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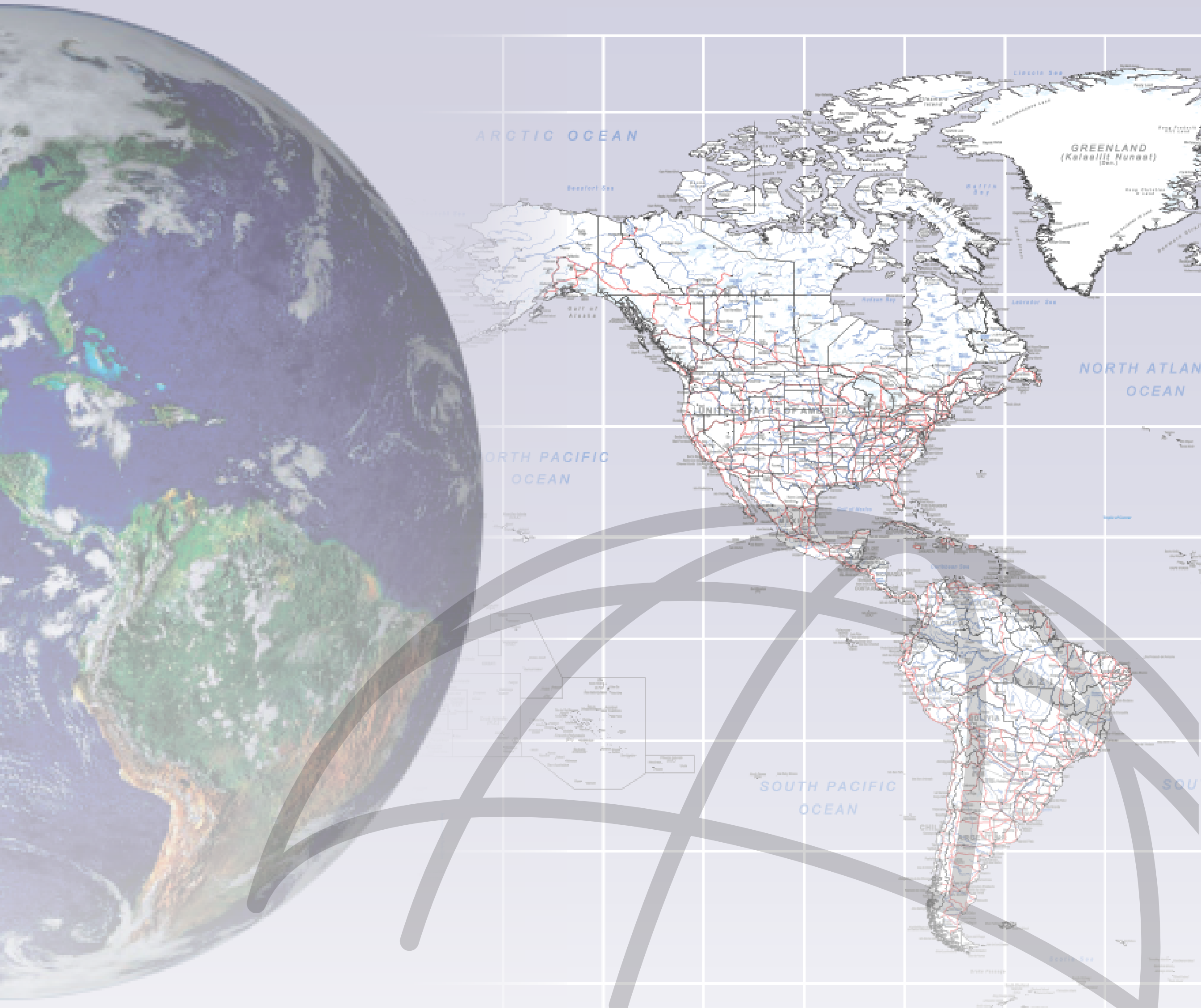
for Adobe® Illustrator®



Avenza® SYSTEMS INC.

Microsoft Windows

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Projections Guide

Avenza Projections Guide

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MAPublisher®
for Adobe® Illustrator®

When Map Quality Matters®

GEOGRAPHIC IMAGER®
for Adobe® Photoshop®

Projections Guide

Avenza®
SYSTEMS INC.

Welcome

Avenza welcomes you to mapmaking in the 21st century!

Combined with Adobe Illustrator, MAPublisher has revolutionized the art of mapmaking by allowing spatial data files to be used to create maps inside a vector graphics program. MAPublisher allows all your cartographic tasks to be performed where they should be done; in a powerful graphics environment.

Combined with Adobe Photoshop, Geographic Imager revolutionizes the way spatial imagery is created, edited and maintained by allowing spatial image files to be created, edited and managed in the familiar and widely-used Adobe Photoshop environment. Geographic Imager allows the most common spatial imaging tasks to be performed where they should be done, in a powerful raster editing environment, and adds the dozens of powerful Adobe Photoshop tools and operations to those that one can perform on such imagery.

MAPublisher and Geographic Imager include an extensive geodetic parameter database called the Geodetic Datasource. It contains all the latest updates from the widely used EPSG Geodetic Parameter Dataset maintained by the Geodesy Subcommittee of OGP (International Association of Oil and Gas producers)—EPSG v6.18— as well as custom systems maintained by Avenza. In addition, the MAPublisher and Geographic Imager Geodetic Datasource supports user's custom definitions and allows for importing external WKT (Well-Know Text) and PRJ (ESRI projection file) parameter files.

Over 3500 pre-defined coordinates systems are readily available for use in most cartographic projects. Even though the current list of systems is comprehensive, there may be instances where the end users may wish to add a brand new coordinate system to meet their particular needs, or perhaps to duplicate and modify an existing definition to change the units for example. The Appendix 2 of the MAPublisher User Guide shows in detail how to use the MAPublisher Geodetic Datasource interface to perform these operations.

This *Projections Guide* is to be used at a complement to the MAPublisher User Guide and Geographic Imager User Guide. All the projections and datum shifts methods supported are fully described to assist users in the process of creating or editing a coordinate system.

Contents

Overview

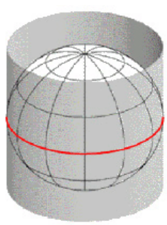
PROJECTIONS OVERVIEW

Map Projections are attempts to show the surface of the Earth, or parts of it, on a flat surface. Some distortions of conformality, distance, direction, scale, and area always result from this process. Certain projections minimize distortions in some of these aspects at the expense of maximizing errors in others, whereas others only moderately distort all of these properties.

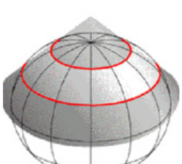
- **Conformality**: The scale at any point on the map is the same in all directions. Meridians (lines of longitude) and parallels (lines of latitude) intersect at right angles. Projections with these properties are **Conformal.**
- **Distance**: A map has an **Equidistant** projection when it portrays equal distances from the centre 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. Projections with these properties are **Azimuthal**.
- **Scale**: 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 of the world they represent, the projection used is an **Equal Area** projection.

PROJECTION CATEGORIES

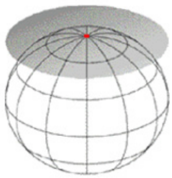
Cylindrical Projection: The result of projecting a spherical surface onto a cylinder. In a typical cylindrical projection, one imagines the paper to be wrapped as a cylinder around the globe, tangent to it along the equator. Light comes from a point source at the centre of the globe or, in some cases, from a filament running from pole to pole along the globe's axis. In the former case the poles clearly cannot be shown on the map, as they would be projected along the axis of the cylinder out to infinity. In the latter case the poles become lines forming the top and bottom edges of the map. The Mercator projection, long popular but now less so, is a cylindrical projection of the latter type that can be constructed only mathematically. In all cylindrical projections the meridians of longitude, which on the globe converge at the poles, are parallel to one another; in the Mercator projection the parallels of latitude, which on the globe are equal distances apart, are drawn with increasing separation as their distance from the equator increases in order to preserve shapes. However, the price paid for preserving shapes is that areas are exaggerated with increasing distance from the equator. The effect is most pronounced near the poles; E.g., Greenland is shown with enormously exaggerated size although its shape in small sections is preserved. The poles themselves cannot be shown on the Mercator projection.



Conic Projection: The result of projecting a spherical surface onto a cone. In a conic projection a paper cone is placed on a globe like a hat, tangent to it at some parallel, and a point source of light at the centre of the globe projects the surface features onto the cone. The cone is then cut along a convenient meridian and unfolded into a flat surface in the shape of a circle with a sector missing. All parallels are arcs of circles with a pole (the apex of the original cone) as their common centre, and meridians appear as straight lines converging toward this same point. Some conic projections are conformal (shape preserving); some are equal-area (size preserving). A polyconic projection uses various cones tangent to the globe at different parallels. Parallels on the map are arcs of circles but are not concentric.



Azimuthal Projection: The result of projecting a spherical surface onto a plane. In an azimuthal projection a flat sheet of paper is tangent to the globe at one point. The point light source may be located at the globe's centre (gnomonic projection), on the globe's surface directly opposite the tangent point (stereographic projection), or at some other point along the line defined by the tangent point and the center of the globe, e.g., at a point infinitely distant (orthographic projection). In all azimuthal projections, the tangent point is the central point of a circular map; all great circles passing through the central point are straight lines, and all directions from the central point are accurate. If the central point is a pole, then the meridians (great circles) radiate from that point and parallels are shown as concentric circles. The gnomonic projection has the useful property that all great circles (not just those that pass through the central point) appear as straight lines; conversely, all straight lines drawn on it are great circles. A navigator taking the shortest route between two points (always part of a great circle) can plot his course on a gnomonic projection by simply drawing a straight line between the two points.



Miscellaneous Projections: Projections that do not fall into the above categories, such as unprojected maps, and rectangular latitude and longitude grids. Also this classification can be applied to modified projections, being altered versions of other projections. Pseudo projections have some of the characteristics of another class of projection. For example the Sinusoidal is called a pseudo-cylindrical projection because all lines of latitude are straight and parallel, and all meridians are equally spaced. However it is not a truly cylindrical projection because all meridians except the central meridian are curved.

DATUMS AND ELLIPSOIDS OVERVIEW

An ellipsoid is a mathematical figure generated by the revolution of an ellipse about one of its axes. The Earth is not a sphere but an ellipsoid distorted by rotation about its axis, with the globe bulging at the equator and flattened at the poles. The actual amount of the flattening is approximately 21.5 km difference between the polar and equatorial radii. Ellipsoidal Earth models are required for accurate range and bearing calculations over long distances. For example 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 100 metres.

Reference Ellipsoids are usually defined by semi-major (equatorial radius) and flattening (the relationship between equatorial and polar radii). Other reference ellipsoid parameters such as semi-minor (polar radius) and eccentricity can be computed form these terms.

A datum is a mathematical model that describes the shape of the ellipsoid, and orientation of coordinate systems used to map the Earth. A datum is a smoothed mathematical surface of the Earth's mean, sea level surface. Different nations and agencies use different datums as the basis for coordinate systems in GIS.

Modern 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.

DATUM EXAMPLES

- **NAD27**: For many years the North American Datum of 1927 was the standard in the United States. NAD27 was based on the Clarke Ellipsoid of 1866, which was developed from ground survey in Europe and North America in the 19th Century. The centre point for NAD27 is Meades Ranch in Kansas, USA.
- **NAD83**: During the 1970's and 1980's satellites were able to measure the ellipsoid flattening more accurately (the World Geodetic System ellipsoid of 1984 or WGS84) and a new datum was developed from these measurements called the North American Datum of 1983. The Global Positioning System is based on WGS84. The centre point for NAD83 is the centre of the Earth's mass and uses the GRS80 spheroid which factors in the Earth's equatorial bulge.

Common Coordinate Systems Classes

GEODETIC

A geodetic gcoordinate system is a three-dimensional coordinate system defined by an ellipsoid, the equatorial plane of the ellipsoidal and a plane defined along the polar axis (a meridional plane).

Coordinates in a Geodetic Coordinate System are given by a geodetic latitude (the angle between the normal to the ellipsoid at a location and the equatorial plane), a geodetic longitude (the angle between the meridional reference plane and a meridional plane containing the normal to the ellipsoid at a location) and a geodetic height (the perpendicular distance of a location from the ellipsoid).

A geodetic datum is the only required defining parameter for a Geodetic Coordinate System in MAPublisher and Geographic Imager. A geodetic datum defines constants that relate a Geodetic Coordinate System to the physical Earth, the dimensions of the reference ellipsoid, the location of the origin of the system, and the orientation of the system.

A geodetic coordinate is specified in MAPublisher or Geographic Imager by latitude, longitude, and ellipsoidal height values. Any angular unit defined may be used to specify latitude and longitude coordinates.

The ellipsoidal height of a location is defined as the elevation of the location above the geoid (essentially a modeled surface representing mean sea level) and the separation of the geoid surface from the ellipsoidal surface. MAPublisher and Geographic Imager assume a value of 0.0 if the ellipsoidal height of a location is unknown. Any distance unit defined may be used to specify ellipsoidal height values.

UNIVERSAL TRANSVERSE MERCATOR

A Universal Transverse Mercator (UTM) coordinate system is an international plane coordinate system developed by the U.S. Army. It extends around the globe from 84 degrees north to 80 degrees south. The world is divided into 60 zones in the Northern Hemisphere and 60 corresponding zones in the southern hemisphere. Each zone covers six degrees of longitude. Each zone extends three degrees eastward and three degrees westward from its central meridian. Zones are numbered west to east from the 180-degree meridian.

The geodetic datum and the UTM zone are required parameters for the UTM Coordinate System supported in MAPublisher and Geographic Imager.

A UTM coordinate is specified by northing and easting values. The metre is the standard unit in the UTM coordinate system. Any distance unit defined within MAPublisher or Geographic Imager may be used to specify UTM coordinates.

US STATE PLANE

There are two sets of State Plane coordinate systems defined in the United States, one based on the North American Datum of 1927 and the other based on the North American Datum of 1983.

Each of the State Plane coordinate systems divides the United States into over 130 sections, each with its own projection surface and grid network. With the exception of very narrow states, such as Delaware, New Jersey, and New Hampshire, most states divide into two to ten zones.

Zones extending primarily in an east-west direction are based on the Lambert Conformal Conic projection, while zones extending in a north-south direction are based on the Transverse Mercator projection. Alaska, Florida and New York use both Transverse Mercator and Lambert Conformal Conic for different areas. The Aleutian panhandle of Alaska uses the Oblique Mercator projection.

Zone boundaries follow state and county lines and, because each zone is small, distortion is less than one in 10,000. Each zone has a centrally located origin and a central meridian that passes through the origin. The United States uses a two-zone numbering system: The United States Geological Survey (USGS) code system and the National Ocean Service (NOS) code system. However, other code systems do exist.

The State Plane zone is the only required defining parameter for any of the State Plane coordinate systems supported in MAPublisher and Geographic Imager.

IT IS STRONGLY RECOMMENDED THAT YOU USE THE NGS NADCON GEODETIC DATUM TRANSFORMATION METHOD WHEN CONVERTING STATE PLANE COORDINATES. HOWEVER, YOU MAY USE THE MOLODENSKY METHOD WHEN CONVERTING STATE PLANE COORDINATE SYSTEM OF 1927 COORDINATES AND SELECT ONE OF THE DEFINED SET OF NAD 27 DATUM TRANSFORMATIONS.

A State Plane coordinate is specified by northing and easting values. The U.S. Survey Foot is the standard unit in the State Plane coordinate system of 1927. The metre is the standard unit in the State Plane Coordinate System of 1983. Any distance unit defined within MAPublisher or Geographic Imager may be used to specify State Plane coordinates.

Avenza Supported Projections

This section helps you become familiar with the map projections that are supported in MAPublisher and Geographic Imager

AITOFF

The Aitoff projection is a modified azimuthal projection that is neither conformal nor equal area. It was developed by David Aitoff (or Altow) in 1889. The central meridian is a straight line half the length of the Equator. Other meridians are equally spaced along the Equator and concave toward the central meridian. The Equator is straight. Other parallels are equally spaced along the central meridian and concave toward the nearest pole. The poles are represented by points. This projections is symmetrical about the Equator and the central meridian. Scale is true along the Equator and the central meridian.

This projection is supported on spheres only.

Aitoff projection parameters:

- *Longitude of the Center of the Projection*
- *False Easting*
- *False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

ALASKA STATE PLANE 27

The State Plane Coordinate System (SPCS) is not a projection; rather it is a system for specifying positions of geodetic stations using plane rectangular coordinates. This coordinate system that divides all fifty states of the United States, Puerto Rico and the U.S. Virgin Islands into over 120 numbered sections, referred to as zones. Each zone has an assigned code number that defines the projection parameters for the region.

There are four possible projections for SPCS. The geometric direction of each state determines the projection utilized. For states that are longer in the east-west direction, the Lambert Conformal Conic is used. States which are longer in the north-south direction use the Transverse Mercator Projection. The panhandle of Alaska, which the sole distinction of lying at an angle, garners the use of the Oblique Mercator Projection. While Guam uses a Polyconic projection

The formulae for these calculations are based on Publication 62-4, **State Plane Coordinates by Automatic Data Processing**, U.S. Department of Commerce 1968. These projections should only be used for data that has been computed using this method. For all other state plane calculations use Exact Methods. The parameters for these coordinate systems are defined in Publication 62-4. For further information, contact the U.S. Department of Commerce.

The **Alaska27** projection is hard-coded and does not require any parameters.

ALBERS EQUAL-AREA CONIC

The Albers Equal-Area Conic projection is a map projection in which the parallels are unequally spaced arcs of concentric circles spaced closer to each other near the north and south edges of the map. The meridians are equally spaced and intersect the parallels at right angles.

The Albers Equal-Area Conic projection is used for equal-area maps of regions with predominant east-west expanse, such as the United States. It is used exclusively by the USGS for sectional maps of all 50 states.

Albers Equal Area projection parameters:

- *False Northing and False Easting*
- *Longitude of the Central Meridian*
- *Latitude of the Origin of the Projection*
- *Latitude of Southern Standard Parallel*
- *Latitude of Northern Standard Parallel*

AZIMUTHAL EQUAL AREA

The Azimuthal Equal Area projection is an equal-area projection with the azimuthal property showing true directions from the center of the projection. Its scale at a given distance from the center varies less from the scale at the center than the scale of any of the other azimuthal projections.

Azimuthal Equal Area projection parameters:

- *False Northing and False Easting*
- *Longitude of the Center of the Projection*
- *Latitude of the Center of the Projection*

AZIMUTHAL EQUAL AREA (POLAR ASPECT)

The Azimuthal Equal Area (Polar Aspect) projection is an equal-area projection with the azimuthal property showing true directions from the center of the projection. Its scale at a given distance from the center varies less from the scale at the center than the scale of any of the other azimuthal projections. All meridians in the polar aspect are straight lines.

Polar Azimuthal EqualArea projection parameters:

- *Longitude of Origin*
- *Latitude of Origin*
- *False Easting*
- *False Northing*

AZIMUTHAL EQUIDISTANT

The Azimuthal Equidistant projection is neither an equal-area nor a conformal projection. The outer meridian of a hemisphere on the equatorial aspect is a circle. Distances and directions measured from the center are true. We recommend using the Azimuthal Equidistant projection for coordinate systems in which distances are measured from an origin.

The Azimuthal Equidistant projection is used in oblique aspect for atlas maps of continents, and in world maps for aviation.

Azimuthal Equidistant projection parameters:

- *False Northing and False Easting*
- *Longitude of the Central Meridian*
- *Latitude of Origin of Projection*

AZIMUTHAL EQUIDISTANT (POLAR ASPECT)

The Azimuthal Equidistant (Polar Aspect) projection is neither an equal-area nor a conformal projection. The outer meridian of a hemisphere on the equatorial aspect is a circle. Parallels on the polar projection are circles spaced at equidistant intervals. All meridians on the polar aspect are straight lines. Distances and directions measured from the center are true.

The **Azimuthal Equidistant (Polar Aspect)** projection is used in the polar aspect for world maps and maps of the polar hemispheres.

Polar Equidistant projection arameters:

- *Longitude of the Central Meridian*
- *Latitude of the Origin of the Projection*
- *False Easting*
- *False Northing*

BEHRMANN

The Behrmann projection is a variation of the generic Equal Area Cylindrical, in which the latitude of the standard parallel is always 30 degrees. It was originally presented by Walter Behrmann in Berlin in 1910. The Equal-Area Cylindrical projection represents an orthographic projection of a sphere onto a cylinder. Like other regular cylindrical projections, the graticule of the normal Equal-Area Cylindrical projection consists of straight equally spaced vertical meridians perpendicular to straight unequally spaced horizontal parallels. To achieve equality of area, the parallels are spaced form the Equator in proportion to the sine of the latitude.

This is the simplest equal-area projection. This projection is supported on spheres only.

Behrmann parameters:

- *Longitude of the Central Meridian*
- *False Easting*
- *False Northing*

BELGIUM 72

The Belgium 72 Projection is a special case of the Lambert Conformal Conic (2-parallel) projection.

Belgium 72 projection parameters:

- *Longitude of the Central Meridian*
- *Latitude of the Origin of the Projection*
- *Latitude of Southern Standard Parallel*
- *Latitude of Northern Standard Parallel*
- *False Easting*
- *False Northing*

BIPOLAR OBLIQUE CONIC CONFORMAL

This conformal projection was constructed specifically for mapping North and South America. It is composed of two oblique adaptations of the Lambert Conformal Conic projection. The juncture of the two conic projections consists of a great circle arc cutting through Central America from southwest to northeast.There is a slight mathematical discontinuity along this arc, which is resolved by an adjustment that leaves a small intermediate area slightly non-conformal. The Earth is treated as a sphere by this projection, due to the relatively small scale of the map.

The **Bipolar Oblique Conformal Conic** projection has no parameters, as the poles and parallels used by the conic projections are set to specific values.

BONNE

The Bonne projection is psuedoconical and equal-area. The central meridian is a straight line.
Other meridians are complex curves. Parallels are concentric circular arcs, but the poles are points.
Scale is true along the central meridian and along all parallels. There is no distortion along the central meridian and along the standard parallel. The Bonne projection is used for atlas maps of continents and for topographic mapping of some countries.

Bonne projection parameters:

- *False Northing and False Easting*
- *Longitude of the Central Meridian*
- *Latitude of Standard Parallel*

CASSINI

The Cassini projection is a cylindrical projection. It is neither equal-area or conformal. The central meridian, each meridian 90 degrees from the central meridian and the Equator are straight lines. Other meridians and parallels are complex curves. Scale is true along the central meridian and along lines perpendicular to the central meridian. Scale is nearly constant but not true along lines parallel to the central meridian. The Cassini projection has been used for topographic mapping in England and currently in a few other countries.

Cassini projection parameters:

- *False Northing and False Easting*
- *Longitude of the Central Meridian*
- *Latitude of True Scale*

CRASTER PARABOLIC

The Craster Parabolic projection is a pseudocylindrical, equal area projection used for thematic world maps in textbooks. It was originally presented by John Evelyn Edmund Craster in 1929. It was further developed by Charles H. Deetz and O.S. Adams in 1934. The central meridian is a straight line half as long as the Equator. Other meridians are equally spaced parabolas intersecting at the poles and concave toward the central meridian. The parallels are unequally spaced, farthest apart near the Equator. They run perpendicular to the central meridian. This projection is symmetrical about the central meridian or the equator. Scale is true along latitudes 36°46′ N and S, and constant along any given latitude. This projection is supported on spheres only.

This projection is also known as Putniņš P4, which was independently presented in Latvia in 1934.

Craster Parabolic projection parameters:

- *Longitude of the Central Meridian*
- *False Easting*
- *False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

DANISH SYSTEM 34

(Pre–1999 variation, using order 11 polynomial)

This projection is a variation of the Transverse Mercator projection used in Denmark, and is also referred to as UTS34. The projection consists of a base UTM (zones 32 and 33) calculation, which is then adjusted by an order 11 polynomial. The polynomials used in the Danish System 34 projection were developed by K. Poder and K. Engsager of Kort and Matrikelstyrelsen. The polynomial coefficients can be obtained by contacting Kort and Matrikelstyrelsen.

Note that this projection was superseded in 1999, by a newer version that uses an order 13 polynomial to further adjust the results achieved using this projection.

Danish System 34 projection parameters:

- *Region*

Region is used to indicate which part of Denmark the projection is being applied to. The valid region values are as follows:

Region	Key
Jylland	"j", "J", or "1"
Sjælland	"s", "S", or "2"
Bornholm	"b", "B", or "3"
National	"u", "U", or "4"

DANISH SYSTEM 34 (1999)

(1999 variation, using order 13 polynomial)

This projection is a variation of the Transverse Mercator projection used in Denmark. The projection consists of a base UTM (zones 32 and 33) calculation, which is then adjusted by an order 11 polynomial, and then further adjusted by an order 13 polynomial. Note that a previous version of this projection was used up until 1999, based solely on the order 11 polynomial. This newer version is a further refinement of those results using the additional order 13 polynomial.

The polynomials used in the Danish System 34 projection were developed by K. Poder and K. Engsager of Kort and Matrikelstyrelsen. The polynomial coefficients can be obtained by contacting Kort and Matrikelstyrelsen.

DanishSystem 34_99 projection parameters:

- *Region*

Region is used to indicate which part of Denmark the projection is being applied to. The valid region values are as follows:

Region	Key
Jylland	"j", "J", or "1"
Sjælland	"s", "S", or "2"
Bornholm	"b", "B", or "3"
National	"u", "U", or "4"

DOUBLE STEREOGRAPHIC

The Double Stereographic projection consists of two mappings. First, the ellipsoidal data is mapped to a conformal sphere. Then a second conformal mapping is done of the spherical data to the plane. This projection is used in New Brunswick, Canada, Netherlands and Poland. This projection is also known as Oblique Stereographic.

Double Stereographic projection parameters:

- *False Northing and False Easting*
- *Longitude of the Center of the Projection*
- *Scale Reduction Factor at the Center of the Projection*
- *Latitude of the Center of the Projection*

ECKERT I

The Eckert I projection is a pseudocylindrical projection that is neither conformal nor equal area. This projection was presented by Max Eckert in 1906, and is generally used for novelty maps of the world showing a straight-line graticule. Meridians in this projection are represented by equally spaced converging straight lines broken at the equator. The central meridian is half as long as the Equator. Parallels are represented by equally spaced straight parallel lines that are perpendicular to the central meridian. Poles are represented by lines half as long as the Equator. This projection is symmetrical about the central meridian or the Equator. Scale is true along latitudes 47°10' N and S, and constant along any given latitude or meridian.

Eckert I projection parameters:

- *Longitude of the Center of the Projection*
- *False Easting*
- *False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) issued for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

ECKERT II

The Eckert II projection is a pseudocylindrical projection that is equal area. This projection was presented by Max Eckert in 1906, and is generally used for novelty maps of the world showing a straight-line equal area graticule. Meridians in this projection are represented by equally spaced converging straight lines broken at the equator. The central meridian is half as long as the Equator. Parallels are represented by unequally spaced straight parallel lines that are perpendicular to the central meridian. Poles are represented by lines half as long as the Equator. This projection is symmetrical about the central meridian or the Equator. Scale is true along latitudes 55°10′ N and S, and constant along any given latitude. This projection is supported on spheres only.

Eckert II projection parameters:

- *Longitude of the Center of the Projection*
- *False Easting*
- *False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the syste wherein this projection is incorporated.

ECKERT III

The Eckert III projection is a pseudocylindrical projection that is neither conformal nor equal area. This projection was presented by Max Eckert in 1906 and is used primarily for world maps. Meridians in this projection are equally spaced semi-ellipses, concave toward the central meridian. The central meridian is a straight line half as long as the Equator. Parallels are represented by equally spaced straight parallel lines that are perpendicular to the central meridian. Poles are represented by lines half as long as the Equator. This projection is symmetrical about the central meridian or the Equator. Scale is true along latitudes 35°58′ N and S, and constant along any given latitude.

Eckert III projection parameters:

- *Longitude of the Center of the Projection*
- *False Easting*
- *False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

ECKERT IV

The Eckert IV was created by Max Eckert in 1906, and is used for world maps. Both are Pseudocylindrical projections whose central meridian is a straight line. 180th meridians of the Eckert IV projection are semicircle, and all other meridians are equally spaced elliptical Arcs. The parallels are unequally spaced straight lines parallel to one another, and the Poles are straight lines half as long as the equator. Scale is true along latitude 40º30’ for the Eckert IV.

Eckert IV projection parameters:

- *Longitude of the Central Meridian*
- *Latitude of Origin*
- *Radius of the Sphere*
- *False Northing*
- *False Easting*

NOTE: If the spherical_radius parameter is set to a value greater than zero, then it will be used as the radius of the sphere. If this parameter is set to a value less than or equal to zero, then the semi-major radius of the ellipsoid will be used as the radius of the sphere.

ECKERT V

The Eckert V projection is a pseudocylindrical projection that is neither conformal nor equal area. This projection was presented by Max Eckert in 1906. Meridians in this projection are equally spaced sinusoids, concave toward the central meridian. The central meridian is a straight line half as long as the Equator. Parallels are represented by equally spaced straight parallel lines that are perpendicular to the central meridian. Poles are represented by lines half as long as the Equator. This projection is symmetrical about the central meridian or the Equator. Scale is true along latitudes 37°55' N and S, and constant along any given latitude.

Eckert V projection parameters:

- *Longitude of Origin*
- *False Easting*
- *False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

ECKERT VI

The Eckert VI was created by Max Eckert in 1906, and is used for world maps. Both are Pseudocylindrical projections whose central meridian is a straight line. Meridians on the Eckert VI projection are equally spaced sinusoidal curves. In both projections, the parallels are unequally spaced straight lines parallel to one another, and the Poles are straight lines half as long as the equator. Scale is true along latitude 49º16’ for Eckert VI.

Eckert VI projection parameters:

- *Longitude of Origin*
- *Latitude of Origin*
- *Radius of Sphere*
- *False Easting*
- *False Northing*

NOTE: If the spherical_radius parameter is set to a value greater than zero, then it will be used as the radius of the sphere. If this parameter is set to a value less than or equal to zero, then the semi-major radius of the Ellipsoid will be used as the radius of the sphere.

EGYSEGES ORSZAGOS VETULET (EOV)

The Egyseges Orszagos Vetulet (EOV) is a conformal cylindrical projection in transversal position used uniformly for the Hungarian civilian base maps and, in general, for spatial informatics.

The current implementation for the **Egyseges Orszagos Vetulet** projection does not require any user defined parameters.

EQUAL-AREA CYLINDRICAL

The Equal-Area Cylindrical projection represents an orthographic projection of a sphere onto a cylinder. Like other regular cylindrical projections, the graticule of the normal Equal-Area Cylindrical projection consists of straight equally spaced vertical meridians perpendicular to straight unequally spaced horizontal parallels. To achieve equality of area, the parallels are spaced form the Equator in proportion to the sine of the latitude. This is the simplest equal-area projection.

Equal-Area Cylindrical projection parameters:

- *False Northing and False Easting*
- *Longitude of the Central Meridian*
- *Latitude of the Standard Parallel*

EQUIDISTANT CONIC

The Equidistant Conic is the simplest kind of conic projection. It is the projection most likely to be found in atlases of small countries, with its equally spaced straight meridians and equally spaced circular parallels.

Equidistant Conic projection parameters:

- *False Northing and False Easting*
- *Longitude of the Central Meridian*
- *Latitude of the Origin of the Projection*
- *Latitude of the Southern Standard Parallel*
- *Latitude of the Northern Standard Parallel*

EQUIDISTANT CYLINDRICAL

The Equidistant Cylindrical projection is probably the simplest of all map projections to construct and one of the oldest. Meridians and parallels are equidistant straight lines, intersecting at right angles. Poles are shown as lines. This projection is used only in spherical form.

If the Equator is made the standard parallel, true to scale and free of distortion, the meridians are spaced at the same distances as the parallels, and the graticule appears square. This form is often called the Plate Carree or the Simple Cylindrical Projection.

Equidistant Cylindrical projection parameters:

- *Radius of the Sphere*
- *Longitude of the Central Meridian*
- *False Northing and False Easting*
- *Latitude of True Scale*

NOTE: Only a spherical form of this projection is used. The radius of the sphere is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated. You are required to specify a geodetic datum when you use this projection as part of a coordinate system in order to perform geodetic datum shifts into other coordinate systems.

EUROPEAN STEREOGRAPHIC

The European Stereographic projection is a derivation of the Stereographic projection for use in the Netherlands.

European Stereographic projection parameters:

- *False Northing and False Easting*
- *Longitude of the Center of the Projection*
- *Latitude of the Center of the Projection*
- *Scale Reduction Factor at the Center of the Projection*

FULLER (DYMAXION)

R. Buckminster Fuller Dymaxion Projection is a method of projecting the spherical Earth onto a twenty-sided polyhedron known as an icosahedron. This icosahedron is then unfolded in such a way that the major land masses will appear whole, without the map borders breaking them apart. More information may be found at the Buckminster Fuller Institute (*www.bfi.org*).

The **Fuller** projection has no parameters. This projection only works on small scale datasets, that are contained in one of the grid faces of the projection.

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

For more information about the map and the work of Buckminster Fuller, visit the Buckminster Fuller Institute at *www.bfi.org*. The Fuller Projection Map design is a trademark of the Buckminster Fuller Institute © 1938, 1967, 1992. All rights reserved. *www.bfi.org*.

GALL PETERS (MAPublisher only)

The Gall-Peters projection is a variation of the generic equal area cylindrical, in which the latitude of the standard parallel is always 45 degrees. It was originally presented by James Gall in 1855, and is also known as the Gall Orthographic projection.

The equal-area cylindrical projection represents an orthographic projection of a sphere onto a cylinder. Like other regular cylindrical projections, the graticule of the normal Equal-Area Cylindrical projection consists of straight equally spaced vertical meridians perpendicular to straight unequally spaced horizontal parallels. To achieve equality of area, the parallels are spaced form the Equator in proportion to the sine of the latitude. This is the simplest equal-area projection. This projection is supported on spheres only.

Gall Peters projection parameters:

- *Longitude of the Central Meridian*
- *False Easting and False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

GALL STEREOGRAPHIC

The Gall Stereographic projection is a cylindrical perspective projection that is neither conformal nor equal area. It is produced geometrically by projecting the Earth perspectively from the point on the Equator opposite a specified meridian, onto a secant cylinder cutting the globe at latitudes 45° N and S. It was presented by James Gall in 1855. It is sometimes known simply as the Gall projection, or as Gall Stereographic projection. This projection is used primarily for world maps in British atlases and some other atlases. It resembles the Mercator, but has less distortion of scale and area near the poles.

The meridians in the Gall Stereographic projection are equally spaced straight parallel lines .77 as long as the Equator. Parallels are unequally spaced straight parallel lines perpendicular to meridians. The poles are represented by straight lines equal in length to the Equator. The projection is symmetrical about any meridian or the Equator. Scale is true along latitudes 45° N and S in all directions, and is constant in any given direction along any other latitude. There is no distortion at latitudes 45° N and S, but shape, area and scale distortion increase moderately away from these latitudes and become severe at the poles.

Gall Stereographic projection parameters:

- *Longitude of Origin*
- *False Easting and False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

GNOMIC

The Gnomic projection is used for plotting great circle arcs as straight lines on a map. Scale, shape and area are badly distorted along these paths, but the great circle routes are precise in relation to the sphere.

Gnomic projection parameters:

- *False Northing and False Easting*
- *Longitude of the Center of the Projection*
- *Latitude of the Center of the Projection*
- *Radius of the Sphere*

GOODE HOMOLOSINE

The Goode Homolosine projection is a pseudocylindrical composite projection that is equal area. It is used primarily for world maps in a number of atlases, including Goode Atlas (Rand McNally). It was developed by J. Paul Goode in 1923 as a merging of the Mollweide (or Homolographic) and Sinusoidal Projections, thus giving rise to the name **Homolosine**.

Each of the six central meridians is a straight line 0.22 as long as the Equator, but not crossing the Equator. Other meridians are equally spaced sinusoidal curves between latitudes 40°44' N and S. The poles are represented by points. Scale is true along every latitude between 40°44' N and S and along the central meridian within the same latitude range.

GoodeHomolosine projection parameters:

- *Longitude of Origin*
- *False Northing*
- *False Easting*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) issued for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

GUAM (MAPublisher only)

This is a special modified version of the azimuthal equidistant projection used in Guam.

Guam projection parameters:

- *Longitude of the Central Meridian*
- *Latitude of the Origin of the Projection*
- *False Easting*
- *False Northing*
- *XY Plane Rotation*

GUAM STATE PLANE 27

The State Plane Coordinate System (SPCS) is not a projection; rather it is a system for specifying positions of geodetic stations using plane rectangular coordinates. This coordinate system that divides all fifty states of the United States, Puerto Rico and the U.S. Virgin Islands into over 120 numbered sections, referred to as zones. Each zone has an assigned code number that defines the projection parameters for the region.

There are four possible projections for SPCS. The geometric direction of each state determines the projection utilized. For states that are longer in the east-west direction, the Lambert Conformal Conic is used. States which are longer in the north-south direction use the Transverse Mercator Projection. The panhandle of Alaska, which the sole distinction of lying at an angle, garners the use of the Oblique Mercator Projection. While Guam uses a Polyconic projection.

The formulae for these calculations are based on Publication 62-4, *State Plane Coordinates by Automatic Data Processing*, U.S. Department of Commerce 1968. These projections should only be used for data that has been computed using this method. For all other state plane calculations use Exact Methods. The parameters for these coordinate systems are defined in Publication 62-4. For further information contact the U.S. Department of Commerce.

The **Guam 27** projection does not require any parameters.

HAMMER AITOFF

The Hammer Aitoff (or simply Hammer) projection is a modified azimuthal projection that is equal area. H.H. Ernst von Hammer developed it in 1892. It is used most often for whole-world maps.

In this projection, the central meridian is depicted as a straight line half the length of the Equator. Other meridians are depicted as complex curves, unequally spaced along the Equator and concave toward the central meridian. The Equator is straight. Other parallels are depicted as complex curves, unequally spaced along the central meridian and concave toward the nearest pole. The poles themselves are represented by points. This projection is symmetrical about the central meridian and the Equator. Scale decreases along the central meridian and the Equator as you move away from the center.

This projection has moderate distortion, with less shearing action on the outer meridians near the poles than may be found in pseudocylindrical projections.

Hammer Aitoff projection parameters:

- *Longitude of Origin*
- *False Easting*
- *False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

HOTINE OBLIQUE MERCATOR (RECTIFIED SKEW ORTHOMORPHIC)

The Hotine Oblique Mercator (HOM) projection is a cylindrical, conformal map projection. It is similar to the Mercator projection, except that the cylinder is wrapped around the sphere so that it touches the surface along the great circle path chosen for the central line, instead of along the Earth's equator. Scale becomes infinite 90 degrees from the central line and is true along a chosen central line, along two straight lines parallel to the central line, or along a great circle at an oblique angle. The HOM projection is used for geographic regions that are centered along lines that are neither meridians nor parallels, but that may be taken as great circle routes passing through the region, such as the Alaskan panhandle. Two cases of the Hotine Oblique Mercator projection are implemented within MAPublisher and Geographic Imager, differing only in their defining parameters.

Hotine Oblique Mercator projection parameters:

- *False Northing and False Easting*
- *Latitude of the Origin of the Projection*
- *Scale factor*
- *Standard Longitude 1st and 2nd Points*
- *Standard parallel 1st and 2nd Points*

The Rectified Skew Orthomorphic (RSO) projection is used throughout the world, particularly in Malaysia. The RSO projection is equivalent to a HOM projection except that the defining parameters are different. You can specify a HOM projection by specifying a point and the azimuth defining the central line. This case allows for the entering of parameters for the RSO projection.

Hotine Oblique Mercator (1 Point) projection parameters:

- *False Northing and False Easting*
- *Latitude of the Origin of the Projection*
- *Longitude at the Center of the Projection*
- *Azimuth of the Central Line*
- *Scale Factor at the Center of the Projection*
- *Skew Azimuth*

NOTE: The Skew Azimuth parameter is essential for correct rectified to skew coordinate transformation. If you have researched a coordinate system and there is no defined skew angle simply enter the azimuth of the central line as the skew angle. This will provide for an identity rectified to skew transformation.

There are two variations of the Hotine Oblique Mercator (1 Point) projection type. These are mathematically identical in terms of results returned. The only difference is that the **Hotine Oblique Mercator (1 Point) Method 2** version uses hyperbolic functions in the underlying mathematical computations.

HYPERBOLIC CASSINI-SOLDNER (MAPublisher only)

A modified form of the standard Cassini-Soldner projection known as the Hyperbolic Cassini-Soldner is used for the island of Vanua Levu, Fiji.

Hyperbolic Cassini Soldner projection parameters:

- *Longitude of the Central Meridian*
- *Latitude of True Scale*
- *False Easting*
- *False Northing*

IMW POLYCONIC

The IMW Polyconic projection is a modified Polyconic projection devised as a basis for the1:1,000,000 scale International Map of the World (IMW) series. The IMW Polyconic projection differs from the ordinary Polyconic in two principle ways. All meridians are straight and two meridians are made true to scale.

IMW Polyconic projection parameters:

- *False Northing and False Easting*
- *Longitude of Central Meridian*
- *Latitude of the Southern Standard Parallel*
- *Latitude of the Northern Standard Parallel*
- *Longitude of the Meridian True to Scale*

KROVAK

The Krovak projection was created and used in Czechoslovakia in the early part of the 20th century. It is an oblique version of the Lambert Conformal Conic projections with a pseudo standard parallel that intersects the centerline of the projection at a defined azimuth. The projection accurately preserves scale and area along the pseudo standard parallel. It is primarily used in the Czech Republic.

Krovak projection parameters:

- *False Northing and False Easting*
- *Origin Latitude*
- *Origin Longitude (centerline)*
- *Latitude of True Scale*
- *Azimuth*

LABORDE

The Laborde projection is an Oblique Mercator projection that is primarily used in Madagascar. It is a cylindrical, conformal map projection similar to the Mercator system, except the cylinder is wrapped around the sphere so that it touches the surface along the great circle path at a chosen azimuth from the centerline. It was adopted for use in the Madagasgar grid system in 1926.

Laborde projection parameters:

- *False Northing and False Easting*
- *Origin Latitude*
- *Origin Longitude (centerline)*
- *Scale Factor*
- *Azimuth*

LAMBERT CONFORMAL CONIC (2 PARALLELS)

The Lambert Conformal Conic (2 parallel) projection is a map projection in which the scale is true along two standard parallels, and the true shape of small areas is preserved. Parallels are unequally spaced arcs of concentric circles spaced closer to each other near the center of the map. The meridians are equally spaced and intersect the parallels at right angles. The scale is true along two standard parallels.

The Lambert Conformal Conic projection is widely used in atlases, in aeronautical charts, and in plane coordinate systems in surveying. It is also used in the State Plane Coordinate System for states with large east-west extents.

Lambert Conformal Conic projection parameters:

- *False Northing and False Easting*
- *Longitude of the Central Meridian*
- *Latitude of the Origin of the Projection*
- *Latitude of the Southern Standard Parallel*
- *Latitude of the Northern Standard Parallel*

LAMBERT CONFORMAL CONIC EXTENDED

This is a variation of the standard Lambert Conformal Conic projection that is provided for the definition of coordinate systems used in specific counties in the U.S. states of Minnesota and Wisconsin. Within a specific county in one of these states, the ellipsoid must be expanded by an additional amount to account for the average elevation within that county. In the case of a Wisconsin county, the ellipsoid must also be adjusted based on the average geoid height for that county. For Minnesota counties, the average geoid height should be set to zero.

Lambert Conformal Conic Extended projection parameters:

- *Longitude of Origin*
- *Latitude of Origin*
- *Scale Factor at projection center*
- *False Easting*
- *False Northing*
- *Average Elevation (Minnesota and Wisconsin)*
- *Average Geoid Height (Wisconsin-only)*

LAMBERT TANGENT

The Lambert Tangent projection is a map projection in which the scale is true along a single standard parallels, and the true shape of small areas is preserved. This projection is also known as Lambert Conformal Conic (1 parallel. Parallels are unequally spaced arcs of concentric circles spaced closer to each other near the center of the map. The meridians are equally spaced and intersect the parallels at right angles. Coordinate systems based on this projection are used extensively in France.

Lambert Tangent projection parameters:

- *False Northing and False Easting*
- *Longitude of the Center of the Projection*
- *Latitude of the Origin of the Projection*
- *Scale Factor at the Center of the Projection*

LAMBERT STATE PLANE 27

The State Plane Coordinate System (SPCS) is not a projection; rather it is a system for specifying positions of geodetic stations using plane rectangular coordinates. This coordinate system that divides all fifty states of the United States, Puerto Rico and the U.S. Virgin Islands into over 120 numbered sections, referred to as zones. Each zone has an assigned code number that defines the projection parameters for the region. There are four possible projections for SPCS. The geometric direction of each state determines the projection utilized. For states that are longer in the east-west direction, the Lambert Conformal Conic is used. States that are longer in the north-south direction use the Transverse Mercator Projection. The panhandle of Alaska, which has the sole distinction of lying at an angle, garners the use of the Oblique Mercator Projection. Conversely Guam uses a Polyconic projection.

The formulae for these calculations are based on Publication 62-4, *State Plane Coordinates by Automatic Data Processing*, U.S. Department of Commerce 1968. These projections should only be used for data that has been computed using this method. For all other state plane calculations use Exact Methods. The parameters for these coordinate systems are defined in Publication 62-4. For further information contact the U.S. Department of Commerce.

The **Lambert 27** projection does not require any parameters.

LOXIMUTHAL

The Loximuthal projection is a pseudocylindrical projection that is neither conformal nor equal area. It was presented by Karl Siemon in 1935, and independently as Loximuthal by Waldo R. Tobler. This projection has the special feature that loxodromes (rhumb lines) from the central point (the intersection of the central meridian and central latitude) are shown straight, true to scale, and correct in azimuth from the center. The azimuths with respect to other points along a rhumb line, however, are not shown correctly, due to angular distortion on the map projection.

The central meridian in the Loximuthal projection is a straight line generally over half as long as the Equator (depending on the central latitude). Other meridians are depicted as equally spaced complex curves that are concave toward the central meridian and which intersect at the poles. The parallels are equally spaced straight parallel lines running perpendicular to the central meridian. The poles are represented as points. The projection in symmetrical about the central meridian, and around the Equator in the case where the central latitude is the Equator. Scale is true along the central meridian, and is constant along any given latitude. Distortion varies from moderate to extreme, and is absent only at the intersection of the central latitude and central meridian.

Loximuthal projection parameters:

- *Longitude of Origin*
- *False Easting*
- *Latitude of Origin*
- *False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

MCBRYDE-THOMAS FLAT-POLAR QUARTIC

The McBryde-Thomas Flat-Polar Quartic projection is a pseudocylindrical, equal area projection. It was presented by F. Webster McBryde and Paul D. Thomas in 1949. It is primarily used for examples in various geography textbooks, and is sometimes known simply as the Flat-Polar Quartic projection.

The central meridian is a straight line 0.45 as long as the Equator. Other meridians are fourth-order (quartic) curves that are equally spaced and concave toward the central meridian. The parallels are unequally spaced straight parallel lines, spaced farthest apart near the Equator and running perpendicular to the central meridian. The poles are represented by lines one-third as long as the Equator. Scale is true along latitudes 33°45′ N and S, and is constant along any given latitude. Distortion is severe near the outer meridians at high latitudes. This projection is free of distortion only at the intersection of the central meridian with latitudes 33°45′ N and S.

McBryde Thomas Flat Polar Quartic projection parameters:

- *Longitude of Origin*
- *False Easting and False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

MERCATOR

The Mercator projection is a cylindrical, conformal map projection in which meridians and parallels are straight lines that cross at 90-degree angles. Angular relationships are preserved. To preserve conformity, parallels are placed increasingly farther apart with increasing distance from the equator. This results in extreme distortion at high latitudes. Scale is true along the equator or along two parallels equidistant from the equator. Despite its drawbacks, the Mercator projection is quite useful for navigation because rhumb lines, which show constant direction, are straight. The Mercator projection is also appropriate for conformal maps of equatorial regions.

Mercator iprojection parameters:

- *False Northing and False Easting*
- *Latitude of True Scale*
- *Longitude of the Central Meridian*

MILITARY GRID REFERENCE SYSTEM (MAPublisher only)

The Military Grid Reference System projection is an extension of the UTM system (between 80° south and 80° north latitude) which uses a standard-scaled grid square, based on a point of origin on a map projection of the surface of the Earth in an accurate and consistent manner to permit either position referencing or the computation of direction and distance between grid positions.

The **Military Grid Reference System** projection has no parameters:

MILLER CYLINDRICAL

Meridians and parallels are straight lines, intersecting at right angles on the Miller Cylindrical projection. Poles are shown as lines. This projection is used only in spherical form and provides a compromise between Mercator and other cylindrical projections.

Miller Cylindrical projection parameters:

- *Radius of the Sphere*
- *False Northing and False Easting*
- *Longitude of the Central Meridian*

NOTE: Only a spherical form of this projection is used. The radius of the sphere is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated. You are required to specify a geodetic datum when you use this projection as part of a coordinate system in order to perform geodetic datum shifts into other coordinate systems.

MOLLWEIDE

The Mollweide projection is a pseudocylindrical equal-area projection. The central meridian is a straight line, 90th meridians are circular arcs, and all other meridians are equally spaced elliptical arcs. Parallels are unequally spaced straight lines, parallel to each other. Poles are shown as points. This projection is used only in spherical form.

Mollweide projection parameters:

- *Radius of the Sphere*
- *False Northing and False Easting*
- *Longitude of the Central Meridian*

NOTE: Only a spherical form of this projection is used. The radius of the sphere is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated. You are required to specify a geodetic datum when you use this projection as part of a coordinate system in order to perform geodetic datum shifts into other coordinate systems.

NEW ZEALAND MAP GRID

The New Zealand Map Grid (NZMG) is a projection that is used to convert latitudes and longitudes to easting and northing coordinates used for most mapping of New Zealand. The projection is unique to New Zealand. It was designed by Dr W. I. Reilly (1973) to minimize the scale error over the land area of the country.

New Zeal and Map Grid projection parameters:

- *Longitude of NZMG Origin*
- *Latitude of NZMG Origin*
- *False Easting*
- *False Northing*

OBLIQUE MERCATOR AZIMUTH

The Oblique Mercator projection is a cylindrical, conformal map projection. It is similar to the Mercator projection, except that the cylinder is wrapped around the ellipsoid so that it touches the surface along the great circle path chosen for the central line, instead of along the Earth’s equator. Scale becomes infinite 90 degrees from the central line and is true along a chosen central line, along two straight lines parallel to the central line, or along a great circle at an oblique angle. The Oblique Mercator projection is used for geographic regions that are centered along lines that are neither meridians nor parallels, but that may be taken as great circle routes passing through the region, such as the Alaskan panhandle. In this variation of the Oblique Mercator projection, a point and an azimuth define the central line where the cylinder touches the ellipsoid.

The planar points determined by this projection may be left unrectified (often these are referred to as the u, v coordinates in published formula) or they may be rectified (often these are referred to as the x, y coordinates in published formula). Rectification consists of rotating the coordinates by a certain angle. This implementation of the Oblique Mercator projection allows for a flag to be set to determine if the points should be rectified, or not. By default, the points will be rectified. If an unrectified version of the projection is desired, the *Unrectified Flag* parameter should be set to 1.5In the case where the points are rectified, the angle of rotation may be one of three values. Most commonly, it may be a user-specified rotation, or a rotation such that the y-axis will be parallel to the meridian through the center of the projection (the angle used in this case is often referred to in published formula

as alpha). Less commonly, it may be a rotation such that the y-axis will be parallel to the meridian through the natural origin of the projection (the angle used in this case is often referred to in published formula as gamma).
If the *Rotation Angle* parameter is a non-zero number, it will be used in the rectification. If the *Rotation Angle* is zero, the default behavior will be to rectify so that the y-axis will be parallel to the meridian through the center of the projection. If it is desired that the rectification cause the y-axis to be parallel to the meridian through the natural origin of the projection, the *Use Gamma Flag* parameter should be set to 1.

By default, the planer coordinates will be provided in terms of the natural origin of the projection. Alternately, they may be shifted based on the center of the projection. If it is desired that the coordinates be shifted, the **Center Flag** parameter should be set to 1. Note that this is only an option in the Oblique Mercator Azimuth projection, and is not currently supported in the Two Point case.

By default, the **Azimuth** parameter provided is assumed to be the angle at the center of the projection (alpha). However, there may be times when you want instead to specify the angle at the natural origin of the projection (gamma). Since each angle may be computed based on the other, either one can be specified when defined in the projection. If the **Azimuth Is Gamma** flag is set, it is assumed that the value passed in via the **Azimuth** parameter is the angle at the natural origin of the projection (gamma). Otherwise, it is assumed that the value passed in via the *Azimuth* parameter is the angle at the center of the projection (alpha).

Oblique Mercator Azimuth projection parameters:

- *Longitude at the Center of the*
- *Latitude of the Origin of the Projection*
- *Azimuth of the Central Line*
- *Scale Factor at the Center of the Projection*
- *False Easting*
- *False Northing*
- *Projection Rotation Angle (Defaults to 0)*
- *Unrectified Flag (Defaults to 0)*
- *Use Gamma Flag (Defaults to 0)*
- *Center Flag (Defaults to 0)*
- *Azimuth is Gamma (Defaults to 0)*

OBLIQUE MERCATOR TWO POINTS

The Oblique Mercator projection is a cylindrical, conformal map projection. It is similar to the Mercator projection, except that the cylinder is wrapped around the ellipsoid so that it touches the surface along the great circle path chosen for the central line, instead of along the Earth's equator. Scale becomes infinite 90 degrees from the central line and is true along a chosen central line, along two straight lines parallel to the central line, or along a great circle at an oblique angle. The Oblique Mercator projection is used for geographic regions that are centered along lines that are neither meridians nor parallels, but that may be taken as great circle routes passing through the region, such as the Alaskan panhandle. In this variation of the Oblique Mercator projection, two points define the central line where the cylinder touches the ellipsoid.

The planar points determined by this projection may be left unrectified (often these are referred to as the u, v coordinates in published formula) or they may be rectified (often these are referred to as the x, y coordinates in published formula). Rectification consists of rotating the coordinates by a certain angle. This implementation of the Oblique Mercator projection allows for a flag to be set to determine if the points should be rectified, or not. By default, the points will be rectified. If an unrectified version of the projection is desired, the *Unrectified Flag* parameter should be set to 1.

In the case where the points are rectified, the angle of rotation may be one of three values. Most commonly, it may be a user-specified rotation, or a rotation such that the y-axis will be parallel to the meridian through the center of the projection (the angle used in this case is often referred to in published formula as alpha). Less commonly, it may be a rotation such that the y-axis will be parallel to the meridian through the natural origin of the projection (the angle used in this case is often referred to in published formula as gamma). If the *Rotation Angle* parameter is a non-zero number, it will be used in the rectification. If the *Rotation Angle* is zero, the default behavior will be to rectify so that the y-axis will be parallel to the meridian through the center of the projection. If it is desired that the rectification cause the y-axis to be parallel to the meridian through the natural origin of the projection, the **Use Gamma Flag** parameter should be set to 1.

Oblique Mercator Two Point projection parameters:

- *Latitude of the Origin of the Projection*
- *Latitude of the First Point*
- *Longitude of the First Point*
- *Latitude of the Second Point*
- *Longitude of the Second Point*
- *False Easting*
- *False Northing*
- *Rotation Angle (Defaults to 0)*
- *Unrectified Flag (Defaults to 0)*
- *Use Gamma Flag (Defaults to 0)*

ORTHOGRAPHIC

The Orthographic projection closely resembles a globe in appearance, since it is a perspective projection from infinite distance. Only one hemisphere can be shown at a time. This projection is used chiefly for pictorial views and is used only in spherical form.

Orthographic projection parameters:

- *Central Meridian*
- *False Northing and False Easting*
- *Latitude of the Center of the Projection*
- *Radius of the Sphere* (use 0 as default)

The Radius of the Sphere parameter is only used for legacy support. When set to 0, the semi-major axis of the ellipsoid specified in the coordinate system datum definition.

The Orthographic projection is an hemispheric projection (valid for half the globe). Therefore, the map or image should be cropped to an extent centered on the central meridian with -90°/+90° range prior to transforming to a coordinate system using this projection.

NOTE: Only a spherical form of this projection is used.

PERSPECTIVE CONIC

The Perspective Conic projection is produced by projecting the Earth perspectively from the center (or from some other point) onto a tangent or secant cone, along the standard parallels. The meridians are equally spaced straight lines converging at a common point representing one of the poles. The parallels are represented as unequally spaced concentric circular arcs centered on the pole of convergence of the meridians. The other pole may not be represented on the projection, though in some cases it may appear as a circular arc. Along the standard parallels scale is true and there is no distortion. Other conformal or equal-area conics demonstrate less rapid distortion in a north-south direction, however, and are preferred to the Perspective Conic.

Perspective Conic projection parameters:

- *Longitude of the Center of the Projection*
- *Latitude of Northern Standard Parallel*
- *False Northing*
- *Latitude of Southern Standard Parallel*
- *False Easting*

POLAR STEREOGRAPHIC

The Polar Stereographic projection somewhat resembles other polar azimuthal projections, with straight radiating meridians and concentric circles for meridians. This projection is used for polar mapping within the Universal Polar Stereographic (UPS) coordinate system.

Three variants of the Polar Stereographic projection are recognized, differentiated by their defining parameters. This projection definition applies for the variant A and B:

- In the basic variant (**variant A**) the latitude of origin is either the north or the south pole, at which is defined a scale factor at the natural origin, the meridian along which the northing axis increments and along which intersecting parallels increment towards the north pole (the longitude of origin), and false grid coordinates.
- In **variant B** instead of the scale factor at the pole being defined, the (non-polar) latitude at which the scale is unity – the standard parallel – is defined.
- In **variant C** the latitude of a standard parallel along which the scale is unity is defined; the intersection of this parallel with the longitude of origin is the false origin, at which grid coordinate values are defined.

Polar Stereographic projection parameters:

- *False Northing and False Easting*
- *Latitude of the Center of the Projection*
- *Longitude of the Center of the Projection*
- *Scale Reduction Factor at the Center of the Projection*

Variant A: the *Scale Factor* must be a value other than 1. In this variation, the *Latitude of Origin* is used only to identify the hemisphere the projection, and thus the only valid values are ±90° or the equivalent in an alternate angle unit.

Variant B: the *Scale Factor* must be equal to 1, and will thus be ignored. The actual scaling factor will be calculated by using the value of the *Latitude of Origin* parameter which in this case actually represents the latitude of the standard parallel (i.e. the latitude of true scale). In this case, the sign of the latitude is likewise used to determine the hemisphere of the projection.

POLAR STEREOGRAPHIC VARIANT C

The Polar Stereographic Variant C projection correspond to the third variant of the Polar Stereographic projection described above.

Polar Stereographic Variant C projection parameters:

- *False Northing and False Easting*
- *Longitude of the Center of the Projection*
- *Latitude of the Center of the Projection*

POLYCONIC

The Polyconic projection is neither an equal-area nor a conformal projection. Scale is true along each parallel and along the central meridian. Parallels of latitude are arcs of non-concentric circles and the projection is free of distortion only along the central meridian. The Polyconic projection can be used to represent small areas on any part of the globe, preserving shapes, areas, distances, and azimuths in their true relation to the surface of the Earth. Polyconic projections over large areas usually result in serious errors and exaggeration of details.

Polyconic projection parameters:

- *False Northing and False Easting*
- *Latitude of the Center of the Projection*
- *Longitude of the Center of the Projection*

POPULAR VISUALISATION PSEUDO-MERCATOR

The Popular Visualisation Pseudo-Mercator projection is utilized by some popular web mapping and visualization applications (such as Google Earth).

This projection is very similar to a standard Mercator projection (spherical case). It applies standard Mercator (Spherical) formulas to ellipsoidal coordinates and the sphere radius is taken to be the semi-major axis of the ellipsoid. This approach only approximates to the more rigorous application of ellipsoidal formulas to ellipsoidal coordinates.

Unlike either the spherical or ellipsoidal Mercator projection methods, this method is not conformal: scale factor varies as a function of azimuth, which creates angular distortion. Despite angular distortion there is no convergence in the meridian.

Popular Visualisation Pseudo-Mercator projection parameters:

- *False Northing and False Easting*
- *Latitude of origin*
- *Longitude of the Center of the Projection*

QUARTIC AUTHALIC

The Quartic Authalic projection is a pseudocylindrical, equal area projection that is used primarily for world maps. It was first presented by Karl Siemon in 1937, and then later presented independently by Oscar Sherman Adams in 1945. This projection serves as a basis for the McBryde-Thomas Flat Polar Quartic projection. The central meridian is depicted as a straight line 0.45 as long as the Equator. Other meridians are equally spaced curves, concave toward the central meridian. The parallels are straight parallel lines perpendicular to the central meridian. These are spaced farthest apart near the Equator, but gradually grow closer spaced when moving toward the poles. The poles are represented by points.

Distortion is significant near the outer meridians, at high latitudes, but is less than in the Sinusoidal projection. There is no distortion and scale is true along the Equator. Scale is constant along any given latitude.

Quartic Authalic projection parameters:

- *Longitude of Origin*
- *False Easting*
- *False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

ROBINSON

The Robinson projection provides a means of showing the entire Earth in an uninterrupted form. The Robinson projection is destined to replace the Van der Grinten projection as the premier projection used by the National Geographic Society.

Robinson projection parameters:

- *Longitude of the Central Meridian*
- *False Northing*
- *False Easting*

SINUSOIDAL

The Sinusoidal projection is pseudocylindrical and equal-area. The central meridian is a straight line. All other meridians are shown as equally spaced sinusoidal curves. Parallels are equally spaced straight lines, parallel to each other. Poles are points. Scale is true along central meridian and all parallels. The Sinusoidal projection is used for maps of South America and Africa.

Sinusoidal projection parameters:

- *Longitude of the Central Meridian*
- *False Northing*
- *False Easting*

SPACE OBLIQUE MERCATOR

The Space Oblique Mercator (SOM) projection is a modified cylindrical projection with the map surface defined by a satellite orbit. The SOM is an extremely complicated projection. We urge you to refer to *Map Projections a Working Manual* by Snyder for a detailed explanation. The SOM projection was designed especially for continuous mapping of satellite imagery. The ellipsoidal form with a non-circular satellite orbit is implemented within MAPublisher and Geographic Imager.

Space Oblique Mercator projection parameters:

- *Longitude of the Center of the Projection*
- *Geodetic longitude of the ascending node at time t=0 (satellite_lon0)*
- *Length of Earth's rotation with respect to the precessed ascending node (satellite_p1)*
- *Time required for revolution of the satellite (satellite_p2)*
- *Semi-major Axis of the Satellite Orbit (satellite_a)*
- *Eccentricity of the Satellite Orbit (satellite_e)*
- *Inclination of the Satellite Orbit (satellite_incl)*
- *Longitude of the perigee relative to the ascending node (satellite_gamma)*

STEREOGRAPHIC

The Stereographic projection is the only known true perspective projection of any kind that is also conformal. The central meridian and a particular parallel (if shown) are straight lines. All other meridians and parallels are shown as arcs of circles.

Stereographic projection parameters:

- *False Northing and False Easting*
- *Longitude of the Center of the Projection*
- *Latitude of the Center of the Projection*
- *Scale Reduction Factor at the Center of the Projection.*

STEREOGRAPHIC 70

Stereographic 70 is a derivation of the Stereographic projection for use in Romania.

Stereographic 70 projection parameters:

- *False Northing and False Easting*
- *Longitude of the Center of the Projection*
- *Latitude of the Center of the Projection*
- *Scale Reduction Factor at the Center of the Projection.*

SWISS OBLIQUE MERCATOR

The Swiss Oblique Mercator projection is a particular case of an Oblique Mercator projection, which in turn differs from the Mercator and Transverse Mercator projections in that the central line with true scale is neither the equator (as in the Mercator), nor a meridian (as in the Transverse Mercator), and is chosen to suit the region to be mapped. In the Swiss Oblique Mercator this line has an azimuth of 90 degrees and contains the centre of the projection.

The **Swiss Oblique Mercator** projection has no parameters.

TILTED PERSPECTIVE

The Tilted Perspective projection represents a view of the Earth from space in which the view is from anywhere other than a point precisely facing the center of the Earth. This projection is therefore used to generate pictoral views of the Earth resembling those seen from space.

It is a modified azimuthal projection that is neither conformal nor equal area. The central meridian and a particular parallel (if shown) are straight lines. Other meridians and parallels are usually arcs of circles or ellipses, but some may be parabolas or hyperbolas. If the point of perspective is above the sphere, less than one hemisphere may be shown.

Tilted Perspective projection parameters:

- *Azimuth*
- *Tilt*
- *Longitude of Origin*
- *Latitude of Origin*
- *False Northing*
- *False Easting*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

TIMES

The Times projection is a pseudo-cylindrical projection that is neither equal area nor conformal. It was first presented by John Moir in 1965. It is used to generate the world maps in The Times Atlas of the World, produced by Collins Bartholomew. The central meridian and Equator are depicted as straight lines. All other meridians are equally spaced curves, concave toward the central meridian. The parallels are straight lines perpendicular to the central meridian, increasing in separation away from the Equator. Scale is correct along the two parallels at 45° N and S.

Times projection parameters:

- *Longitude of Origin*
- *False Easting*
- *False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

TRANSVERSE MERCATOR (GAUSS-KRUGER)

The Transverse Mercator projection is similar to the Mercator Projection, except that the axis of the projection cylinder is rotated 90 degrees from the polar axis. This projection does not have the straight meridians and straight parallels of the Mercator projection, except for the central meridian, the two meridians 90 degrees away, and the equator. Nor does the Transverse Mercator projection have the straight rhumb lines of the Mercator projection;

rather, it is a conformal projection. Scale is true along the central meridian or along two straight lines equidistant from and parallel to the central meridian. **The Transverse Mercator projection is only reasonably accurate within 15° from the central meridian, distortions appear rapidly outside of the 15° band.**

The Transverse Mercator projection is the projection used in the State Plane Coordinate System for states with predominant north-south extent. It is also the geometric basis for the UTM Coordinate System. The term Gauss-Kruger, or simply Gauss, refers to coordinate systems in parts of the world, for example, Germany and South America, based on the Transverse Mercator projection.

Transverse Mercator projection parameters:

- *False Northing and False Easting*
- *Longitude of the Central Meridian*
- *Latitude of the Origin of the Projection*
- *Scale Reduction Factor at the Central Meridian*

TRANSVERSE MERCATOR EXTENDED

This is a variation of the standard Transverse Mercator projection that is provided for the definition of coordinate systems used in specific counties in the U.S. states of Minnesota and Wisconsin. Within a specific county in one of these states, the ellipsoid must be expanded by an additional amount to account for the average elevation within that county. In the case of a Wisconsin county, the ellipsoid must also be adjusted based on the average geoid height for that county. For Minnesota counties, the average geoid height should be set to zero.

Transverse Mercator Extended projection parameters:

- *Longitude of the Central Meridian*
- *Latitude of the Origin of the Projection*
- *Scale Reduction Factor at the Center of the Projection*
- *False Easting*
- *False Northing*
- *Average Elevation (Minnesota and Wisconsin)*
- *Average Geoid Height (Wisconsin only).*

TRANSVERSE MERCATOR SNYDER

This projection is based on the description and formulae in John P. Snyder Map Projections-- A Working Manual (U.S. Geological Survey Professional Paper 1395), pp. 60-64. These formulas have been superseded by more precise versions. There are, however, some instances where users may want to use the older, less precise formulas (for example, if the results will be compared to old data).

Transverse Mercator Snyder projection parameters:

- *Longitude of the Central Meridian*
- *Latitude of the Origin of the Projection*
- *Scale Reduction Factor at the Center of the Projection*
- *False Easting*
- *False Northing*

TRANSVERSE MERCATOR SOUTH ORIENTED

This is a projection used in the southern hemisphere. It is identical to the standard Transverse Mercator, except that the false easting and northing are interpreted instead as a false westing and southing.

Transverse Mercator South Oriented projection parameters:

- *Longitude of the Central Meridian*
- *Latitude of the Origin of the Projection*
- *Scale Reduction Factor at the Center of the Projection*
- *False Easting*
- *False Northing*

TRANSVERSE MERCATOR STATE PLANE 27

The State Plane Coordinate System (SPCS) is not a projection; rather it is a system for specifying positions of geodetic stations using plane rectangular coordinates. This coordinate system that divides all fifty states of the United States, Puerto Rico and the U.S. Virgin Islands into over 120 numbered sections, referred to as zones. Each zone has an assigned code number that defines the projection parameters for the region.

There are four possible projections for SPCS. The geometric direction of each state determines the projection utilized. For states that are longer in the east-west direction, the Lambert Conformal Conic is used. States that are longer in the north-south direction use the Transverse Mercator Projection. The panhandle of Alaska, which has the sole distinction of lying at an angle, garners the use of the Oblique Mercator Projection. Conversely, Guam uses a Polyconic projection.

The formulae for these calculations are based on Publication 62-4, *State Plane Coordinates by Automatic Data Processing*, U.S. Department of Commerce 1968. These projections should only be used for data that has been computed using this method. For all other state plane calculations use Exact Methods. The parameters for these coordinate systems are defined in Publication 62-4. For further information contact the U.S. Department of Commerce.

The **Mercator 27** projection does not require any parameters.

TWO-POINT FIT

The Two-Point Fit Projection is used when a local grid needs to be converted to another coordinate system. From two known points (with both easting/northing and lat/long values for each point), the remainder of the grid values can be derived and used for coordinate conversion purposes.

Two-Point Fit projection parameters:

- *False Northing Northing and False Easting of the first point*
- *Northing and False Easting of the second point*
- *Latitude and Longitude of the first point*
- *Latitude and Longitude of the second point*

What happens is that MAPublisher and Geographic Imager takes two points (i.e. a line) from one coordinate system (lat/long for example) and THE SAME two points from a second coordinate system (e.g. local survey coordinates) and matches them. You must have TWO points that you know what the coordinates are in BOTH systems.

Example Situation:

For example: A surveyor ties into two benchmarks (BM1 = 45N, 84W and BM2 = 45 00 01N, 84W).
She starts at BM1 and calls it 10000/10000(Northing/Easting) and traverses to BM2 and gets some N/E value. You now have two points (BM1 and BM2) that have Lat/Long coordinates and Local coordinates. That is, you now have the endpoints and orientation of a common line in two coordinate systems. You need to define a new coordinate system using those two points as the references. Any scaling, rotation, etc. issues are taken care of because you have just linked two points (i.e. defined a line length and orientation in space) that are common to both coordinate systems.

UNIVERSAL TRANSVERSE MERCATOR (MAPublisher only)

The Universal Transverse Mercator (UTM) projection class is an extension of the Transverse Mercator projection class that allows all UTM zones in a given horizontal datum to be represented by a single Geodetic Datasource object.

Universal Transverse Mercator projection parameters, all of which are optional:

- *Current zone number*
- *Currently in northern hemisphere (is_north)*
- *Automatically set zone (autoset)*

The actual Transverse Mercator parameter values to use when converting between geodetic and projected coordinate are determined from the values of the zone and is_north parameters. If the autoset parameter is set to 1, then the zone and is_north parameters will be automatically recomputed each time a conversion from geodetic coordinates is performed, based on the input geodetic coordinates. Conversions from projected coordinates always use the UTM projection currently specified by the parameters.

NOTE: Military Grid Reference System (MGRS) and U.S. National Grid (USNG) coordinate systems are defined with a UTM projection and a point style with the appropriate string format option.

V AND H

V and H Projection for lat and long transform to the V[ertical] and H[orizontal] coordinates used for wired telephone (AT&T). Created by Jay K. Donald of AT&T in 1957 to simplify the calculation of distance between telephone rate centers. The system is based on Donald Elliptic Projection. It is a two-point equidistant projection for the continental United States and Canada. It uses units of the square root of one-tenth of a mile.

The **V and H** projection has no parameters.

VAN DER GRINTEN

This projection is neither conformal nor equal-area, but shows the globe enclosed in a circle. This projection is exclusively used for world maps. The central meridian and Equator are straight lines, with scale true along the equator only.

Van der Grinten projection parameters:

- *False Northing and False Easting*
- *Longitude of the Center of the Projection*
- *Radius of the Sphere*

VAN DER GRINTEN IV

This projection is neither conformal nor equal-area, but shows the globe enclosed in an apple shape. This projection is used rarely for world maps. The central meridian and Equator are straight lines, with scale true along the equator only.

Van der Grinten IV projection parameters:

- *False Northing*
- *Longitude of the Center of the Projection*
- *False Easting*
- *Radius of the Sphere*

VERTICAL PERSPECTIVE

The Vertical Perspective projection represents a view of the Earth from space in which the view is from a point precisely facing the center of the Earth. This projection is therefore used to generate pictoral views of the Earth resembling those seen from space. It is an azimuthal projection that is neither conformal nor equal area. The central meridian and a particular parallel (if shown) are straight lines. Other meridians and parallels are usually arcs of circles or ellipses, but some may be parabolas or hyperbolas. If the point of perspective is above the sphere, less than one hemisphere may be shown.

Vertical Perspective projection parameters:

- *Longitude of the Center of the Projection*
- *False Northing*
- *False Easting*
- *Latitude of the Center of the Projection*
- *Height*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

WINKEL I

The Winkel I projection is a pseudocylindrical projection that is neither conformal nor equal area. Oswald Winkel developed it in 1914 as the average of the Sinusoidal and Equidistant Cylindrical (Equirectangular) projections. It is used primarily for world maps. The central meridian is a straight line, while other meridians are equally spaced sinusoidal curves concave toward the central meridian. The parallels are equally spaced straight parallel lines perpendicular to the central meridian. The poles are represented by lines. If the latitude of true scale is chosen to be 50°28', the total area scale will be correct, though local area scales will vary.

Winkel I projection parameters:

- *Longitude of the Center of the Projection*
- *False Easting*
- *•False Northing*
- *Latitude of True Scale*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

WINKEL II

The Winkel II projection is a pseudocylindrical projection that is neither conformal nor equal area. Oswald Winkel developed it in 1918 as the average of the Mollweide and Equidistant Cylindrical (Equirectangular) projections. It is used primarily for world maps.

The central meridian is a straight line, while other meridians are equally spaced curves concave toward the central meridian. The parallels are equally spaced straight parallel lines perpendicular to the central meridian. The poles are represented by lines. The length of the poles and of the central meridian will depend on the choice of the latitude of true scale. Scale is true along the north and south latitudes specified by the latitude of true scale, but the projection is generally distorted.

Winkel II projection parameters:

- *Longitude of the Center of the Projection*
- *False Easting*
- *False Northing*
- *Latitude of True Scale*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

WINKEL TRIPEL

The Winkel Tripel projection is a modified azimuthal projection that is neither conformal nor equal area. Oswald Winkel developed it in 1921 as the average of the Aitoff and Equidistant Cylindrical (Equirectangular) projections. It is used primarily for whole world maps.

In this projection, the central meridian is a straight line. Other meridians are equally spaced along the Equator and are concave toward the central meridian. The Equator and the poles are straight lines, while all other parallels are curves, equally spaced along the central meridian and concave toward the nearest pole. Scale is true along the central meridian and constant along the Equator. Distortion is moderate, except near the outer meridians in the polar regions.

Winkel Tripel projection parameters:

- *Longitude of the Center of the Projection*
- *False Easting*
- *Standard Parallel*
- *False Northing*

NOTE: Only a spherical form of this projection is used. The semi-major axis of the ellipsoid (sphere) is used for forward and inverse projection from grid to geodetic coordinates within the system wherein this projection is incorporated.

Datum Shifts

7 PARAMETER METHODS

There are two types of seven parameter transformation available. The difference between the two is the rotation sense (which direction the rotations take place in.) This method is sometimes referred to as the Bursa-Wolfe method. The seven parameter methods incorporate three geocentric translations, three geocentric rotations, and a scale correction factor. To change parameters from one rotation sense to the other, you must simply reverse the sign of the rotation values.

The parameters to define a seven parameter transformation are:

Parameter	Often Noted as
X Translation	dX
Y Translation	dY
Z Translation	dZ
Scale	k
X Rotation	rX
Y Rotation	rY
Z Rotation	rZ
Scale	k

NOTE: To properly define a seven parameter translation, you MUST know which rotation sense is used for your transformation parameters.

The two types of rotation sense for seven parameter transformations are:

Position Vector Rotation (PVR)
The rotations are defined as positive clockwise, as may be imagined to be seen by an observer at the origin of the coordinate frame, looking in the positive direction of the axis about which the rotation is taking place.

Coordinate Frame Rotation (CFR)
Rotation is positive counter-clockwise, as may be imagined to be seen by an observer at the origin of the coordinate frame, looking in the positive direction of the axis about which the rotation is taking place.

CANADIAN NATIONAL TRANSFORMATION VERSION 2 (NTV2)

MAPublisher and Geographic Imager support the definition of a geodetic datum based on the Canadian National Transformation Version 2.0 directly. The Canadian National Transformation originally defined an accurate transformation from NAD27 to NAD83 for Canada, but the method has been adopted by Australia, New Zealand, Spain, and several other locations around the world. The shift values for a geographic area are stored in a single grid file, representing latitude and longitude shifts (named with the extension .gsb).

MAPublisher or Geographic Imager use grid files in a format published and provided by the Canadian Government. While the definition of this method is supported, it does require additional files to implement new datum transformations using this method. Contact information is as follows:

Address:	Natural Resources Canada Geodetic Survey Division Geomatics Canada Room 440 615 Booth Street Ottawa, Ontario K1A 0E9	Phone: FAX: Email: Web:	(613) 995-4410 (613) 995-3215 information@geod.NRCan.gc.ca *www.geod.NRCan.gc.ca*

ED50 TO ED87 NORTH SEA

The ED50 to ED87 North Sea Transformation consists of 4th order reversible polynomial that is used to convert coordinates between the ED50 and ED87 datums. This formula was published in a 1991 note created by the Norwegian Mapping Authority (Statens Kartverk) entitled *Om Transformasjon mellom Geodetiske Datum i Norge*. The **ED50ToED87NorthSea** transformation method is hard-coded and does not require any parameters.

FOUR PARAMETER METHOD

Based on the Helmert family of transformations, a Four parameter transformation is similar to a Seven parameter transformation, except it does not include rotations.

Parameters needed to define a four parameter transformation are:

Parameter	Often Noted as
X Translation	dX
Y Translation	dY
Z Translation	dZ
Scale	k

GEOCENTRIC TRANSFORMATIONS

A three-parameter translation between two geocentric coordinate systems. This is a non-simplified Molodensky transformation. There are three steps that are performed by this transformation. First the input point is represented as a Cartesian point in three dimensions on the input datum. The coordinates of this point are then translated using the dx, dy, and dz parameters. Finally, the translated point is represented converted to a geodetic point on the output datum.

HARN

MAPublisher and Geographic Imager support the definition of a geodetic datum based on a NGS High Accuracy Reference Network (HARN). The National Geodetic Survey is establishing HARNs within the U.S. on a state-by-state basis.

You can think of a HARN as a geodetic datum, most easily viewed as an enhanced NAD83 datum. HARNs are also known as NAD83/91 and High Precision Grid Networks (HPGN). The NGS HARN method is actually very similar to the NGS NADCON method. As with the NADCON method the shift values for a geographic area are stored in a set of grid files, one representing latitude shifts (named with the extension .las) and one representing longitude shifts (named with the extension .los). The major difference is that the HARN data files contain shifts from NAD83 to a HARN instead of NAD27 to NAD83. MAPublisher and Geographic Imager use grid files in a format published and provided by the National Geodetic Survey. Questions about the availability of other HARN grid files (and the HARN systems in general) should be addressed to:

Address:	NGS Information Services, NOAA, N/NGS12 National Geodetic Survey SSMC-3, #9202 1315 East-West Highway Silver Spring, MD 20910-3282	Phone: Web:	(301) 713-3242 *www.ngs.noaa.gov*

The current HARNs are already pre-defined within MAPublisher and Geographic Imager. As new HARNs are completed and made available, they will be added to avenza.xml.

LONGITUDE ROTATION

The Longitude Rotation datum shift method is a transformation on a two-dimensional or three-dimensional geographic coordinate system that changes the longitude values by a rotation value and leaves the latitude and elevation values unchanged.

The one parameter to define a longitude rotation is the angle of rotation.

MOLODENSKY TRANSFORMATIONS

The Molodensky transformation method shifts coordinate values between local and geocentric datums using three linear shift parameters. It provides a general solution with limited accuracy. The Molodensky method provides a transformation that is accurate to within 5-10 metres. For a detailed discussion of the Molodensky algorithms and parameters for a variety of local geodetic datums, please refer to: Defense Mapping Agency, Technical Report TR 8350.2, 1991 *Department of Defense World Geodetic System 1984: Its Definition and Relationships with Local Geodetic Systems.* The Molodensky method can be defined for local geodetic datums worldwide.

MRE (MULTIPLE REGRESSION EQUATIONS)

The DMA Multiple Regression Equations transformation method shifts coordinate values between geodetic datums. It can be defined for local geodetic datums worldwide. The DMA Multiple Regression Equations method uses Doppler-derived parameters and provides a general solution with limited accuracy. It provides a transformation

that is accurate to within 3-10 metres.
For a detailed discussion of the DMA Multiple Regression Equations algorithms and parameters for a variety of local geodetic datums, please refer to Defense Mapping Agency Technical Report TR 8350.2, 1991*Department of Defense World Geodetic System 1984: Its Definition and Relationships with Local Geodetic Systems*.

The main advantage of the DMA Multiple Regression Equations method lies in the modeling of distortions for datums that cover continental-sized land areas. This achieves a better fit in geodetic applications than the Molodensky method.

NOTE: The DMA Multiple Regression Equations method is an application of the theory of least squares. The coefficients for the mathematical regression equations are determined by fitting a polynomial to predicted shifts in a local area. If the DMA Multiple Regression Equations method is applied outside of the local area for which the coefficients of the equations are determined, the results may be unpredictable.

NADCON METHOD

The NGS NADCON method transforms coordinate values between the North American Datum of 1927 (NAD 27) and the North American Datum of 1983 (NAD 83). The NGS NADCON method provides a transformation that is accurate to within 0.15-0.5 metres. (Please refer to NOAA Technical Memorandum NOS NGS-50 *NADCON - The Application of Minimum Curvature-Derived Surfaces in the Transformation of Positional Data from the North American Datum of 1927 to the North American Datum of 1983*).

The NGS NADCON method applies a simple interpolation algorithm using a gridded set of standard datum shifts as parameters. The shift values for a geographic area are stored in a set of grid files, one representing latitude shifts (named with the extension .las) and one representing longitude shifts (named with the extension .los). MAPublisher and Geographic Imager use grid files in a format published and provided by the National Geodetic Survey. Questions about the availability of other NADCON grid files (and the NGS NADCON method in general) should be addressed to:

Address:	National Geodetic Survey 11400 Rockville Pike Rockville, MD 02852	Phone: Web:	(301) 713-3242 *www.ngs.noaa.gov*

NTF TO RGF93

Converts coordinates from NTF (Nouvelle Triangulation de la France) to RGF93 (Réseau Géodesique Français) using a grid file defined by IGN (*Institut Géographique National*, the French National Geographical Institute). The default grid file assumes a Greenwich prime meridian.

ORDNANCE SURVEY GRID (OSTN 02)

To cope with the distortions in the OSGB36 TRF, different transformations are needed in different parts of the country. For this reason, the national standard datum transformation between OSGB36 and ETRS89 is not a simple Helmert datum transformation. Instead, Ordnance Survey has developed a rubber-sheet type transformation which works with a transformation grid expressed in easting and northing coordinates. The grids of northing and easting

shifts between ETRS89 and OSGB36 cover Britain at a resolution of one kilometre. From these grids a northing and easting shift for each point to be transformed is obtained by a bi-linear interpolation.
The National Grid Transformation copes not only with the change of datum between the two coordinate systems, but also with the TRF distortions in the OSGB36 triangulation network, which make a simple datum transformation of the Helmert type limited to applications at 5m and larger accuracy levels. This transformation removes the need to estimate local Helmert transformations between ETRS89 and OSGB36 for particular locations.

Because the National Grid Transformation works with easting and northing coordinates, other ETRS89 coordinate types (3-D Cartesian or latitude and longitude) must first be converted to eastings and northings. This is done using the same map projection as is used for the National Grid (see section 7 below), except that the GRS80 ellipsoid rather than the Airy ellipsoid is used. After the transformation, the resulting National Grid eastings and northings can be converted back to latitude and longitude (this time using the Airy ellipsoid) if required.

POLYNOMIAL

The Polynomial datum shift methods uses a collection of parameters which define a high order mathematical function for transforming between two horizontal datums. These equations are usually created by local and regional geodetic authorities. They generally provide high accuracy transformations, but are limited to specific areas of use. In many cases the accuracy of these transformations is around one metre.

For a detailed description of generalized polynomial datum transformations, please refer to the OGP guidance notes. These are freely available from *www.epsg.org*.

NOTE: Polynomial datum shifts are generally computed for specific areas of use. Since the derivations of the formula are based on a limited number of reference points, using the transformation for data outside of the pre-determined envelopes may cause unreliable results.

SIX PARAMETER METHOD

Based on the Helmert family of transformations, the six parameter transformation is very similar to a seven parameter transformation, except it does not contain a scale parameter.

The Six parameters needed, are:

Parameter	Often Noted as
X Translation	dX
Y Translation	dY
Z Translation	dZ
Scale	k
X Rotation	rX
Y Rotation	rY

Parameter	Often Noted as
Z Rotation	rZ

TEN PARAMETER MOLODENSKY-BADEKAS METHOD

The Molodensky-Badekas 10 parameter transformation method allows for very high accuracy transformation of coordinates between datums over large areas. For a detailed reference on Molodensky-Badekas coordinate transformations, refer to the EPSG Surveying and Positioning Guidance Note Number 7, part 2: *www.epsg.org/guides/G7-2.html.*

Parameters needed to define a 10 parameter transformation are:

Parameter	Often Noted as
X Translation	dX
Y Translation	dY
Z Translation	dZ
Scale	k
X Rotation	rX
Y Rotation	rY
Z Rotation	rZ
Scale	k
X Ordinal	X
Y Ordinal	Y
Z Ordinal	Z

TOKYO TO JGD2000

Converts coordinates from the Tokyo datum to the JGD 2000 (Japan Geodetic Datum of 2000) using a grid file defined by GSI (Japanese Geographical Survey Institute).

UTM Map Zones

UTM Zone	Central Meridian	Longitude Range
1	177W	180W-174W
2	171W	174W-168W
3	165W	168W-162W
4	159W	162W-156W
5	153W	156W-150W
6	147W	150W-144W
7	141W	144W-138W
8	135W	138W-132W
9	129W	132W-126W
10	123W	126W-120W
11	117W	120W-114W
12	111W	114W-108W
13	105W	108W-102W
14	99W	102W-96W
15	93W	96W-90W
16	87W	90W-84W
17	81W	84W-78W
18	75W	78W-72W
19	69W	72W-66W
20	63W	66W-60W
21	57W	60W-54W
22	51W	54W-48W
23	45W	48W-42W
24	39W	42W-36W
25	33W	36W-30W
26	27W	30W-24W
27	21W	24W-18W
28	15W	18W-12W
29	9W	12W-6W
30	3W	6W-0
31	3E	0-6E
32	9E	6E-12E
33	15E	12E-18E
34	21E	18E-24E
35	27E	24E-30E
36	33E	30E-36E
37	39E	36E-42E
38	45E	42E-48E
39	51E	48E-54E
40	57E	54E-60E
41	63E	60E-66E
42	69E	66E-72E
43	75E	72E-78E
44	81E	78E-84E
45	87E	84E-90E
46	93E	90E-96E
47	99E	96E-102E
48	105E	102E-108E
49	111E	108E-114E
50	117E	114E-120E
51	123E	120E-126E
52	129E	126E-132E
53	135E	132E-138E
54	141E	138E-144E
55	147E	144E-150E
56	153E	150E-156E
57	159E	156E-162E
58	165E	162E-168E
59	171E	168E-174E
60	177E	174E-180E