Chapter 2

Setting Coordinate System and Creating Georeferencing

Learning Objectives

After completing this chapter, you will be able to:

- *Understand the geographic coordinate system*
- *Learn about different types of map projections*
- *Learn about commonly used map projections*
- *Understand the projected coordinate system*
- *Understand the geocoding toolbar*
- *Understand the georeferencing toolbar*

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INTRODUCTION

A geographic information system (GIS) is a conceptualized framework that provides ability to capture and analyze real world geographic data. GIS uses maps as input and output of geographic data.

The GIS users work with map features on a plane surface. These map features represent spatial features of the surface of the earth. The features located at different places on the map are based on a plane coordinate system expressed in *x* and *y* coordinates, whereas the spatial features located on the Earth's surface are based on a geographic coordinate system expressed in longitude and latitude values. But the locations of real-world features are based on three-dimensional (3D) geographic coordinate system (GCS) in terms of latitude, longitude, and altitude.

For the GIS analyst to make use of the simple spatial entities (point, lines and areas), it is necessary to locate them in two dimensions. To achieve this, the analyst, like the cartographer, must treat the world as a flat surface. The method by which the curved earth's surface is laid flat is known as map projection.

SETTING GEOGRAPHIC COORDINATE SYSTEM

Ribbon:	Geographic Coordinate System > World > WGS 1984 (world)

A geographic coordinate system is a system that uses latitude and longitude to define locations on the spherical surface of the globe, refer to Figure 2-1. Latitude is the angular distance, in degrees, minutes, and seconds of a point north or south of the Equator. Lines of latitude are often referred as parallels. Longitude is the angular distance, in degrees, minutes, and seconds, of a point east or west of the Prime (Greenwich) Meridian. Lines of longitude are often referred as meridians, refer to Figure 2-1. All imaginary circles perpendicular to the Equator are called meridians of longitudes. These circles have the same center, which is also the center of the earth. The Prime Meridian which passes through Greenwich, England, is used as the zero line from which the measurements are made in degrees east and west to 180°½. Meridians are therefore used for measuring location in the E-W direction.

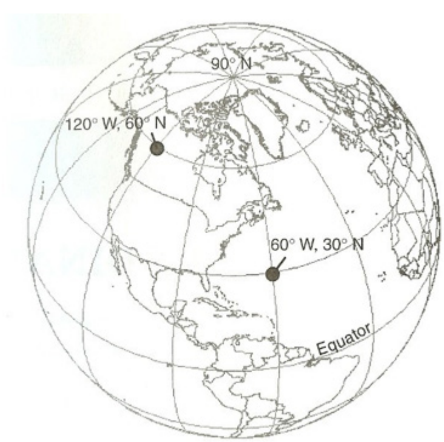

Figure 2-1 *The geographic coordinate system*

All imaginary circles parallel to the Equator are called parallels of latitudes. These circles have varying center and all these central points lie on the same line that is the axis of the earth. Using the equator as 0° latitude, you can measure the latitude value of a point as 0° to 90° north or south of the equator. Parallels are therefore used for measuring location in the N-S direction. A point location denoted by (120° W, 60° N) means that it is 120° west of the prime meridian and 60° north of the equator.

The prime meridian and the equator serve as baselines of the geographical coordinate system. The geographic coordinates are therefore like plane coordinates: longitude values are equivalent to *x* values and latitude values are equivalent to *y* values. Also, it is conventional in GIS to enter longitude and latitude values with positive or negative signs. Longitude values are positive in the eastern hemisphere and negative in the western hemisphere. Latitude values are positive toward the north of the equator, and negative toward the south of the equator.

To set the geographic coordinate system, right-click on **Layers** in **Table of Contents**; a menu is displayed. Choose **Properties** from the menu; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose the **Coordinate System** tab, expand **Geographic Coordinate System**, and then expand **World**. Next, select **WGS 1984** which is specified according to the specified latitude and longitude and then click on the **Apply** button and then the **OK** button.

PERFORMING DIFFERENT TYPES OF MAP PROJECTIONS

The types of map projections can be grouped by either the preserved property or the projection surface. There are hundreds of map projections used throughout the world. Out of the hundreds of map projections, some common types of map projections used are conformal, equal area or equivalent and azimuthal or true direction which is described below. A conformal projection preserves local shape. To preserve individual angles describing the spatial relationships, a conformal projection must show perpendicular graticule lines intersecting at 90° angles on the map. No map projection can preserve shapes of larger regions. The equivalent projection represents areas in correct relative size. The equidistant projection preserves the distances between certain points. Scale is not maintained correctly by any projection throughout an entire map. The azimuthal projection retains certain accurate directions.

Some of the important types of projections are cylindrical projection, conical projection, and azimuthal projection.

Projecting a Cylindrical Projection

Ribbon:	Projected Coordinate System > World > Equidistant Cylindrical (world)

Cylindrical projections, also known as mercator projections, are the projections which project a spherical surface onto a cylinder, refer to Figure 2-2. In such projections, graticule is prepared on the surface of a hollow cylinder. Graticule is a grid of intersecting meridians and parallels on a cylindrical surface. The cylinder is cut along any meridian to produce the final cylindrical projection. The meridian opposite the cut-line becomes the central meridian. The meridians are equally spaced whereas the spacing between parallel lines of latitude increases towards the poles. This projection is conformal and displays true direction along straight lines.

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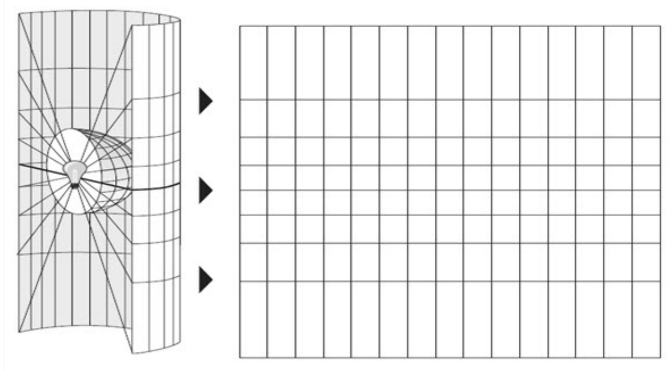

Figure 2-2 *Cylindrical projection*

To project the equidistant cylindrical projection, right-click on **Layers** in **Table of Contents**, a menu is displayed. Choose **Properties** from the menu; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose the **Coordinate System** tab, expand **Projected Coordinate System**, and then expand **World**. Next, select **Equidistant Cylindrical (world)** after that click on **Apply** button and then on the **OK** button. On doing so, the coordinate system is added to the **Current coordinate system** area and the projection is added to the data view area, as shown in Figure 2-3.

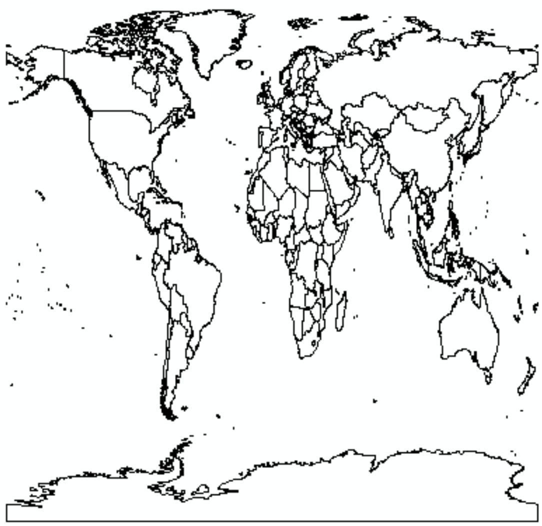

Figure 2-3 *Equidistant cylindrical projection added to the data view area*

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Projecting a Conical Projection

Ribbon:	Projected Coordinate System > World > Equidistant Conic (world)

Conical projection is formed by projecting a spherical surface onto a cone, refer to Figure 2-5. This projection can represent one hemisphere or a portion of one hemisphere. The cone does not extend far beyond the center of the sphere. The most simple conic projection is tangent to the globe along a line of latitude. This line is called the standard parallel. The meridians are projected onto the conical surface, meeting at the point, of the cone. Parallel lines of latitude are projected onto the cone as rings. The cone is then cut along any meridian to produce the final conic projection, which has straight converging lines for meridians and concentric circular arcs for parallels. The meridian opposite the cut line becomes the central meridian. Generally, a secant projection has less overall distortion than a tangent case. In a complex conic projection, the axis of the cone does not line up with the polar axis of the globe. Such projections are called oblique.

In a tangential projection, refer to Figure 2-4, a cone is placed over a globe. The cone and globe meets along a latitude line. This is the standard parallel. The cone is cut along the line of longitude that is opposite the central meridian and flattened into a plane.

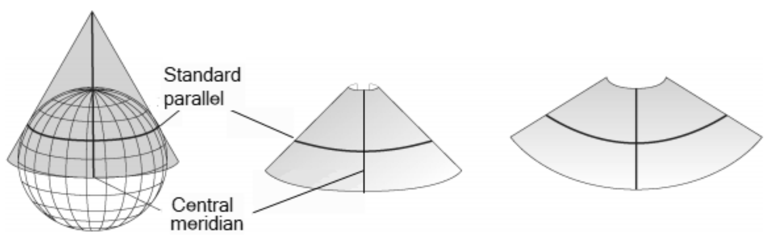

Figure 2-4 *Tangent conical projection*

In secant projection, refer to Figure 2-5, a cone is placed over a globe but cuts through the surface. The cone and globe meets along two latitude lines. These are the standard parallels. The cone is cut along the line of longitude that is opposite the central meridian and flattened into a plane.

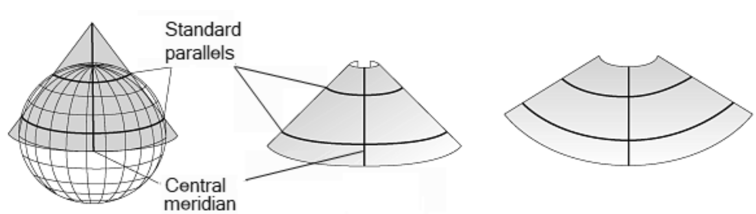

Figure 2-5 *Secant conical projection*

To project the equidistant conic projection, right-click on **Layers** in **Table of Contents**; a menu is displayed. Choose **Properties** from the menu; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose the **Coordinate System** tab, expand **Projected Coordinate System**, and then expand **World**. Next, select **Equidistant Conic (world)** and then choose the **Apply** button and then on the **OK** button; the coordinate system is added to the **Current coordinate system** area and the projection is added to the data view area, as shown in Figure 2-6.

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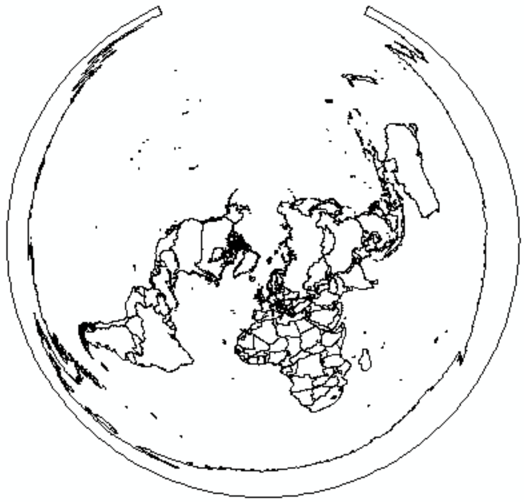

Figure 2-6 Equidistant conic projection added to the data view area

Note
The concept of two parallels for secant case is applicable for cylindrical projections as well in same concept, but unlike conical projections, they have same radius.

Projecting an Azimuthal Projection

Ribbon:	Projected Coordinate System > World > Azimuthal Equidistant (world)

Azimuthal projection is formed from projecting a spherical surface onto a plane. This projection is also known as planar projection or zenithal projection.

To project an azimuthal equidistant projection, right-click on **Layers** in **Table of Contents**; a menu is displayed. Choose **Properties**; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose the **Coordinate System** tab, expand **Projected Coordinate System**, and then expand **World**. Now select **Azimuthal Equidistant (world)** and then choose the **Apply** button and then on the **OK** button; the coordinate system is added to the **Current coordinate system** area and the projection is added to the data view area shown in Figure 2-7.

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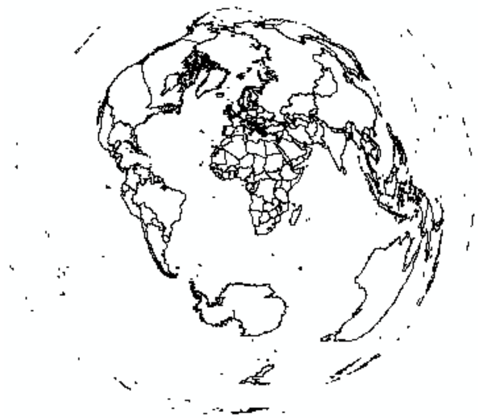

Figure 2-7 *Azimuthal equidistant projection added to the data view area*

Planar projection basically projects map data onto a flat surface touching the globe. The flat surface touching the globe is usually tangent to the globe at one point. The point of contact may be the North Pole, the South Pole, a point on the equator, or any point in between. This point specifies the aspect and is the focus of the projection. The focus is identified by a central longitude and a central latitude. Possible aspects are polar, equatorial, and oblique, refer to Figure 2-8.

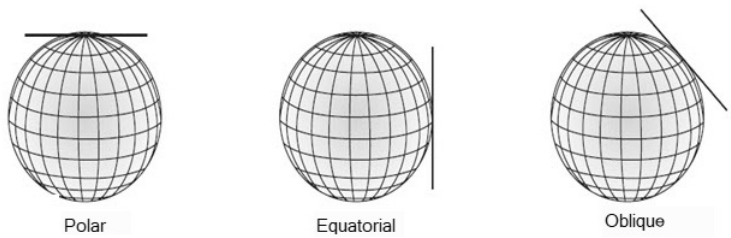

Figure 2-8 *Polar, equatorial, and oblique projection*

The figure below compares three planar projections with polar aspects but different perspectives. The Gnomonic projection, Stereographic projection, and Orthographic projection are the three planar projections. All the three projections have difference types of distortion toward the equator, refer to Figure 2-9.

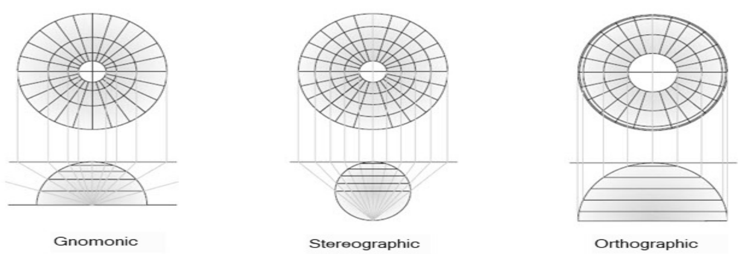

Figure 2-9 *Types of azimuthal projection based on focus perspective point*

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Projecting the Gnomonic Projection

Ribbon: Projected Coordinate System > Polar > North Pole Gnomonic
Projected Coordinate System > Polar > South Pole Gnomonic

The gnomonic projection views the surface data from the center of the earth. In this projection type, there is distortion in the equator.

To project gnomonic projection, right-click on **Layers** in **Table of Contents**; a menu is displayed. From the menu, choose the **Properties** option; the **Data Frame Properties** dialog box is displayed. In this dialog, a menu is displayed. From the menu, choose the **Properties** option; the **Coordinate System** tab, expand **Projected Coordinate System**, and then expand **Polar**. For the north pole, select **North Pole Gnomonic** and for the south pole. Select **South Pole Gnomonic** in the polar node. Next, click on the **Apply** button and then the **OK** button; the coordinate system is added to the **Current coordinate system** area and the projection is added to the data view area.

Projecting the Stereographic Projection

Ribbon: Projected Coordinate System > Polar > North Pole Stereographic
Projected Coordinate System > Polar > South Pole Stereographic

The stereographic projection views it from pole to pole and also there is distortion towards the equator.

To project stereographic projection, right-click on **Layers** in **Table of Contents;** a menu is displayed. From the menu, choose the **Properties** option; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose the **Coordinate System** tab, expand **Projected Coordinate System**, and then expand **Polar**. For the north pole, select **North Pole Stereographic** and for the south pole, select **South Pole Stereographic** in the polar node. Next, choose the **Apply** button and then the **OK** button; the coordinate system is added to the **Current coordinate system** area and the projection is added to the data view area.

Projecting Orthographic Projection

Ribbon: Projected Coordinate System > Polar > North Pole Orthographic
Projected Coordinate System > Polar > South Pole Orthographic

The Orthographic projection views the earth from an infinite point, as if viewed from deep space. Also there is distortion as you move towards equator.

To project an orthographic projection, right-click on **Layers** in **Table of Contents**; a menu is displayed. From the menu, choose the **Properties** option; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose the **Coordinate System** tab, expand **Projected Coordinate System**, and then expand **Polar**. Next, for the north pole, select **North Pole Orthographic** and for the south pole, select **South Pole Orthographic** in the polar node. Choose the **Apply** button and then on **OK** button; the coordinate system is added to the **Current coordinate system** area and the projection is added to the data view area.

PERFORMING COMMONLY USED MAP PROJECTIONS

There are numerous projection systems adopted to project the surface of earth on to a 2D plane to create maps. Transverse mercator projection, polyconic projection, lambert azimuthal equal-area projection are some of the commonly used map projections and have been explained next to provide a better understanding of the concepts.

Projecting Transverse Mercator Projection

Ribbon: Projected Coordinate System > World > Mercator (world)

Transverse mercator projection is one of the most commonly used projections. Transverse Mercator projection contains straight meridians and parallels that intersect at right angles, refer to Figure 2-10.

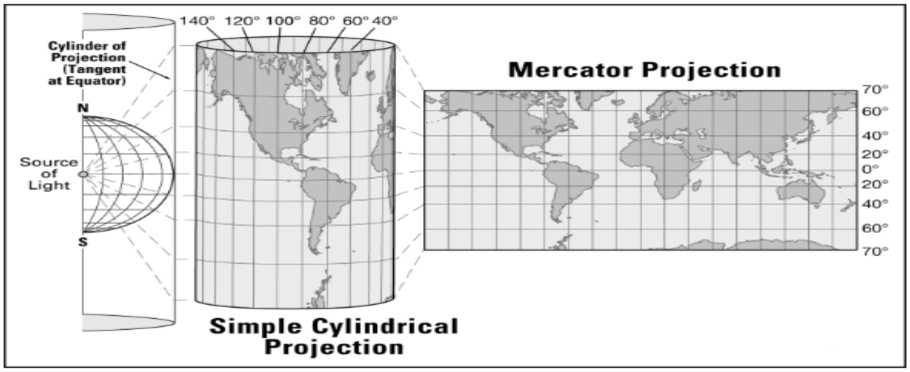

Figure 2-10 *Mercator projection*

Transverse Mercator projection forms by 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 from the central meridian. Many national grid systems are based on Transverse Mercator projection. A line parallel to and midway between the secants is often called central meridian. Central meridian extends north and south through transverse mercator projections.

To set the coordinate system to mercator projection, right-click on **Layers** in **Table of Contents**; a menu is displayed. Choose **Properties** from the menu; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose the **Coordinate System** tab, expand **Projected Coordinate System**, and then expand **World** and select **Mercator (world)** in the world node. Next, choose the **Apply** button and then the **OK** button; the coordinate system is added to the **Current coordinate system** area and the projection is added to the data view area, as shown in Figure 2-11.

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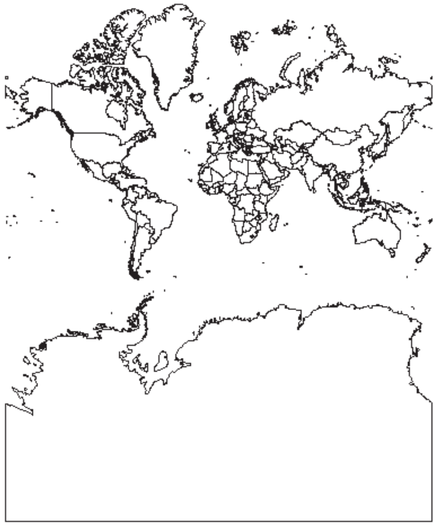

Figure 2-11 *Mercator projection added to the data view area*

Projecting a Polyconic Projection

Ribbon:	Projected Coordinate System > World > Polyconic (world)

Polyconic projection is the second most commonly used projection. The word polyconic means many cones and refers to the projection methodology. This system is more complex than the regular conic projections. This projection is created by lining up an infinite number of cones along the central meridian. Central meridian on the map is straight and all the others are slightly curved and not quite parallel. Similarly, the parallels are slightly curved and not quite parallel; therefore, they are not precisely perpendicular to the meridians. An example of a polyconic map projection, as shown in Figure 2-12.

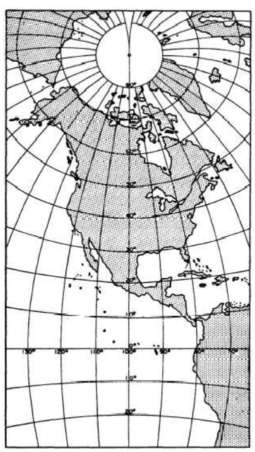

Figure 2-12 *Polyconic projection*

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Basically polyconic projection preserves the area, shape, distance, and azimuth for small areas. Polyconic projection best for north-south extents; the scale increase away from the central meridian and it is applied for topographic maps. It is generally considered that the scale distortion is acceptable only up to 9° which is away from the central meridian. It is not recommended for larger areas because of distortion.

To set the polyconic projection, right-click on **Layers** in **Table of Contents**; a menu is displayed. Choose **Properties** from the menu; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose the **Coordinate System** tab, expand **Projected Coordinate System**, and then expand **World**. In world node, select **Polyconic (world)** and then choose the **Apply** button and **OK** button. The coordinate system is added to the **Current coordinate system** area. Also, the projection is added to the data view area, as shown in Figure 2-13.

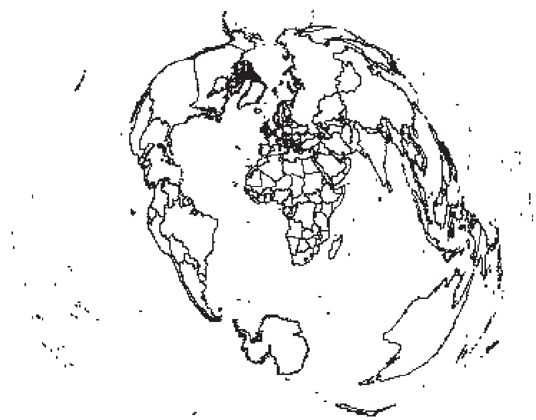

Figure 2-13 *Polyconic projection is added to the data view area*

Projecting Lambert's Azimuthal Equal-area Projection

Ribbon:	Projected Coordinate System > Polar > North Pole Lambert's Azimuthal Equal-area Projection Projected Coordinate System > Polar > South Pole Lambert's Azimuthal Equal-area Projection

Lambert azimuthal equal-area projection is the third most commonly used projection. This projection was first presented by Johann Heinrich Lambert (1728-77) of Alsace in 1772. It is an azimuthal, equal-area projection, but is not perspective. This map projection is one of the most popular projections used in atlases to map large areas such as an entire country, polar area, oceanic mapping, and many more. This projection can accommodate all aspects of azimuthal projection, that is equatorial, polar, and oblique.

This projection distorts shape minimally. Area is equal, distortion is zero at the center of the projection, and increases radially away from this point. Only the center is free from distortion. Distortion is moderate for one hemisphere but becomes extreme for a map of the entire earth.

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Meridians are equally spaced lines intersecting at the poles, as shown in Figure 2-14. Parallels are unequally spaced circles, centered at the pole. Spacing of the circles in parallels gradually decreases away from the poles. Central meridian is a straight line. Other meridians are complex curves, unequally spaced along the equator and intersecting at each pole.

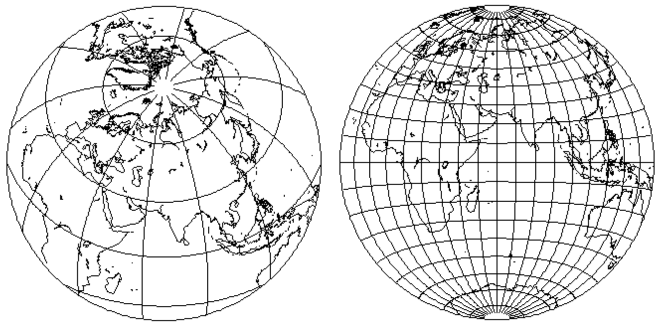

Figure 2-14 *Lambert azimuthal equal-area projection*

Lambert azimuthal equal-area projection is used to project both the north and south poles. To do so, right-click on **Layers** in **Table of Contents**; a menu is displayed. From the menu, choose **Properties**; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose the **Coordinate System** tab, expand **Projected Coordinate System**, and then expand **Polar**. For north pole, select **North Pole Lambert's Azimuthal Equal-area Projection** and for south pole, select **South Pole Lambert's Azimuthal Equal-area Projection** in the polar node. Choose the **Apply** button and then the **OK** button. Both the coordinate systems are added to the **Current coordinate system** area and to the data view area. The figure at the right is the North Pole Lambert azimuthal equal-area projection and the figure on the left is the South Pole Lambert azimuthal equal-area projection, as shown in Figure 2-15.

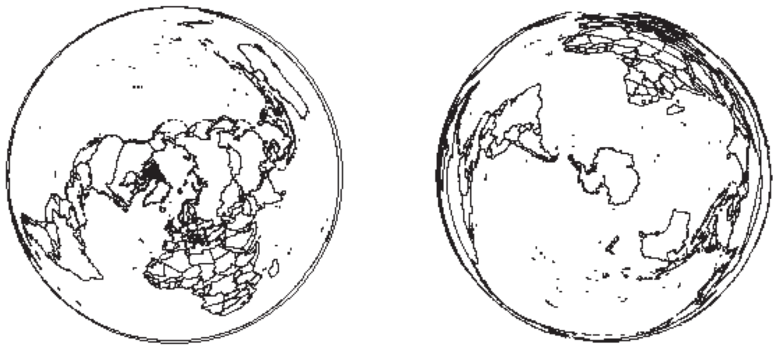

Figure 2-15 *Lambert azimuthal equal-area projection added to the data view area*

SETTING PROJECTED COORDINATE SYSTEM

A projected coordinate system is defined on a flat, two dimensional surface. Unlike a geographic coordinate system, a projected coordinate system has constant lengths, angles, and areas across the two dimensions. A projected coordinate system is always based on a geographic coordinate

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system. Projected coordinate system, also called a plane coordinate system, is built on a map projection.

In projected coordinate system, location are identified by *x*, *y* coordinates on a rectangular grid, with the origin at the center of the grid. Each position has two values that refer to its central location. One specifies its east-west position and the other specifies the north-south position. The two values are called the *x*-coordinate and the *y*-coordinate. The coordinate at the origin are $x = 0$ and $y = 0$. Horizontal lines above the origin and vertical lines to the right of the origin have positive values; those below or to the left have negative values. The four quadrants represent the four possible combinations of positive and negative *x* and *y* coordinates.

To set the projected coordinate system to particular map, right-click on **Layers** in **Table of Contents**; a menu is displayed. From the menu, choose **Properties**; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose **Coordinate System** tab, expand **Projected Coordinate System**, and then select the projected coordinate system according to the location.

Note

A geocentric coordinate system has its origin at the center of the earth ellipsoid. The z-axis equals the rotational axis of the earth, and the x-axis passes through the Greenwich meridian. The y-axis is perpendicular to both z-axis and x-axis, so as to create a 3D coordinate system that follows the right-hand rule.

A topocentric coordinate system has its origin at the center of the center of the map projected on the earth ellipsoid. The three perpendicular coordinate axes are defined on a tangential plane on a center point. The plane is called the reference plane or the local datum. The x-axis is oriented eastward, the y-axis northward, and the z-axis is vertical to the reference plane (up).

Universal Transverse Mercator (UTM) grid system, and Universal Polar Stereographic (UPS) grid system are some of the projected coordinate system which are discussed in the next section.

Setting Universal Transverse Mercator (UTM) Grid System

Ribbon: Projected Coordinate System > UTM > NAD 1927
Projected Coordinate System > UTM > NAD 1983
Projected Coordinate System > UTM > WGS 1984 > Northern Hemisphere
Projected Coordinate System > UTM > WGS 1984 > Southern Hemisphere

The Universal Transverse Mercator (UTM) system is a specialized application of the transverse mercator projection. The UTM coordinate is commonly used in GIS because it has been included since the late 1950s on most USGS topographic maps. The choice of the transverse mercator is probably now used more than any other projection for accurate mapping.

Used worldwide, the UTM grid system divides the surface of the earth between 84° N and 80° S into 60 zones. Each zone covers 6° of longitude and is numbered sequentially with zone 1 beginning at 180° W. Each zone is further divided into the northern and southern hemispheres. The designation of a UTM zone therefore carries a number and a letter. For example, UTM

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Zone 10° N refers to the zone between 126° W and 120° W in the northern hemisphere. The UTM zones in the conterminous United States, as shown in Figure 2-16.

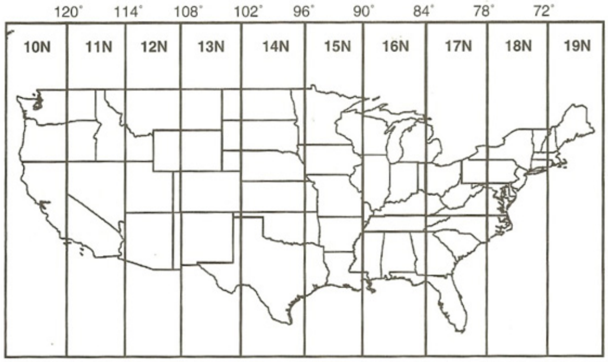

Figure 2-16 *Lambert azimuthal equal-area projection*

The datum is part of the definition of a projected coordinate system, the UTM grid system may be based on NAD27, NAD83, or WGS84. To set the UTM projection that may be NAD27, or NAD83, or WGS84 according to the specified zone, right-click on **Layers** in **Table of Contents**; a menu is displayed. From the menu, choose **Properties**; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose **Coordinate System** tab, expand **Projected Coordinate System**, and then expand **UTM**. To project UTM grid system according to NAD 1927 and zone expand **NAD 1927**. After that select **NAD 1927 UTM Zone 6N** or choose other option based on the zone. Similarly to project UTM grid system according to NAD 1983 and zone, expand **NAD 1983** and then select **NAD 1983 UTM Zone 9N** or choose other options based on the zone. To project UTM grid system according to WGS 1984, hemisphere and zone, expand **WGS 1984**. Next, expand **Northern Hemisphere** and select **WGS 1984 UTM Zone 10N** or choose other option based on the zone. Also, for southern hemisphere, expand **Southern Hemisphere** and then select **WGS 1984 UTM Zone 10S** or choose other option based on the zone. After selecting UTM grid system, choose the **Apply** button and then the **OK** button. The projection is added to the data view area.

Setting Universal Polar Stereographic (UPS) Grid System

Ribbon: Projected Coordinate System > Polar > UPS North
Projected Coordinate System > Polar > UPS South

The stereographic projection is centered on the pole and is used for dividing the polar area into a series of 100,000-meter squares, similar to the UTM grid system. The Universal Polar Stereographic (UPS) grid system covers the polar areas. To do so, right-click on **Layers** in **Table of Contents**; a menu is displayed. Choose **Properties** from the menu; the **Data Frame Properties** dialog box is displayed. In this dialog box, choose the **Coordinate System** tab, expand **Projected Coordinate System**, and then expand **Polar**. For north pole, select **UPS North** in polar node and for south pole, select **UPS South** in polar node then choose the **Apply** button and then the **OK** button. The coordinate system is added to the **Current coordinate system** area. Also, the projection is added to the data view area, as shown in Figure 2-17.

Figure 2-17 *Universal polar stereographic projection added to the data view area*

DISPLAYING GEOCODING TOOLBAR

Ribbon: Customize > Toolbars drop-down > Geocoding

Geocoding toolbar is used to assign spatial locations to data that are in tabular format but have fields that describe their locations. Once you have created an address locator, you can begin using it to geocode addresses. However, understanding how an address locator prepares the input address data, searches the address attributes, and matches addresses as well as knowing how modifying an address locator's settings affects this process can help you improve both the performance and accuracy of geocoding.

Geocoding toolbar contains all the tools that are used for geocoding. To display the geocoding toolbar, click on **Customize**; a menu is displayed. Choose **Toolbars** from the menu, and then choose **Geocoding** from another menu; the **Geocoding** toolbar is displayed, refer to Figure 2-18.

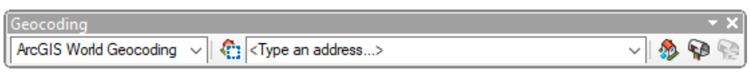

Figure 2-18 Geocoding *toolbar from the* ***Toolbar*** *menu*

DISPLAYING GEOREFERENCING TOOLBAR

Ribbon: Customize > Toolbars drop-down > Georeferencing

Georeferencing toolbar is used to assign geographic coordinate from a reference system, such as latitude and longitude. The registration process involves fitting one raster with another so that overlay of multiple data layers can be obtained. This is often required to match data of different scales or resolutions.

Georeferencing toolbar contains all the tools that are used for georeferencing. To display the georeferencing toolbar, click on **Customize** menu bar; a menu is displayed. Choose **Toolbars** from the menu, and then choose **Georeferencing** from another menu, the **Georeferencing** toolbar is displayed, refer to Figure 2-19. The most common tools used from the georeferencing toolbar are **Control Points** and **View Link Table**.

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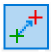
Figure 2-19 *The **Georeferencing** toolbar*

Control Points Tool



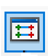
Control Points play a key role in determining the accuracy of an affine transformation. An affine transformation requires a minimum of three control points to estimate its six coefficients. But often four or more control points are used to reduce problems with measurement errors and to allow for a least-squares solution. After the control points are selected, they are digitized along with map features onto the digitized map.

Control points for an image-to-map transformation are usually called ground control points (GCPs). Ground control points are points where both image coordinates (in columns and rows) and real-world coordinates can be identified.

GCP are selected directly from a satellite image. Therefore the selection is not as straight forward as selecting four tics for digitized map. Ideally, GCPs are those features that show up clearly as single distinct pixels. Examples include road intersections, small ponds, or distinctive features along shorelines.

To invoke control points, choose the **Control Points** tool from the **Georeferencing** toolbar and then add control points to the shapefile and then to the image.

View Link Table Tool



The root mean square (RMS) error represents the difference between the original control points and the new control point location calculation by the transformation process. The transformation scale indicates how much the map being digitized will be scaled to match the real-world coordinates.

To maintain highly accurate geographic data, the RMS error should be kept under 0.004 inches (or its equivalent measurement in the coordinate system being used). For less accurate data, the value can be as high as 0.008 inches or its equivalent measure.

Common causes of high RMS error are incorrectly digitized control points, careless placement of control points on the map sheet, and digitizing from a wrinkled map. To get more accurate results while digitizing a control point, check that the crosshairs of the digitizer remain centered on the control point.

To get the root mean square (RMS) error, choose the **View Link Table** tool from the **Georeferencing** toolbar; the **Link** dialog box is displayed. In this dialog box, all the RMS error are added. You can also remove the control point which has highest RMS Error.

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TUTORIAL

Before starting the tutorial, you need to download and save the tutorial files on your computer. To do so, follow the steps given below:

1. Log on to *www.cadcim.com* and browse to *Textbooks > Civil/GIS > ArcGIS > Exploring ArcMap 10.5*. Next, select *c02_Arc_Map_10.5_tut.zip* file from the **Tutorial Files** drop-down list. Choose the corresponding **Download** button to download the data file.

2. Now, save and extract the downloaded folder to the following location:

   C:\Arc_Map_10.5

Tutorial 1 Georeferencing image to map

In this tutorial, you will create the control points from the **Georeference** toolbar and save the scanned map to raster image. **(Expected time: 30 min)**

The following steps are required to complete this tutorial:

a. Open ArcMap.
b. Set the data frame.
c. Open the files.
d. Georeference the files.
e. Save the file.

Starting ArcMap

1. Open ArcMap.

   When the ArcMap software is opened, the **ArcMap - Getting Started** dialog box is displayed, refer to Figure 2-20.

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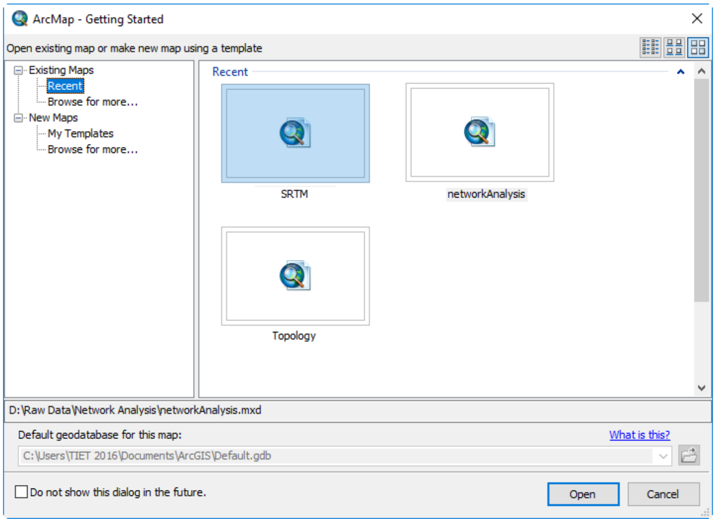

Figure 2-20 *The* ***ArcMap - Getting Started*** *dialog box*

2. Choose the **Cancel** button in the **ArcMap - Getting Started** dialog box to open a new blank ArcMap document.

Setting the Data Frame

1. In the **Table of Contents**, right-click on the layer icon; a menu appears. Choose the **Properties** option from the menu; the **Data Frame Properties** dialog box is displayed, as shown in Figure 2-21.

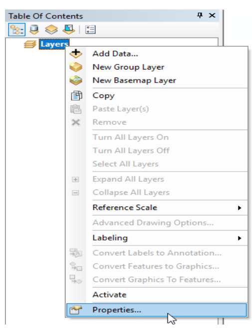

Figure 2-21 *Choosing the* ***Properties*** *option from* ***Table of Contents*** *window*

2. In this dialog box, select the **Coordinate System** tab and that choose **Geographic Coordinate >World >WGS 84** and then choose the **OK** button, refer to Figure 2-22. The **Data Frame Properties** dialog box is closed and the data frame is set.

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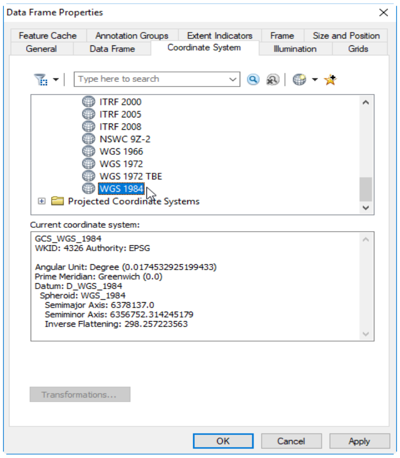

Figure 2-22 *Selecting* ***WGS 84*** *coordinate from the* ***Coordinate System*** *tab in the* ***Data Frame Properties*** *dialog box*

Opening the Files

1. Choose the **Add Data** tool in the **Standard** toolbar; the **Add Data** dialog box is displayed, as shown in Figure 2-23.

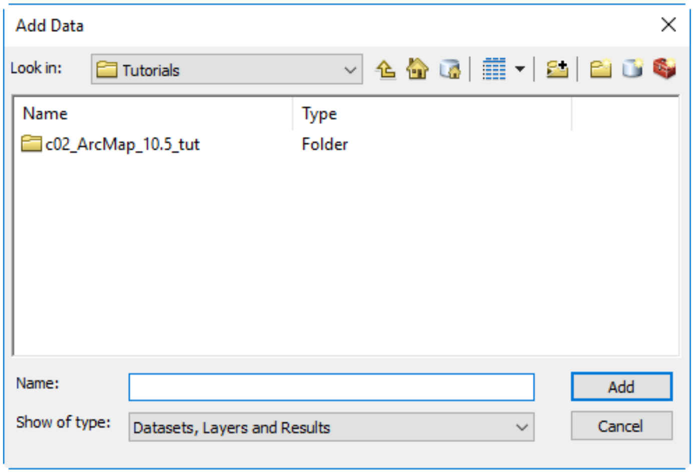

Figure 2-23 *The* ***Add Data*** *dialog box*

2. In this dialog box, browse to the location *C:\Arc_Map_10.5\c02_Arc_Map_10.5_tut*. Next, select the two files *c02_Arc_Map_10.5_tut01.shp* and *c02_Arc_Map_10.5_tut01.jpg*.

3. Choose the **Add** button; the **Unknown Spatial Reference** warning box is displayed. Choose the **OK** button to open the file, as shown in Figure 2-24.

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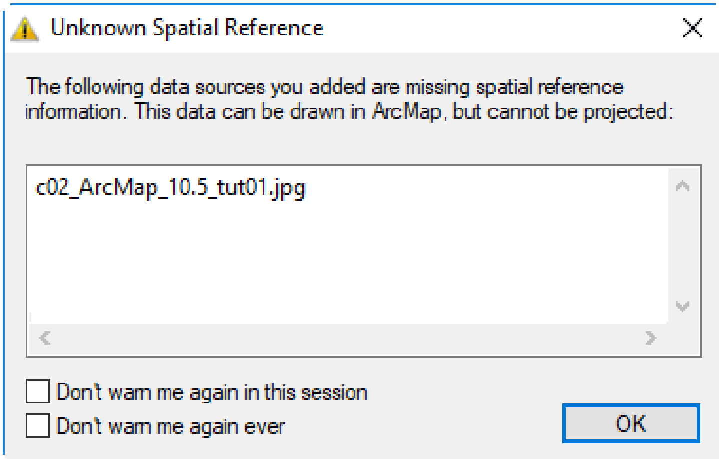


Figure 2-24 The ***Unknown Spatial Reference*** *warning box*

The opened drawing file consists of a shapefile and jpg file.

Georeferencing the File

1. In the **Georeference** toolbar, click the drop- down in the **Georefrence** tool. Choose the **Fit to Display** option from the menu, as shown in Figure 2-25.

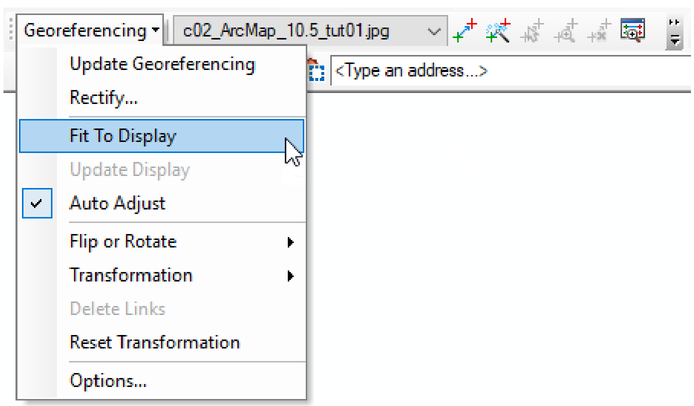
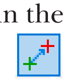


***Figure 2-25 Choosing** the **Fit to Display** option from the **Georeferencing** toolbar*

Tip
*If the **Georeferencing** toolbar is not displayed then click on **Customize > Toolbars > Georeferencing**. The drop-down menu in the **Georeferencing** toolbar should display the filename of the raster file added to the map document.*

2. Next identify an area where it could be a good ground control point and then zoom in the map. Next, choose the **Add Control Points** tool from the **Georeferencing** toolbar and start adding control points. 

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3. Click the first control point on the scanned map and then on the referenced map, as shown in Figure 2-26.

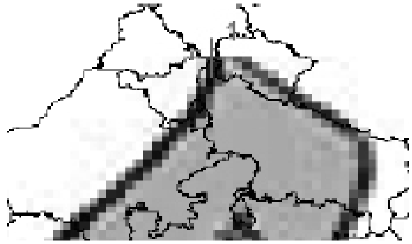


***Figure 2-26** An example showing the control point created*

4. Repeat the procedure given in steps 2 to 3 and add control points until the scan map fits the referenced map, as shown in Figure 2-27.

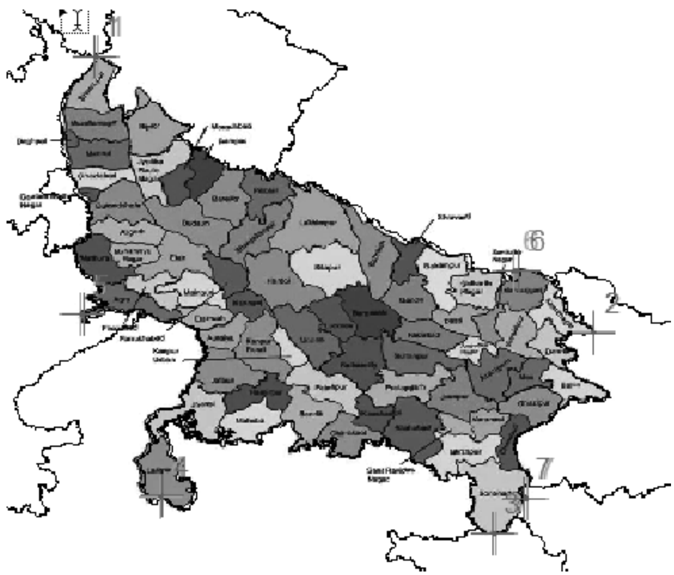
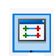
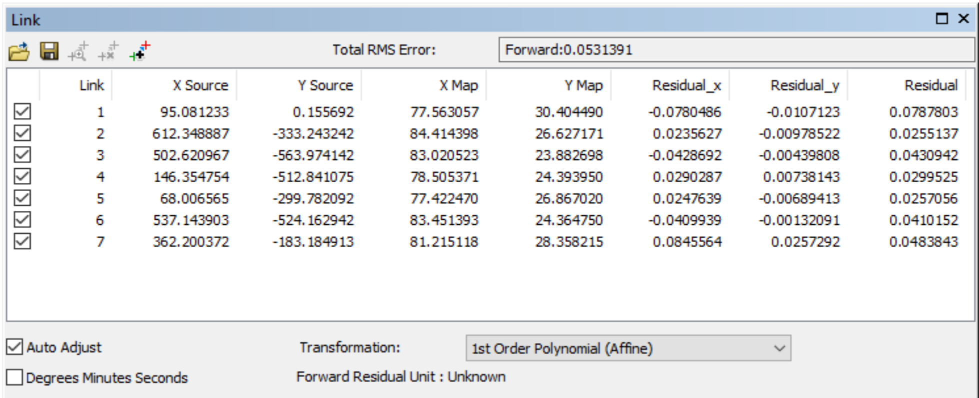


***Figure 2-27** All the control points created*

5. In order to view the errors of the control point, choose the **View Link Table** tool from the **Georeferencing** toolbar; the **Link** dialog box is displayed, as shown in Figure 2-28. 

Evaluation Copy. Do not reproduce. For information visit www.cadcim.com



Link	X Source	Y Source	X Map	Y Map	Residual_x	Residual_y	Residual
1	95.081233	0.155692	77.563057	30.404490	-0.0780486	-0.0107123	0.0787803
2	612.348887	-333.243242	84.414398	26.627171	0.0235627	-0.00978522	0.0255137
3	502.620967	-563.974142	83.020523	23.882698	-0.0428692	-0.00439808	0.0430942
4	146.354754	-512.841075	78.505371	24.393950	0.0290287	0.00738143	0.0299525
5	68.006565	-299.782092	77.422470	26.867020	0.0247639	-0.00689413	0.0257056
6	537.143903	-524.162942	83.451393	24.364750	-0.0409939	-0.00132091	0.0410152
7	362.200372	-183.184913	81.215118	28.358215	0.0845564	0.0257292	0.0483843

Figure 2-28 *The* ***Link*** *dialog box showing the control points with RMS Error*

6. Ensure that the residuals value should be less than 1 in the **Residuals** columns in the **Link** dialog box for better ground control points. Also, to improve the georeferencing, delete the points with the highest residuals by choosing the **Delete Link** button.

Saving the File

1. In order to save the control point, choose the **Save** button; the **Save As** dialog box is displayed.

2. In this dialog box, browse to the following location:

   C:\Arc_Map_10.5\c02_Arc_Map_10.5_tut

3. In the **File name** edit box, enter **c02_tut01.** Also ensure that **text** is selected in the **Save as type** drop-down list.

Note

This file is important because if you want to change the georeferenced image later, you will still have the points that you have used and you can reload them.

4. Choose the **Save** button; the dialog box is closed and the file is saved with the name *c02_tut01.txt* at the specified location. Next, close the **Link** dialog box.

5. In order to save the actual raster image file, click on the **Georeferencing** toolbar and then select **Update Georeferencing** from the drop-down list, as shown in Figure 2-29.

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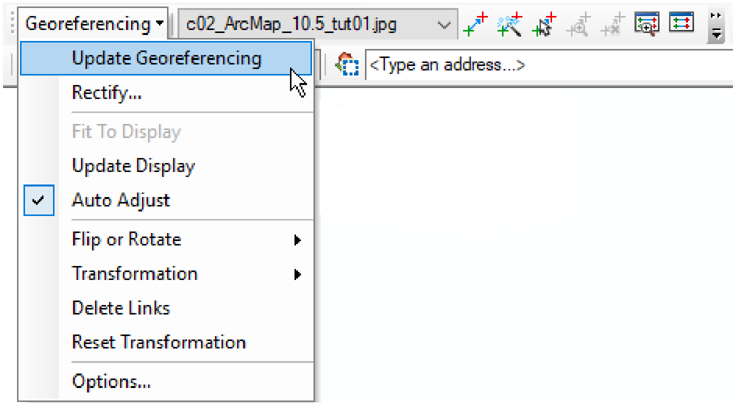

Figure 2-29 *Selecting **Update Georeferencing** option from the **Georeferencing** toolbar*

Note

*Using the **Update Georeferencing** tool will store the transformation information with the raster file, which can be internal or external depending on the type of raster dataset being used (that is for a the current raster dataset, that is a TIFF file, the transformation will be stored in what is known as a world file, with a .tfw or .tfwx extension).*

*Using the **Rectify** command will allow you to create a new raster dataset that is georeferenced using both map co-ordinates and spatial references which can be saved in a number of different formats (BIL, BIP, BMP, DAT, GIF, TIFF, ESRI GRID, IMG, JPEG, JPEG 2000, PNG). This command can be useful if you wish to perform further analysis with the raster dataset or use it in an external program that does not recognize the external georeference information created in the ArcGIS world file (example. tfwx).*

The new raster file is saved automatically at the same location, as shown in Figure 2-30.

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Figure 2-30 *New raster image is overlapped to the scanned map*

Self-Evaluation Test

Answer the following questions and then compare them to those given at the end of this chapter:

1. Azimuthal projection is also known as _________.
2. Geographic coordinate system specifies _________ and _________ of a particular area.
3. The Universal Transverse Mercator grid system divides the surface of the earth between _________ and _________ into 60 zones.
4. Cylindrical projection is formed from projecting a spherical surface onto a cone. (T/F)
5. A projected coordinate system is called a plane coordinate system. (T/F)
6. Control points for an image-to-map transformation are usually called ground control points. (T/F)

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Review Questions

Answer the following questions:

1. Which of the following projections is used for polar projection?

   a) Azimuthal projection b) Transverse Mercator projection
   c) Conical projection d) None of these

2. Which of the following transformations converts the newly digitized map into projected coordinates?

   a) Map-to-map transformation b) Geometric transformation
   c) Image-to-map transformation d) None of these

3. What is the other name of cylindrical projection?

   a) Conical projection b) Polyconic projection
   c) Mercator projection d) None of these

4. The other name of projected coordinate system is ________ which is used to build on a map projection.

5. The distortion is zero at the ________ of the projection in lambert azimuthal equal-area projection.

6. All imaginary circles perpendicular to the Equator are called __________.

EXERCISE

Before starting the exercises, you need to download and save the exercise files on your computer. To do so, follow the steps given below:

1. Log on to *www.cadcim.com* and browse to *Textbooks > Civil/GIS > ArcGIS > Exploring ArcMap 10.5*. Next, select *c02_Arc_Map_10.5_exer.zip* file from the **Exercise Files** drop-down list. Choose the corresponding **Download** button to download the data file.

2. Now, save and extract the downloaded folder to the following location:

   C:\Arc_Map_10.5

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Exercise 1

Open the *c02_Arc_Map_10.5_ex01.shp* and *c02_Arc_Map_10.5_ex01.jpg* files and add the ground control points to the scanned map and the referenced map to do georeferencing, as shown in Figure 2-31. **(Expected time: 30 min)**

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Save the control points as *c02_ex01.txt*.

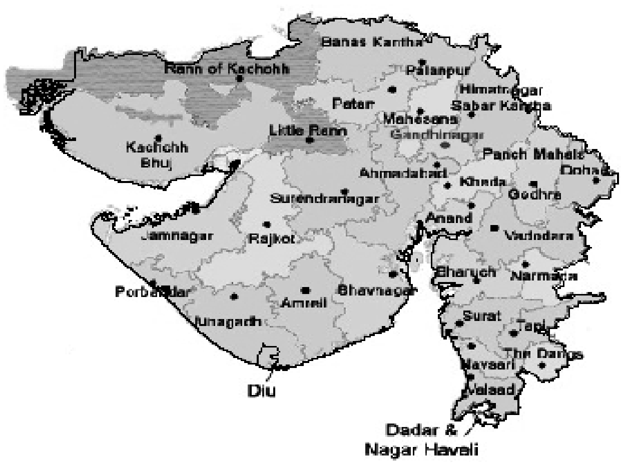

Figure 2-31 *New raster image created of the scanned map*

Answers to Self-Evaluation Test

1. zenithal projection, **2.** latitude, longitude, **3.** 84° N and 80° S, **4.** F, **5.** T, **6.** T