the conical surface.

A scale factor is used to resolve the differences between geodetic (ground) measurements and grid (map projection) measurements. It is the quantity by which a geodetic length is multiplied in order to obtain the corresponding grid length. The magnitude of the scale factor is a function of the position of the point with respect to the lines of exact scale. With the conical Mercator projection, the scale factor is 1 at the Equator. The scale factor decreases as you move away from the Equator.

Consider the following example. A total station surveyor uses two published UTM map projection coordinates, or grid coordinates, to create a survey control network for a new 200-parcel subdivision project. The calculated grid distance between the two control coordinates is 10 kM. The surveyor then uses total station survey equipment to measure the ground distance between the two control points. The field measurement is different from the distance calculated from the two control coordinate pairs. This is because distances calculated from grid coordinates are different from measurements made from ground coordinates. Refer to the following figure.



Surveyors can apply a scale factor in the field to adjust field or geodetic measurements to create maps that reference grid coordinates. Grid coordinates are the bases of geospatial data stored in a GIS.

Key Terms

Cartesian Coordinate System	A Cartesian, or rectangular, coordinate system that uses orthogonal rectilinear axes in the X, Y, and sometimes Z directions (if three-dimensional) to uniquely identify the location of a point.
Polar Coordinate System	A polar coordinate system indicates position on space based on two angles and a distance. One angle is measured on the XY plane from the X axis to the point, and the second angle is measured from the XY plane vertically to the point.
Latitude and Longitude	The most common polar coordinate system for mapping. Lines of latitude run east-west and indicate south and north position relative to the Equator. Lines of longitude run north-south and indicate the east and west position relative to the Prime Meridian.

Map Projection	A mathematical method of projecting features from a spherical or ellipsoidal surface to a flat surface. This is analogous to using cylindrical, conical, or planar paper shapes on which to map the earth.
Conic Projection	A map projection in which the surface of the earth is drawn as it would appear if projected on a cone wrapped around the earth. The Lambert Conformal Conic is often used for maps of the continental United States, France, and other countries.
Cylindrical Projection	A map projection in which the surface of the earth is drawn as it would appear if projected on a cylinder wrapped around the earth.
Ellipsoid	An approximation of the shape of the earth that does not account for variations caused by the nonuniform density of the earth.
Horizontal Datum	A horizontal datum is a mathematically balanced model of actual measured horizontal positions on the earth. NAD27 and NAD83 are examples of a horizontal datum.
Geoid	A geoid is a surface that approximates the mean ocean surface level. It is often referred to as a close representation of the physical shape of the earth.
Vertical Datum	A vertical datum is a mathematically balanced model of actual measured vertical (elevation) measurements on the earth and uses a geoid model for balancing.
Universal Transverse Mercator Coordinate System	The UTM coordinate system was developed by the U.S. Department of Defense and subdivides the world into 60 narrow 6-degree longitudinal zones, which are projected onto a Transverse Mercator projection.
State Plane Coordinate System	The State Plane Coordinate System divides all fifty states of the United States, Puerto Rico, and the U.S. Virgin Islands into over 120 numbered zones. Each zone is mapped into its own coordinate system, which may use different projections depending on the shape and size of the zone.
Ground and Grid Coordinates	Ground level distances and coordinates are measurements made directly on the surface of the earth. Grid distances are calculations made on a map projection, or a grid surface. A scale factor is used to resolve the differences between ground measurements and grid measurements.

Exercise 1: Assign a Coordinate System to a Drawing

In this exercise, students assign a coordinate system to the drawing. By assigning the coordinate system, data in different systems can be used together.

For this exercise, open *…\I_Geodetics-EX1.dwg (M_Geodetics-EX1.dwg).*

Exercise 2: Assign a Coordinate System to Data

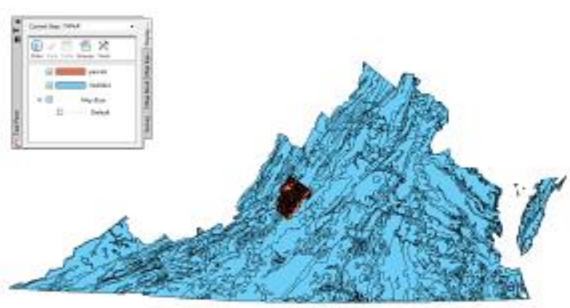
In this exercise, students assign a coordinate system to a data source. By assigning the coordinate system to the data, Civil 3D can interpret the coordinate system correctly.

For this exercise, open *…\I_Geodetics–EX2.dwg (M_Geodetics–EX2.dwg).*

Exercise 3: Assemble Data from Multiple Coordinate Systems

In this exercise, students assemble data that resides in different coordinate systems.

At the end of this exercise, the drawing displays as shown.



For this exercise, open *…\I_Geodetics–EX3.dwg (M_Geodetics–EX3.dwg).*

Assessment

Challenge Exercise

Instructors provide a master or challenge exercise for students to do based on this lesson.

Questions

1. What is the name of the coordinate system that is used to measure planar geometry using an X axis and a Y axis?
2. What three measurements indicate the position on a polar coordinate system?
3. What type of map projection is most commonly used to create world maps?
4. What is the most common type of polar coordinate system?
5. Why are mapping projections used?
6. What two methods are used to assign a coordinate system to a Civil 3D drawing?

Answers

1. The Cartesian coordinate system.
2. Angle relative to the Equator, angle relative to the prime meridian, and distance from the pole (center of the earth).
3. The Mercator projection.
4. Latitudes and longitudes.
5. Mapping projections are used to map features from the curved surface of the earth to flat surfaces, such as maps using a Cartesian coordinate system.
6. First, you can use the Drawing Settings dialog box in Civil 3D Toolspace. Another method uses the Assign Global Coordinate Systems command.

Lesson Summary

In this lesson, students learned about basic geodesy, including projections, datums, and coordinate systems. Then students used this knowledge to assign a coordinate system to a drawing. Students connected to a vector data layer and discovered how to assign a coordinate system to the data layer. Finally, students assembled data using different coordinate systems into the same drawing. It is important to understand the geospatial reference for all data layers in order to properly display the data together.