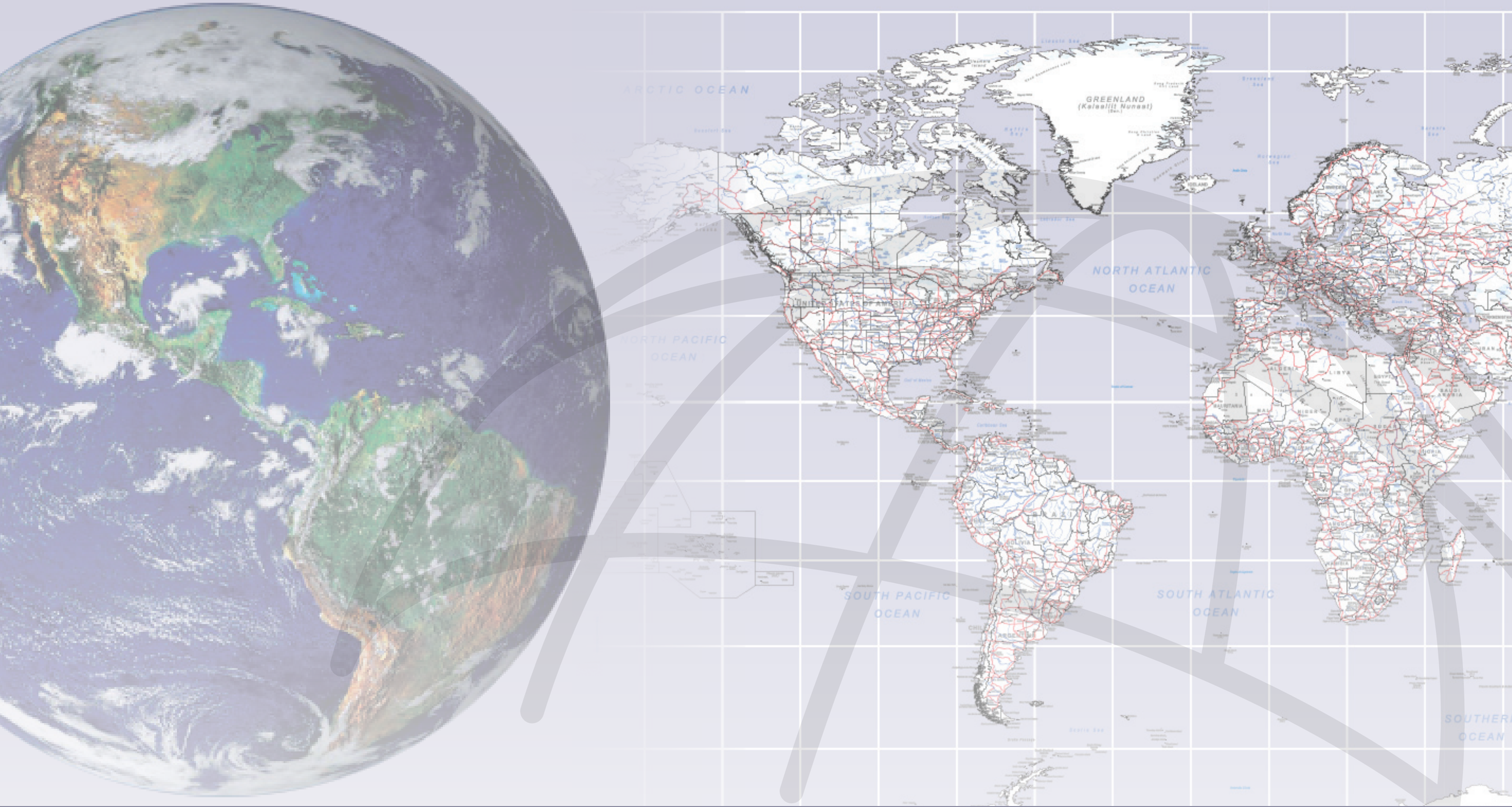
GEOGRAPHIC IMAGER®

for Adobe® Photoshop®

MAPublisher® 8

for Adobe® Illustrator®



Projections Guide

Avenza® SYSTEMS INC.

Microsoft Windows

Mac OS

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 coordinate 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 coordinate systems are readily available for use in most cartographic projects. Even though the current list of systems is comprehensive, there may be instances where users may wish to add a brand new coordinate system to meet their particular needs, or perhaps to duplicate and modify an existing definition. Appendix 2 of the MAPublisher User Guide and Chapter 4 of the Geographic Imager User Guide show in detail how to use the Geodetic Datasource interface to perform these operations.

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

Contents

Mapping Fundamentals

Most maps are representations of the Earth upon a flat surface, designed to convey spatial information of various type.

An accurate map depends upon a precise knowledge of the Earth's shape (geodesy) and the mathematical mechanisms required to convey spherical coordinates to a flat medium (paper or computer screen). These referencing properties form the map coordinate system.

When opening geographic data in MAPublisher or Geographic Imager, coordinate systems are applied so that different dataset can be matched together geographically or transformed to a new reference specified by the user.

This chapter describes the fundamentals of map projections and coordinate systems.

Concepts

COORDINATE SYSTEMS

Coordinate systems are a fundamental concept associated with spatial data. When mapping the Earth's terrain and natural and cultural features, it is important that all mapped objects be accurately located with respect to an accepted geographic frame of reference. This is particularly important when spatial data from multiple sources are being integrated. If any of the spatial data sets are not accurately defined in an accepted frame of reference, then gaps, overlaps, and mismatches will occur. Several reference systems include: geodetic, geocentric, and map projection.

Geodetic coordinates, for specifying point locations relative to the Earth's surface, are: latitude, longitude and height. These coordinates all depend upon a reference ellipsoid for their basis. Latitude and longitude are horizontal components, while the vertical component is height.

Geocentric coordinates are three dimensional x,y,z Cartesian system that provides an Earth-centered definition of position, independent of any reference surface. This system has its x,y plane in the plane of the equator with the z-axis extending through the north pole. This system is not frequently used in general cartography.

Maps are representations of the Earth's surface on a flat, two-dimensional surface such as a sheet of paper or a computer display. It is impossible to represent a curved shape to a two-dimensional medium without distortion. Map projections are created to accomplish this with a carefully defined and understood amount of distortion. A map projection can preserve some properties at the expense of other properties, but not all of them simultaneously. Distortions of conformality, distance, direction, scale, or area always result from map projections. The main properties of map projections are listed below.

PROJECTION PROPERTIES

Conformal: 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. It preserves the *shape* of areas.

Equal area: This refers to the ratio between the area on the map and the area on the Earth. A constant proportion between areas on the map and ground can be made possible by compensating the scale so that it varies across the map

Equidistant: Equidistant maps show true distances (or correct scale) only from the centre of the projection or along a special set of lines.

True Direction (azimuthal): A map preserves direction when azimuths (angles from a point on a line to another point) are portrayed correctly in all directions.

Perspective: some azimuthal projections are true perspective, that is to say they can be constructed mechanically, projecting the surface of the Earth by extending lines from a point of perspective onto the plane.

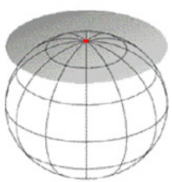
Compromise: some projections offer a compromise of several properties (e.g. the projection *Equidistant Conic* is not conformal, perspective, or equal area, but a compromise between *Lambert Conformal Conic* and *Albers Equal Area Conic*).

Straight Rhumb: A rhumb line is a line on the surface of the Earth cutting all meridians at the same angle. A rhumb line shows true direction. Parallels and meridians, which also maintain constant true directions, may be considered special cases of the rhumb line. A rhumb line is a straight line on a Mercator projection. A straight rhumb line does not show the shorter distance between points unless the points are on the Equator or on the same meridian.

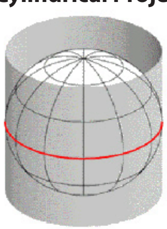
Some other map properties related to the projection are:

- **Scale**: The relationship between a distance portrayed on a map and the same distance on the Earth.
- **Accuracy**: Depending on how much of the Earth is being mapped and how the distortion is arranged. If it is a small region of the Earth's surface, the curvature is slight and therefore a slight scale distortion will result. A cartographer must place more accurate distances where they are most important to the user or to the purpose of the map. The coverage scale and maximum scale error (greatest departure from 1.0) are factors to be considered.

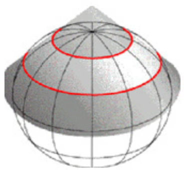
PROJECTION CATEGORIES



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 or perspective projection), or at some other point along the line defined by the tangent point and the centre 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.



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.

Miscellaneous Projections: There is a large set of projections that are modifications of the other three traditional groups. For example the Sinusoidal is called a *pseudocylindrical* 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. Another type of projection is called *lenticular* (lens shaped), where meridians and parallels curve toward the poles and maintain or decrease their distances from each other going from the centre to the edges of the map. Many other useful types of projections are difficult to categorize and can be called simply *miscellaneous* (some can be named pseudoazimuthal, polyconic, polycylindrical, pseudoconic, and so on.)

DATUMS AND ELLIPSOIDS OVERVIEW

An ellipsoid is a mathematical object 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. Historically a series of control points are used to build the mathematical model that best fits the Earth shape locally. 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.

MAP SCALE

$$\text{Map Scale} = \frac{\text{Map Distance}}{\text{Ground Distance}}$$

Representative Fraction
e.g. 1:25,000

A map scale is the ratio of the distance on the map face and the actual real world ground distance. The scale ratio is commonly referred to as a representative fraction—one unit on the map is equal to *x* units on the Earth.

A large scale map (e.g. 1:10,000) covers a smaller portion of the Earth is covered. It will have more detail and in effect it is zoomed in on an area (like a city). A small scale map (e.g. 1:1,000,000) covers a larger area of the Earth. On a small scale map features appear to be smaller, as the map is in effect zoomed out (to view a country). The effectiveness of the scale determines how successful the map is in communicating the desired information to the user.

Large scale map

- Features are larger
- More detail
- Covers a smaller geographic area
- More variety in map content
- Less generalization of features

Small scale map

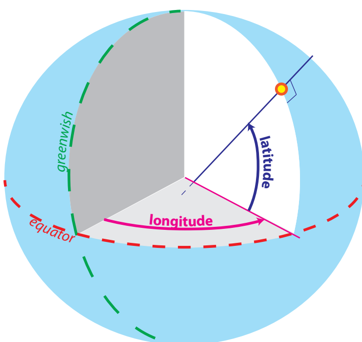
- Features are smaller
- Less detail
- Covers a larger geographic area
- Less variety in map content
- More generalization of map features

Common Coordinate Systems Classes

The two types of coordinate systems supported by MAPublisher and Geographic Imager are geodetic and projected systems:

- Geodetic systems are described below in detail.
- There is almost limitless ways to define projected system, they are based on a projection (i.e. mathematics formulas) and associated parameters. Each projection and set of parameters creates a different "projected system". The chapter 3 of this document describes the supported projections and their parameters — users can create custom systems by entering their own parameters, or use the pre-defined coordinate systems provided in the Geodetic Data Source (see Appendix 2 of MAPublisher User Guide and Chapter 4 of Geographic Imager User Guide). Two common projected coordinate systems classes are Universal Transverse Mercator system and US State Plane. Both are described here.

GEODETIC



A geodetic coordinate system is a three-dimensional coordinate system defined by an ellipsoid, the equatorial plane of the ellipsoid 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.

PROJECTED: UNIVERSAL TRANSVERSE MERCATOR

The Universal Transverse Mercator (UTM) system is an international system developed by the U.S. Army Corps of Engineers in the 1940s. This system extends around the globe from 84 degrees north to 80 degrees south and divides the world 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.

Note: A map of the UTM zones is provided in Appendix of this guide.

Each UTM zone uses a different coordinate system as reference. All of them are based on the *Transverse Mercator* projection, but with a different Central Meridian parameter (the False Easting and False Northing parameters may also vary).

In MAPublisher and Geographic Imager, the coordinate system definition of each zone can be found in the *Specify Coordinate System* dialog box under **Coordinate Systems > Projected > UTM**. Different versions of each UTM zone coordinate system can be found in subfolders organized by base geodetic datum and distance unit.

The standard unit of the UTM system is the metre, and the most commonly used geodetic base is WGS84. These definitions are found under **Coordinate Systems > Projected > UTM > WGS8**4, the coordinate system names match the zone names and extents — e.g. *UTM zone 10N (126W to 120W)*.

PROJECTED: US STATE PLANE

The "State Plane Coordinate System" (SPCS) convention 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 projected coordinate system defined by a projection and its parameters for the region. Each zone coordinate system can be found in MAPublisher and Geographic Imager library.

There are four 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 has the sole distinction of lying at an angle, garners the use of the *Oblique Mercator* projection, while Guam uses a *Polyconic* 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.

Note: A map of the US State Plane zones is provided in Appendix of this guide.

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. 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.

In the MAPublisher and Geographic Imager coordinate systems library, the different versions of the US State Plane system can be found in the folder **Coordinate Systems > North America > United States:**

- The **US State Plane NAD27** folder contains the coordinate system definition for each zone (sorted by zone name) - for each coordinate system, the distance unit is set to US foot.
- The **US State Plane NAD83** folder contains sub-categories for each different version of the system: different unit, or NAD83 versions. The most common version used are in *NAD83 (Meters)* or *NAD83 (US Feet)*. In all cases, the coordinate system definitions are sorted by zone name.

2

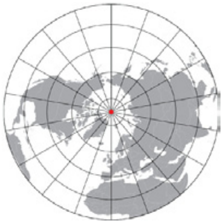
Projections Summary

There is no "best" projection to use as every projection has its own set of advantages and disadvantages. The mapmaker must select the most appropriate for each situation, choosing a projection that reduces distortion of the most important features.

This chapter gives the key properties, characteristics, and preferred uses of the projections available in MAPublisher and Geographic Imager in an effort to assist map makers in their selection of an adapted projection.

Properties for a given projection are indicated with ●. Properties that are partially valid are indicated with ⦸.

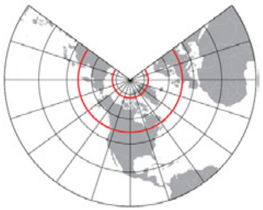
Detailed information for each projection is provided in the chapter 3.



Azimuthal Projections

	Conformal	Equal area	Equidistant	True direction	Perspective	Compromise	Straight Rhumbs	Spherical only	Usage
Azimuthal Equal Area		●		⊘					Hemisphere, continent, regional maps. Not really for large scale
Polar Azimuthal Equal Area		●		⊘					Polar areas
Azimuthal Equidistant			⊘	⊘					Can be used for world maps but usually for hemisphere. Works on large scale maps
Polar Equidistant			⊘	⊘					Polar navigation map
Double Stereographic	●			⊘	●				Large scale maps - New Brunswick and the Netherlands
European Stereographic	●			⊘	●				Large scale maps of the Netherlands
Gnomic				⊘	●			●	Navigational maps.
Guam			⊘	⊘					Maps of Guam island
Orthographic				⊘	●			●	Aesthetic hemispherical maps
Polar Stereographic	●			⊘					Polar areas
Polar Stereographic Variant C	●			⊘					Polar areas
Stereographic	●			⊘	●				Hemispherical maps
Stereographic 70	●			⊘	●				Maps of Romania
Vertical Perspective				●	●			●	Represent view of Earth from space

● = Yes
⊘ = Partially



Conic Projections

	Conformal	Equal area	Equidistant	True direction	Perspective	Compromise	Straight Rhumbs	Spherical only	Usage
Albers Equal-Area Conic		●							Maps of regions with predominant east-west extent - small extents or countries but not continents
Belgium 72	●			⦸					Maps of Belgium
Bipolar Oblique Conic Conformal	●								Maps of North and South America together
Bonne		●	⦸	⦸					Atlas maps of continents and topographic mapping in some countries
Equidistant Conic			⦸						Atlases of small countries
*Guam 27 **			⦸			●			*Deprecated projection - Guam data*
IMW Polyconic			⦸			●			Large scale maps
Krovak †						●			*Map data of Czech Republic and Slovak Republic*
Lambert Conformal Conic (2 parallels)	●			⦸					US State plane
Lambert Conformal Conic Extended	●			⦸					Maps of counties in Wisconsin and Minnesota
*Lambert 27 **	●			⦸					*Deprecated projection - US state plane*
Lambert Tangent	●			⦸					Maps of France
Perspective Conic			⦸			●		●	Aesthetic maps of the Earth
Polyconic			⦸			●			USGS 7.5 and 15 minutes quad sheets.

* Deprecated projection: use only for importing data to be transformed to a more current projection.

† Not recommended for cartographic purpose: use only to import or export data using this projection. See details in next chapter.

● = Yes
⦸ = Partially

Cylindrical Projections

	Conformal	Equal area	Equidistant	True direction	Perspective	Compromise	Straight Rhumbs	Spherical only	Usage
*Alaska 27**	●								*Deprecated projection - US state plane*
Behrmann		●		⦸					World maps
Cassini						●			Large–scale maps of areas predominantly north–south in extent
Danish System 34 †	●								*Map data of Denmark*
Danish System 34 1999 †	●								*Map data of Denmark*
Egyseges Orszagos Vetulet (EOV)									Hungarian civilian base maps and spatial informatics
Equal-Area Cylindrical		●		⦸					Equatorial regions
Equidistant Cylindrical	●								City maps or small area maps
Gall Peters		●		⦸					World map
Gall Stereographic	⦸	⦸	⦸	⦸				●	World map
*Hotine Oblique Mercator (1 Point) **	●							●	*Deprecated projection*
*Hotine Oblique Mercator (1 Point) Method 2 **	●							●	*Deprecated projection*
*Hotine Oblique Mercator **	●							●	*Deprecated projection*
Hyperbolic Cassini-Soldner						●			Maps of Island of Vanua Levu, Fidji
Laborde	●								Maps of Madagascar
Mercator	●			⦸			●		Standard sea navigation charts. Aeronautical, wind, current maps, conformal world maps
Miller Cylindrical						●		●	World maps

* Deprecated projection: use only for importing data to be transformed to a more current projection.

† Not recommended for cartographic purpose: use only to import or export data using this projection. See details in next chapter.

● = Yes
⦸ = Partially

	Conformal	Equal area	Equidistant	True direction	Perspective	Compromise	Straight Rhumbs	Spherical only	Usage
Oblique Mercator Azimuth	●								Conformal mapping of regions that have an oblique orientation
Oblique Mercator Two Points	●								Conformal mapping of regions that have an oblique orientation
Popular Visualisation Pseudo-Mercator				⦸			●	●	Projection used in Google Earth/Map
Space Oblique Mercator †	●								*Continuous mapping of LANDSAT satellite imagery*
Swiss Oblique Mercator	●								Maps of Switzerland
Transverse Mercator	●								UTM zones US State plane (N-S zones) Maps of Germany or South America USGS 7 1/2 minute quad sheets Topo maps
Transverse Mercator Extended	●								Minnesota and Wisconsin counties
Transverse Mercator Snyder †	●								*Old USGS maps*
Transverse Mercator South Oriented †	●								*South hemisphere large scale maps*
*Transverse Mercator 27 **	●								*Deprecated projection - US state plane*
Universal Transverse Mercator †	●								*Not recommended - use only for specific data format within one cell of the system*

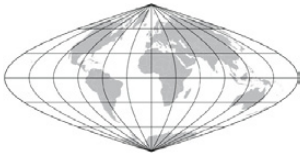
* Deprecated projection: use only for importing data to be transformed to a more current projection.

† Not recommended for cartographic purpose: use only to import or export data using this projection. See details in next chapter.

● = Yes
⦸ = Partially

Miscellaneous Projections

PSEUDOCYLINDRICAL PROJECTIONS



	Conformal	Equal area	Equidistant	True direction	Perspective	Compromise	Straight Rhumbs	Spherical only	Usage
Craster Parabolic	⦸	●	⦸	⦸				●	Thematic world maps
Eckert I	●		⦸					●	Novelty maps
Eckert II		●	⦸					●	Novelty maps
Eckert III			⦸			●		●	Thematic maps of the world
Eckert IV						●		●	Thematic maps of the world (climate)
Eckert V			⦸			●		●	Thematic maps of the world
Eckert VI						●		●	Thematic maps of the world
Goode Homolosine		●						●	World maps
Loximuthal						●	●	●	Display of loxodromes (rhumb lines)
McBryde-Thomas Flat-Polar Quartic		●						●	Thematic world maps
Mollweide		●				●		●	Thematic or distribution maps
Quartic Authalic		●						●	Thematic world maps
Robinson						●			Thematic world maps
Sinusoidal		●	⦸						World maps, maps of South America and Africa
Times						●		●	World maps
Winkel I						●		●	World maps
Winkel II						●		●	World maps

● = Yes
⦸ = Partially

LENTICULAR PROJECTIONS

	Conformal	Equal area	Equidistant	True direction	Perspective	Compromise	Straight Rhumbs	Spherical only	Usage
Aitoff						●		●	World maps only
Hammer Aitoff		●		⦸				●	Thematic world maps
Winkel Tripel						●		●	World maps only

● = Yes
⦸ = Partially

OTHER MISCELLANEOUS PROJECTIONS

	Conformal	Equal area	Equidistant	True direction	Perspective	Compromise	Straight Rhumbs	Spherical only	Usage
Fuller (Dymaxion) †						●		●	*Not recommended - use only for specific data format within one cell of the system*
Military Grid Reference System †	●								*Not recommended - use only for specific data format within one cell of the system*
New Zealand Map Grid	●					●			Large-scale maps of New Zealand
Tilted Perspective					●	●		●	Represent view of Earth from space
Two-Point Fit †						●			*Very large scale maps (surveying)*
V and H †						●			*AT&T Canada and USA maps*
Van der Grinten						●		●	World maps
Van Der Grinten IV						●		●	World maps (rarely used)

† Not recommended for cartographic purpose: use only to import or export data using this projection. See details in next chapter.

● = Yes
⦸ = Partially

3

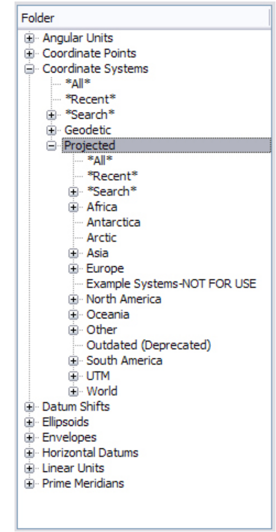
Avenza Supported Projections

This chapter provides detailed information on the projections supported by MAPublisher and Geographic Imager.

This information is valuable to understand the pre-defined coordinate systems installed with the software, or to create new custom coordinate systems.

Avenza Projections Introduction

A coordinate system within MAPublisher defines a mathematical model to represent a specific location on the Earth as a set of coordinates. A model is specified by the coordinate system parameters, including the Earth model (ellipsoid or datum), the units used to measure the coordinates, the projection type, and any parameters specific to the projection type.



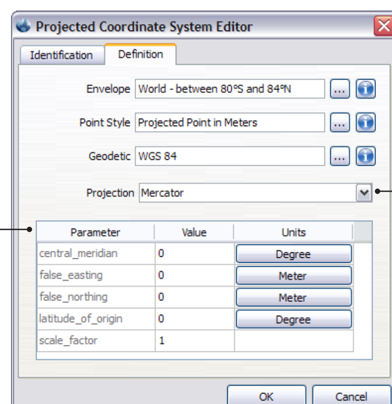
Within MAPublisher and Geographic Imager, coordinate systems are organized in coordinate system categories (**Geodetic** or **Projected**). This structure allows grouping into a logical collection for convenience (per continent, country or local sub-divisions).

In projected coordinate systems, the map **projection** provides the mathematical formulas used to convert a three-dimensional geodetic coordinate system (latitude, longitude) to a two-dimensional flat projected coordinate system (x,y). The transformation a projection will perform is determined by a set of parameters. Some projections have fixed parameters (e.g. *Gall Peters* projection has a standard parallel fixed at 45°N). But, in general, projections have several variable parameters that will be described in this chapter.

In MAPublisher and Geographic Imager, the projection is indicated or selected in the **Definition** tab of the **Projected Coordinate System Editor*** (accessed by clicking the information button or when creating a new coordinate systems). Depending on the selected projection, a different list of mandatory parameters will appear.

** For more information, refer to the MAPublisher (appendix 2) or Geographic Imager (chapter 4) User Guides.*

For pre-defined coordinate systems provided by Avenza Systems, the *envelop* is a good indication of the geographical area of validity of the system (although it does not always have to be limited to it). For projected systems, the *central meridian* and/or *latitude of origin* values are also a good indication (e.g. a central meridian of 0° indicates a European and African centered map, while a central meridian of -100 would be centered on the Americas).



Parameters - Specific parameters required for the selected projection.

Value - Parameter value.

Units - Unit of the parameter's value. Click on the button to make a selection.

Projection- List of supported projections.

Azimuthal Projections

AZIMUTHAL EQUAL AREA

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

This projection provides an optional parameter that will rotate the planar coordinates by the specified amount after the projection (or before the inverse). The value should be provided as an angular value east of north. If this parameter is not provided, it will default to 0 (no rotation).

Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of the centre of the projection
xy_plane_rotation	XY plane rotation (optional)

Usage:
Hemisphere, continent, regional maps. Not really for large scale.

Notes:
This projection is also known as *Lambert Azimuthal Equal Area*.

POLAR AZIMUTHAL AREA

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

Parameters:

central_meridian	Longitude of origin
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin

Usage:
Polar maps.

Notes:
This projection is also known as *Lambert Azimuthal Equal Area (polar aspect)*.

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 centre 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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection

Usage:
Can be used for world maps but usually for hemispheres. Works on large scale maps

Notes:
This projection is also known as *Equidistant*. ESRI software supports this projection on spheres only so use a spherical geodesic base (e.g. GRS Authalic Sphere) to obtain comparable results.

POLAR AZIMUTHAL EQUIDISTANT

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 centre are true.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection

Usage:
Polar aspect for world maps and maps of the polar hemispheres.

Notes:
This projection is also known as *Equidistant*.

DOUBLE STEREOGRAPHIC

The Double Stereographic projection consists of two mappings. First, the ellipsoidal data is mapped conformally to a conformal sphere. Then a second conformal mapping transforms the spherical data to the plane.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
scale_factor	Scale reduction factor at the centre of the projection

Usage:
Large scale maps - New Brunswick, Canada and the Netherlands.

Notes:
This projection is also known as *Oblique Stereographic*

EUROPEAN STEREOGRAPHIC

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

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
scale_factor	Scale reduction factor at the centre of the projection

Usage:
Large scale maps of the Netherlands.

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.

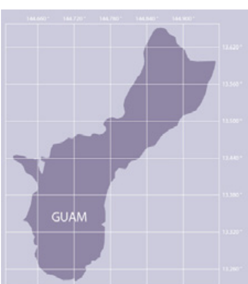
Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of the centre of the projection
spherical_radius	Radius of the sphere (e.g. 6378137m)

Usage:
Navigational maps.

Notes:
Should not be used for areas extending more than 60° from the centre. Only a spherical form of this projection is supported.

GUAM



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

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
xy_plane_rotation	XY plane rotation.

Usage:
Maps of Guam island.

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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
spherical_radius	Radius of the sphere (e.g. *6378137*)

Usage:
Aesthetic hemispherical maps.

Notes:
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.

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

POLAR STEREOGRAPHIC

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

Three variants of the Polar Stereographic projection are recognized and 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. See next projection.

Parameters:

		Variant A	Variant B
central_meridian	Longitude of natural origin of the projection		
false_easting	False easting		
false_northing	False northing		
latitude_of_origin	Latitude of natural origin of the projection	± 90°	
scale_factor	Scale reduction factor at the centre of the projection	≠ 1	=1

Usage:
Polar maps (UPS system).

Notes:
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 (+ or -) is likewise used to determine the hemisphere of the projection.

POLAR STEREOGRAPHIC VARIANT C

The Polar Stereographic Variant C projection corresponds to the third variant of the Polar Stereographic projection described earlier

Parameters:

central_meridian	Longitude of natural origin of the projection
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection

Usage:
Polar maps (UPS system).

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.

This projection provides an optional parameter that will rotate the planar coordinates by the specified amount after the projection (or before the inverse). The value should be provided as an angular value east of north. If this parameter is not provided, it will default to 0 (no rotation).

Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of the centre of the projection
scale_factor	Scale reduction factor at the centre of the projection
xy_plane_rotation	XY plane rotation (optional).

Usage:
Hemispherical maps.

STEREOGRAPHIC 70

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

Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of the centre of the projection
scale_factor	Scale reduction factor at the centre of the projection

Usage:
Maps of Romania

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 centre 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.

Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of the centre of the projection
height	Height of the view.

Usage:
Aesthetical view of Earth from space.

Notes:
The *Height* should be set to 10000km or so to get an interesting view from space.

Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

Conic Projections

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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
standard_parallel1	Latitude of southern standard parallel
standard_parallel2	Latitude of northern standard parallel

Usage:
Equal-area maps of regions with a predominantly east-west expanse, such as the United States, and valid for small extents or countries but not continents. It is used exclusively by the USGS for sectional maps of all 50 states.

BELGIUM 72

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

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
standard_parallel1	Latitude of southern standard parallel
standard_parallel2	Latitude of northern standard parallel

Usage:
Maps of Belgium.

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.

Usage:
Maps of North and South America together

BONNE

The Bonne projection is pseudoconical 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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of standard parallel

Usage:
Atlas maps of continents and topographic mapping in some countries.

Notes:
In this projection, a world map has a heart shape.

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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
standard_parallel1	Latitude of southern standard parallel
standard_parallel2	Latitude of northern standard parallel

Usage:
Atlases of small countries.

GUAM 27

Important Notes:
NOT FOR CARTOGRAPHIC USE. Use only to import legacy data that might have been saved in this system and then transform to a new coordinate system

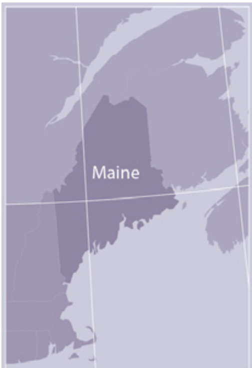
Information:
The State Plane Coordinate System (SPCS) is not a projection; rather it is a system for specifying positions of geodetic stations using plane rectangular coordinates. This coordinate system divides all fifty states of the United States, Puerto Rico and the U.S. Virgin Islands into over 120 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 has 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 *Guam27* projection does not require any parameters.

IMW POLYCONIC



The IMW Polyconic projection is a modified Polyconic projection devised as a basis for the 1:1,000,000-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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
standard_parallel1	Latitude of southern standard parallel
standard_parallel2	Latitude of northern standard parallel

Usage:
Very large scale maps part of the IMW series.

Notes:
Only valid about 8-10 degree from central meridian and latitude of origin.

KROVAK

Important Notes:
NOT FOR RECOMMENDED CARTOGRAPHIC USE. This projection uses Westing and Southing instead of the regular Easting and Northing value, maps created in this system in Adobe Illustrator would look flipped in north/south and east/west directions. Use this projection only to import source data in this system and then transform to a different choice, or for export.

Information:
The Krovak Projection was created and used in former 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.

Parameters:

azimuth	Azimuth
central_meridian	Origin longitude (centerline)
false_easting	False easting
false_northing	False northing
latitude_of_origin	Origin latitude
latitude_of_true_scale	Latitude of true scale
scale_factor	Scale reduction factor at the centre of the projection
x_scale	Scale reduction on the X axis (default is 1)
xy_plane_rotation	XY plane rotation (optional, default is 0).
y_scale	Scale reduction on the Y axis (default is 1)

Usage:
Maps of Czech Republic or Slovakia.

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 centre of the map. The meridians are equally spaced and intersect the parallels at right angles. The scale is true along two standard parallels.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
standard_parallel1	Latitude of southern standard parallel
standard_parallel2	Latitude of northern standard parallel

Usage:
Widely used in atlases, in aeronautical charts, and in plane coordinate systems in surveying. It is also used in the US State Plane Coordinate System for states with large east-west extents.

LAMBERT TANGENT

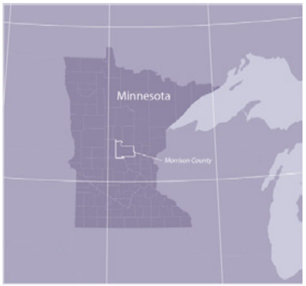
The Lambert Tangent or Lambert Conformal Conic (1 parallel) projection is a map projection in which the scale is true along a single standard parallel, and the true shape of small areas is preserved. Parallels are unequally spaced arcs of concentric circles spaced closer to each other near the centre of the map. The meridians are equally spaced and intersect the parallels at right angles.

Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
scale_factor	Scale reduction factor at the centre of the projection

Usage:
Used extensively in France.

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.

Parameters:

		Minnesota
average_elevation	Average elevation (Minnesota and Wisconsin)	
average_geoid_height	Average geoid height (Wisconsin-only)	0
central_meridian	Longitude of origin	
false_easting	False easting	
false_northing	False northing	
latitude_of_origin	Latitude of origin of the projection	
scale_factor	Scale reduction factor at the centre of the projection	
standard_parallel1	Latitude of southern standard parallel	
standard_parallel2	Latitude of northern standard parallel	

Usage:
County maps of Minnesota and Wisconsin.

LAMBERT 27

Important Notes:
NOT FOR CARTOGRAPHIC USE. Use only to import legacy data that might have been saved in this system and then transform to a new coordinate system

Information:
The Lambert State Plane 27 is part of the State Plane Coordinate System (SPCS). See **Guam27** for more information.

The Lambert 27 projection does not require any parameters.

PERSPECTIVE CONIC

The Perspective Conic projection is produced by projecting the Earth perspectively from the centre (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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
standard_parallel1	Latitude of southern standard parallel
standard_parallel2	Latitude of northern standard parallel

Usage:
Aesthetical maps of Earth.

Notes:
Should not be used on non-hemispherical area — requires crop before transforming. Quick distorsions appear away from standard latitudes and central meridians. Only a spherical form is supported (using semi-major axis of ellipsoid)

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.

Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection

Usage:
This 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. Used in USGS 7.5 and 15 minutes quad sheets.

Cylindrical Projections

ALASKA 27

Important Notes:
NOT FOR CARTOGRAPHIC USE. Use only to import legacy data that might have been saved in this system and then transform to a new coordinate system

Information:
The Alaska State Plane 27 is part of the State Plane Coordinate System (SPCS). See **Guam27** for more information.

The Alaska 27 projection does not require any parameters.

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.

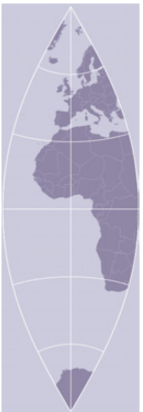
The Equal-Area Cylindrical projection represents an orthographic projection of a sphere onto a cylinder. Like other regular cylindrical projections, the graticule of the normal Equal-Area Cylindrical projection consists of straight equally spaced vertical meridians perpendicular to straight unequally 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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing

Usage:
World maps only.

CASSINI



The Cassini projection is a cylindrical projection. It is neither equal-area nor 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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of true scale

Usage:
Large–scale maps of areas predominantly north–south in extent. Used by the UK Ordance Survey.

Notes:
Also known as *Cassini-Soldner* projection.

DANISH SYSTEM 34

Important Notes:
NOT RECOMMENDED FOR CARTOGRAPHIC USE. This projection uses Westing instead of the regular Easting. Maps created in this system in Adobe Illustrator would look flipped in the east/west direction. Use this projection only to import source data in this system and then transform to a different choice, or for export.

Information:
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 & 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 & Matrikelstyrelsen. The polynomial coefficients can be obtained by contacting Kort & 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.

Parameters:

		Jyland	Sjælland	Bornholm	National
region	Region	“j”, “J”, or “1”	“s”, “S”, or “2”	“b”, “B”, or “3”	“u”, “U”, or “4”

Usage:
Maps of Denmark

DANISH SYSTEM 34 (1999)

Important Notes:
NOT RECOMMENDED FOR CARTOGRAPHIC USE. This projection uses Westing instead of the regular Easting. Maps created in this system in Adobe Illustrator would look flipped in the east/west direction. Use this projection only to import source data in this system and then transform to a different choice, or for export.

Information:
This projection is a variation of the Transverse Mercator projection used in Denmark. The projection consists of a base UTM (zones 32 & 33) calculation, which is then adjusted by an order 11 polynomial, and then further adjusted by an order 13 polynomial. The polynomials used in the Danish System 34 projection were developed by K. Poder and K. Engsager of Kort & Matrikelstyrelsen. The polynomial coefficients can be obtained by contacting Kort & Matrikelstyrelsen.

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.

Parameters:

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

Usage:
Maps of Denmark

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 projection is Conformal Cylindrical and is referenced to the GRS 1967 ellipsoid. One zone covers the whole territory of Hungary in an East-West direction.

The current implementation for the "EgysegesOrszagosVetulet" Projection does not require any user defined Parameters.

Usage:
Hungarian civilian base maps and Spatial Informatics.

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.

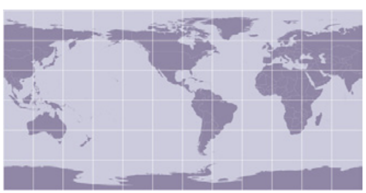
Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of standard parallel

Usage:
Maps of equatorial regions.

Notes:
Also known as *Equal-Area* or *Lambert Cylindrical Equal-Area.*

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.

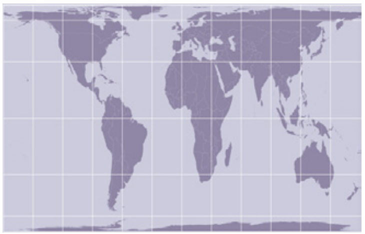
If the Equator is made the standard parallel, true to scale and free of distortion, the meridians are spaced at the same distances as the parallels, and the graticule appears square. This form is often called the Plate Carree or the Simple Cylindrical Projection.

Parameters:

		Plate Carrée
central_meridian	Longitude of the central meridian	
false_easting	False easting	
false_northing	False northing	
latitude_of_origin	Latitude of true scale	= 0°

Usage:
Often used for city maps or small area maps.

GALL-PETERS



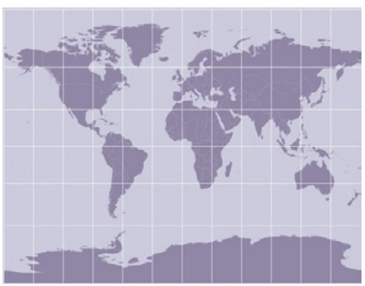
The Gall-Peters projection is a variation of the generic *Equal Area Cylindrical*, in which the latitude of the standard parallel is always 45 degrees. It was originally presented by James Gall in 1855, and is also known as the *Gall Orthographic projection*.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing

Usage:
World maps.

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's 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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing

Usage:
World maps

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

HOTINE OBLIQUE MERCATOR (DEPRECATED)

Important Notes:
NOT FOR CARTOGRAPHIC USE. Use only to import legacy data that might have been saved in this system and then transform to a new coordinate system. For similar aspects, use the *Oblique Mercator* projection.

Information:
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. 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_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
latitude_of_true_scale	Latitude of true scale
scale_factor	Scale reduction factor at the centre of the projection
standard_longitude1	Standard longitude of 1st point
standard_longitude2	Standard longitude of 2nd point
standard_latitude1	Standard latitude of 1st point
standard_latitude2	Standard latitude of 2nd point

Hotine Oblique Mercator (1 Point) projection parameters:

azimuth	Azimuth of the central line
azimuth_skew	Skew azimuth
central_meridian	Longitude at the centre of the projection
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
scale_factor	Scale reduction factor at the centre of the projection

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

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

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of true scale

Usage:
Maps of Island of Vanua Levu, Fiji.

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.

Parameters:

azimuth	Azimuth of the central line
azimuth_skew	Skew azimuth
central_meridian	Origin longitude (centerline)
false_easting	False easting
false_northing	False northing
latitude_of_origin	Origin latitude
scale_factor	Scale reduction factor at the centre of the projection

Usage:
Maps of Madagascar.

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 conformality, 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.

Using these parameters, there are two different variations of the Mercator projection that can be supported.

Parameters:

		Variant 1	Variant 2
central_meridian	Longitude of the central meridian		
false_easting	False easting		
false_northing	False northing		
latitude_of_origin	Latitude of true scale	Ignored, always using Equator	Used to calculate scale factor at the Equator
scale_factor	Scale scale factor	$\neq 1$	$=1$

Usage:
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.

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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
spherical_radius	Radius of the sphere (e.g. *6378137*)

Usage:
World maps

Notes:
Only a spherical form of this projection is supported. The specified geodetic datum is required to perform geodetic datum shifts into other coordinate systems.

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. 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" (u, v coordinates) formula) or they may be "rectified" (x, y coordinates) by rotating the coordinates by a certain angle. This angle can be user defined or calculated so that the y axis is parallel to the central meridian or meridian of natural origin (see diagram next page). The parameter settings below show how to set up one option or the other.

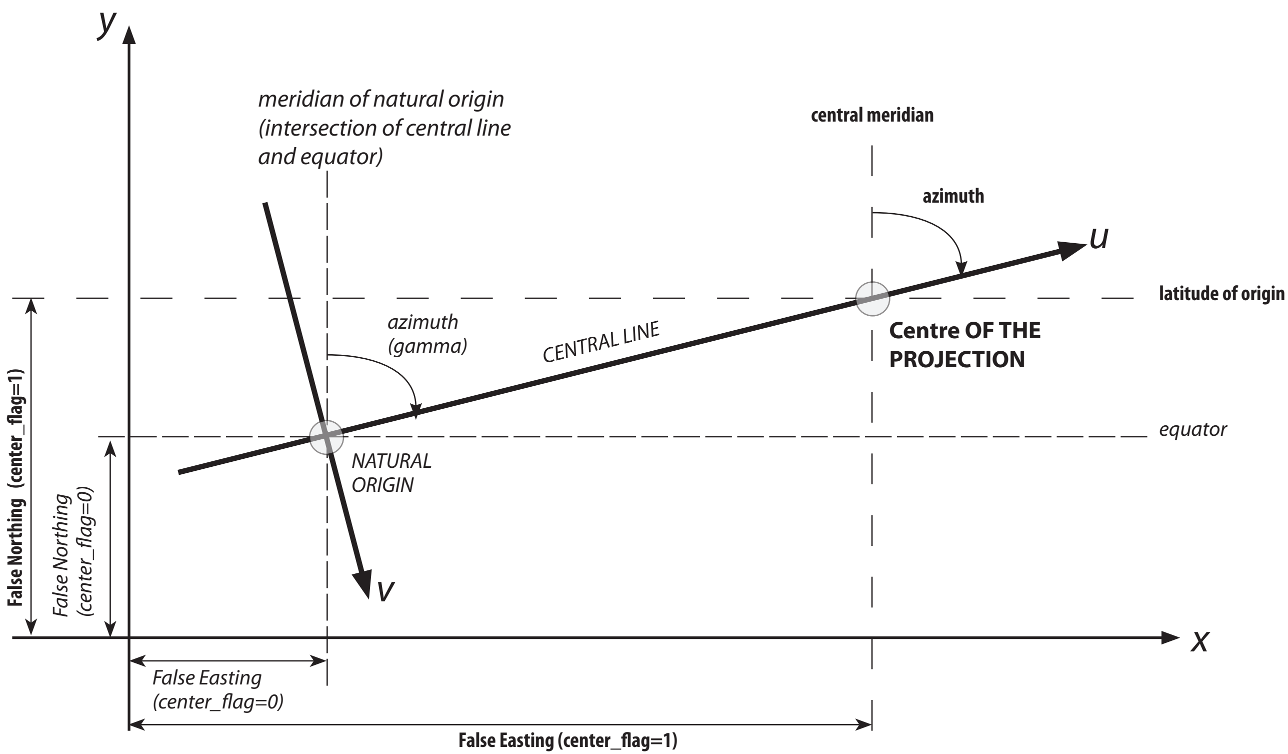
Parameters:

		Unrectified case	User defined rectification angle	Y axis parallel to central meridian	Y axis parallel to meridian of natural origin
azimuth	Azimuth of central line				
azimuth_is_gamma	Flag to use azimuth as gamma (default is 0)				
center_flag	Flag to shift centre (default is 0)				
central_meridian	Longitude at the centre of the projection				
false_easting	False easting				
false_northing	False northing				
latitude_of_origin	Latitude of origin of the projection				
rotation_angle	Rotation angle for rectification (default is 0)	n/a	≠0	=0	=0
scale_factor	Scale reduction factor at the centre of the projection				
unrectified_flag	Flag for unrectified version (default is 0)	=1	=0	=0	=0
use_gamma_flag	Flag to change the centre of rectification (default is 0)	n/a	n/a	=0	=1

By default, the X,Y coordinates are relative to the natural origin. If the **center_flag** parameter is set to **1**, the coordinates are shifted to the centre of the projection (see diagram next page).

By default, the **azimuth** is the angle at the centre of projection. If the **azimuth_is_gamma** flag is set to **1**, the azimuth parameter value will define the angle at the natural origin of the projection (see diagram next page).

Oblique Mercator Azimuth notations:
This simplified diagram shows the meaning of some of the parameters described above.



Usage:
Conformal mapping of regions that have an oblique orientation. Traditionally used for maps of Malaysia.

Notes:
Accurate only within 15° from the line of tangency (central line above).

The case when *center_flag=0* (using natural origin as centre) corresponds to the *Hotine Oblique Mercator* method in EPSG standards. If *center_flag=1* (using the centre of projection as centre), the projection corresponds to the *Oblique Mercator* method in EPSG standards.

OBLIQUE MERCATOR TWO POINTS

This variation of the Oblique Mercator projection uses two points to define the central line where the cylinder touches the ellipsoid (see diagram on previous page for the definition of the central line). See Oblique Mercator Azimuth for more information.

Usage:
Conformal mapping of regions that have an oblique orientation. Traditionally used for maps of Malaysia.

Notes:
Accurate only within 15° from the line of tangency (central line).

Parameters:

		Unrectified case	User defined rectification angle	Y axis parallel to central meridian	Y axis parallel to meridian of natural origin
false_easting	False easting				
false_northing	False northing				
latitude_of_origin	Latitude of origin of the projection				
rotation_angle	Rotation angle for rectification (default is 0)	n/a	≠0	=0	=0
scale_factor	Scale reduction factor at the centre of the projection				
standard_longitude1	Longitude of the first point				
standard_longitude2	Longitude of the second point				
standard_latitude1	Latitude of the first point				
standard_latitude2	Latitude of the second point				
unrectified_flag	Flag for unrectified version (default is 0)	=1	=0	=0	=0
use_gamma_flag	Flag to change the centre of rectification (default is 0)	n/a	n/a	=0	=1

In this case the *central meridian* is defined as the intersection of the central line (line connecting the two points defined by their latitude and longitude) and the latitude of origin.

POPULAR VISUALISATION PSEUDO-MERCATOR

This method is utilised by some popular web mapping and visualisation applications. 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 the more rigorous application of ellipsoidal formulas to ellipsoidal coordinates.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of true scale

Usage:
Google Earth/Map data (image geometry). Note that KML files use WGS84 geodesic coordinate system.

Notes:
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.

SPACE OBLIQUE MERCATOR

Important Notes:
NOT FOR CARTOGRAPHIC USE. This projection is specific to individual Landsat scenes — the projection parameters depend on the Landsat satellite type and position at the time of capture. As such, it is supposed to be used to only import images rather than to create new cartography.

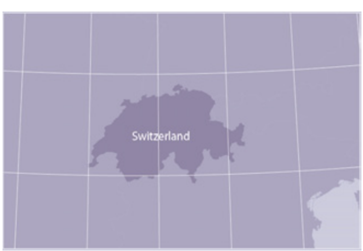
Information:
The Space Oblique Mercator (SOM) projection is a modified cylindrical projection with the map surface defined by a satellite orbit. The SOM is an extremely complicated projection. We urge you to refer to "Map Projections a Working Manual" by Snyder for a detailed explanation. The parameters are rather complicated and will vary depending on the Landsat satellite number (1, 2, 3, 4 or 5) and on the time of capture of the imagery (position of the satellite at the time.).

Parameters:

central_meridian	Origin longitude (centerline)
satellite_a	Semi-major axis of the satellite orbit
satellite_e	Eccentricity of the satellite orbit
satellite_gamma	Longitude of the perigee relative to the ascending node
satellite_incl	Inclination of the satellite orbit
satellite_long0	Geodetic longitude of the ascending node at time=0 (start of image capture)
satellite_p1	Length of Earth's rotation with respect to the precessed ascending node
satellite_p2	Time required for revolution of the satellite

Usage:
The SOM projection was designed especially for continuous mapping of satellite imagery.

SWISS OBLIQUE MERCATOR

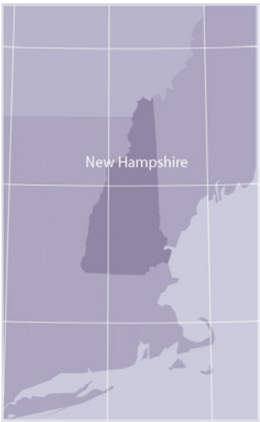


The Swiss Oblique Mercator projection is a particular case of an Oblique Mercator projection, which in turn differs from the Mercator and Transverse Mercator projections in that the central line with true scale is neither the equator (as in the Mercator), nor a meridian (as in the Transverse Mercator), 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 "SwissObliqueMercator" projection has no parameters.

Usage:
Maps of Switzerland

TRANSVERSE MERCATOR



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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of the projection
scale_factor	Scale reduction factor at the central meridian

Usage:
This projection is 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 (see UTM map zones in Appendix).

Notes:
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.

The Transverse Mercator projection is only reasonably accurate within 15° from the central meridian, distortions appear rapidly outside the 15° band.

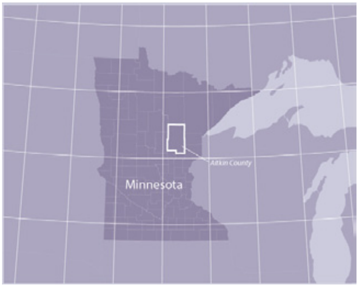
TRANSVERSE MERCATOR SOUTH ORIENTED

Important Notes:
NOT FOR RECOMMENDED CARTOGRAPHIC USE. This projection uses Westing and Southing instead of the regular Easting and Northing value, maps created in this system in Adobe Illustrator would look flipped in north/south and east/west directions. Use this projection only to import source data in this system and then transform to a different choice, or for export.

Information:
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. See the parameters above.

Usage:
Data from south hemisphere (particularly South Africa and Botswana)

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.

Parameters:Parameters:

		Minnesota
average_elevation	Average elevation (Minnesota and Wisconsin)	
average_geoid_height	Average geoid height (Wisconsin-only)	0
central_meridian	Longitude of origin	
false_easting	False easting	
false_northing	False northing	
latitude_of_origin	Latitude of origin of the projection	
scale_factor	Scale reduction factor at the centre of the projection	

Usage:
County maps of Minnesota and Wisconsin.

TRANSVERSE MERCATOR SNYDER

Important Notes:
NOT FOR RECOMMENDED CARTOGRAPHIC USE. This projection has been superseded by the newer *Transverse Mercator* projection. Use this projection only to import source data in this system and then transform to a different choice, or to compare results with old data.

Information:
This projection is based on the description and formulae in John P. Snyder's Map Projections-- A Working Manual (U.S. Geological Survey Professional Paper 1395), pp. 60-64.

The parameters are the same as the regular *Transverse Mercator* projection.

Usage:
Old USGS maps.

TRANSVERSE MERCATOR 27

Important Notes:
NOT FOR CARTOGRAPHIC USE. Use only to import legacy data that might have been saved in this system and then transform to a new coordinate system

Information:
The Transverse Mercator State Plane 27 is part of the State Plane Coordinate System (SPCS). See **Guam27** for more information.

The Transverse Mercator 27 projection does not require any parameters.

UNIVERSAL TRANSVERSE MERCATOR

Important Notes:
NOT FOR CARTOGRAPHIC USE. Use only to import data that might have been saved in this system and then transform to a new coordinate system. To create user-defined coordinate systems or to update a standard UTM coordinate system, please use the *Transverse Mercator* projection method instead. This projection only works on small scale datasets that are contained in one of the grid cell of the system.

Information:
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.

The actual Transverse Mercator parameter values to use when converting between geodetic and projected coordinates 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.

Parameters:

autoset	Automatically set zone (if set to 1, the other parameters are automatically calculated)
is_north	Currently in northern hemisphere
zone	Current zone number

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

Pseudocylindrical Projections

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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing

Usage:
Thematic world maps.

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

Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

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.

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.

Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing

Usage:
Generally used for novelty maps of the world showing a straight-line graticule..

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

ECKERT II

The Eckert II projection is a pseudocylindrical projection that is equal area. This projection was presented by Max Eckert in 1906.

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.

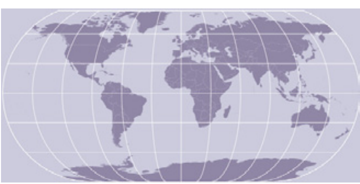
Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing

Usage:
Generally used for novelty maps of the world showing a straight-line equal area graticule.

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

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 .

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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing

Usage:
Primarily used for world maps.

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

ECKERT IV

The Eckert IV projection was created by Max Eckert in 1906.

It is a pseudocylindrical projection 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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
spherical_radius	Radius of the sphere

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.

Usage:
World maps.

Notes:
Only a spherical form of this projection is used (see parameters).

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.

Parameters:

central_meridian	Longitude of origin
false_easting	False easting
false_northing	False northing

Usage:
World maps.

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

ECKERT VI

The Eckert VI projection was created by Max Eckert in 1906. It is a Pseudocylindrical projection 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.

Parameters:

central_meridian	Longitude of origin
false_easting	False easting
false_northing	False northing
spherical_radius	Radius of the sphere

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.

Usage:
World maps.

Notes:
Only a spherical form of this projection is used (see parameters).

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's 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.

This Goode Homolosine projection is the **uninterrupted** version. Some other software may use the interrupted version (e.g. ArcMap) which has a different aspect.

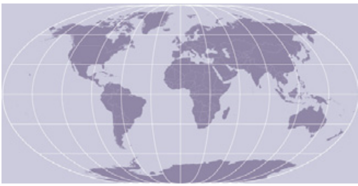
Parameters:

central_meridian	Longitude of origin
false_easting	False easting
false_northing	False northing

Usage:
World maps (Goode Atlas).

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

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 centre. The azimuths with respect to rhumb lines that do not pass through the origin, 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 is 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.

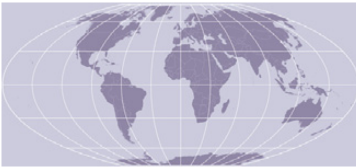
Parameters:

central_meridian	Longitude of origin
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin

Usage:
Maps that display loxodromes (rhumb lines)

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

MCBRIDE 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.

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.

Parameters:

central_meridian	Longitude of origin
false_easting	False easting
false_northing	False northing

Usage:
It is primarily used for examples in various geography textbooks, and is sometimes known simply as the Flat-Polar Quartic projection.

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
spherical_radius	Radius of the sphere

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.

Usage:
Thematic or distribution maps.

Notes:
Only a spherical form of this projection is used (see parameters).

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.

Parameters:

central_meridian	Longitude of origin
false_easting	False easting
false_northing	False northing

Usage:
Thematic world maps.

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing

Usage:
World maps

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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing

Usage:
Maps of South America and Africa

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.

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

Parameters:

central_meridian	Longitude of origin
false_easting	False easting
false_northing	False northing

Usage:
It is used to generate the world maps in The Times Atlas of the World, produced by Collins Bartholomew.

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

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.

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.

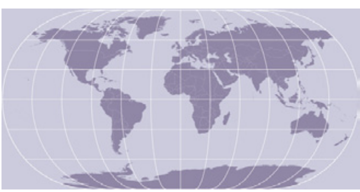
Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of origin of true scale

Usage:
World maps

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

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.

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.

Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of true scale

Usage:
World maps

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

Lenticular Projections

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 projection 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.

Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing

Usage:
World maps.

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

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.

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 centre.

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

Parameters:

central_meridian	Longitude of origin
false_easting	False easting
false_northing	False northing

Usage:
Thematic world maps.

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

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.

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.

Parameters:

central_meridian	Longitude of the central meridian
false_easting	False easting
false_northing	False northing
latitude_of_origin	Standard parallel

Usage:
World maps.

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

Miscellaneous Projections

FULLER

Important Notes:
NOT RECOMMENDED FOR CARTOGRAPHIC USE. Use only to import data that might have been saved in this system and then transform to a new coordinate system. This projection only works on small scale datasets that are contained in one of the grid faces of the projection.

Information:
R. Buckminster Fuller's 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. 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.

The Fuller projection has no parameters.

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

MILITARY GRID REFERENCE SYSTEM (DEPRECATED)

Important Notes:
NOT FOR CARTOGRAPHIC USE. Use only to import legacy data in this system and then transform to a new coordinate system. This projection only works on small scale datasets that are contained in one of the grid cells of the system.

Information:
This projection has been deprecated and should not be used. It is provided for backwards compatibility only. MGRS conversions are now performed using an instance of the UTM projection.

The "Military Grid Reference System" projection has no parameters.

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.

Parameters:

central_meridian	Longitude of the NZMG origin
false_easting	False easting
false_northing	False northing
latitude_of_origin	Latitude of the NZMG origin

Usage:
Large-scale maps of New Zealand.

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 centre of the Earth.

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.

Parameters:

azimuth	Azimuth
central_meridian	Longitude of origin
false_easting	False easting
false_northing	False northing
height	Height
latitude_of_origin	Latitude of origin of the projection
tilt	Tilt

Usage:
Used to generate pictorial views of the Earth resembling those seen from space.

Notes:
Should not be used on non-hemispherical area — requires crop before transforming. 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

TWO-POINT FIT

Important Notes:
NOT RECOMMENDED FOR CARTOGRAPHIC USE. Use only to import legacy data that might have been saved in this system and then transform to a new coordinate system. This projection is an approximation and can only be valid for very large scale maps (surveying).

Information:
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.

This projection 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 2 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 & 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..

Parameters:

east1	Easting of the 1st point
east2	Easting of the 2nd point
north1	Northing of the 1st point
north2	Northing of the 2nd point
standard_latitude1	Standard latitude of 1st point
standard_latitude2	Standard latitude of 2nd point
standard_longitude1	Standard longitude of 1st point
standard_longitude2	Standard longitude of 2nd point

Usage:
Very large scale survey data.

V AND H

Important Notes:

NOT FOR CARTOGRAPHIC USE. **This coordinate system is not supported for vector data conversions.** Only applicable in MAPublisher with the MAP Point Plotter function

Information:

The Bell Labs V & H coordinate system, developed in 1957 by J. K. Donald, was invented to more easily calculate distances between wire centres (pre-defined nodes) with published V&H coordinates using a slide rule. The V & H (Vertical and Horizontal) coordinate system is useful for the utility for which it was developed (i.e. distance-based telephone rate computations), but is not nearly as accurate at geodetic coordinates.

The coordinate system is based on the Donald two-point elliptical projection (uses Clarke 1866 ellipsoid). The most valuable feature of the projection is the balance of error (+0.3% scale error east-west along the Mexican and Canadian borders; -0.3% scale error along the approximate centre of the United States.) The unit of measurement in the V & H coordinate system is defined as SQRT .1 mile (~1669.68 ft). These units are to be used only in the V & H coordinate system.

Reference: Peter H. Dana supplied J.K. Donald's 1957 Bell Labs paper.

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.

Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing
spherical_radius	Latitude of origin of the projection

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.

Usage:

World maps. Formerly the standard world map projection of the National Geographic Society

Notes:

Only a spherical form of this projection is used (see parameters).

VAN DER GRINTEN IV

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

Parameters:

central_meridian	Longitude of the centre of the projection
false_easting	False easting
false_northing	False northing

Usage:
World maps

Notes:
Only a spherical form of this projection is used. The semi-major axis of the ellipsoid specified in the coordinate system datum definition is used as sphere radius.

4

Appendices

This chapter provides additional information on:

Datum transformation methods (datum shifts
UTM zones map
United State Plane Coordinate System zones map
Projections Index

Datum Transformation Methods

7 PARAMETER (POINT VECTOR ROTATION)

The Seven Parameter PVR (also known as the Bursa-Wolfe) method incorporates three translations, three rotations, and a scale correction factor. The rotations are defined as positive **clockwise**, as may be imagined to be seen by an observer in the origin of the coordinate frame, looking in the positive direction of the axis about which the rotation is taking place. The MAPublisher and Geographic Imager implementation of the Seven Parameter PVR method uses the "Helmert" style of transformation. This family of transformations is usually performed in three steps. First, a geodetic input point is transformed to 3D geocentric coordinates according to the horizontal datum. Then a core transformation is performed, and finally the geocentric coordinates are transformed back to geodetic coordinates. The control parameters for a Helmert transformation specify the details of the core transformation. In general, the core transformation consists of a rotation around the x axis, a rotation around the y axis, a rotation around the z axis, a scaling that is the same for all dimensions, and a vector shift (any combination of x, y and z), performed in that order.

The parameters to define a Seven Parameter PVR transformation are:

Parameter	Often Noted as
X Translation	dX
Y Translation	dY
Z Translation	dZ
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.

7 PARAMETER (COORDINATE FRAME ROTATION)

The Seven Parameter CFR method incorporates three translations, three rotations, and a scale correction factor. The rotations are defined as positive **counter-clockwise**, as may be imagined to be seen by an observer in the origin of the coordinate frame, looking in the positive direction of the axis about which the rotation is taking place. The MAPublisher and Geographic Imager implementation of the Seven Parameter CFR method uses the "Helmert" style of transformation. This family of transformations is usually performed in three steps. First, a geodetic input point is transformed to 3D geocentric coordinates according to the horizontal datum. Then a core transformation is performed, and finally the geocentric coordinates are transformed back to geodetic coordinates. The control parameters for a Helmert transformation specify the details of the core transformation. In general, the core transformation consists of a rotation around the x axis, a rotation around the y axis, a rotation around the z axis, a scaling that is the same for all dimensions, and a vector shift (any combination of x, y and z), performed in that order.

The parameters to define a Seven Parameter CFR transformation are:

Parameter	Often Noted as
X Translation	dX
Y Translation	dY
Z Translation	dZ
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.

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: (613) 995-4410
FAX: (613) 995-3215
Email: information@geod.NRCan.gc.ca
Web: *www.geod.NRCan.gc.ca*

Note: When browsing through the datasource some objects may be flagged with a red exclamation point symbol . These objects are incomplete definitions. MAPublisher and Geographic Imager include a number of datum transformation definitions that require supplementary data files to function properly. These objects are not able to be used until the supplementary files are added. Some are proprietary and must be purchased from a specific government agency.

CUSTOM MRE

This is a customizable variation of the DMA Multiple Regression Equations transformation method. It allows users to set up input files containing the coefficients for the latitude, longitude and height equations used in the transformation, as well as a scale factor and offsets for latitude and longitude.

Parameters needed to define a Custom MRE transformation are:

Parameter	Often Noted as
Latitude Coefficient File	lat_coefficient_file
Longitude Coefficient File	lon_coefficient_file
Height Coefficient File	hgt_coefficient_file
Scale Factor	scale_factor
Latitude Offset	lat_offset
Longitude Offset	lon_offset

ED50 TO ED87 NORTH SEA

The ED50 to ED87 North Sea Transformation consists of a 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 TRANSLATION

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 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.

Note: The definition of datum transformations using this method includes parameters specifying the required grid files. If the system cannot find the specified file the shift will be marked unusable in the Datasource, and may not be selected for use.

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.

MADRID TO ED50 POLYNOMIAL

The Madrid to ED50 Polynomial transformation method allows the transformation of coordinates between the Madrid 1870 and the ED50 datums.

For a detailed reference on the Madrid to ED50 Polynomial transformation, refer to 2.3.1.3 "Polynomial transformation for Spain" in the EPSG Surveying and Positioning Guidance Note Number 7, part 2: http://www.epsg.org/guides/G7-2.html

Note: This datum transformation has been computed for a specific area of use and specific datums. The base Geodetic Datasource contains the standard datum transformations using this method. Creating new transformations using this method or using the transformation for data outside of the pre-determined envelopes may cause unreliable results.

MOLODENSKY

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.

MOLODENSKY-BADEKAS

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 Molodensky-Badekas 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
X Ordinal	Xp
Y Ordinal	Yp
Z Ordinal	Zp

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

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: (301) 713-3242
Web: *www.ngs.noaa.gov*

Note: The definition of datum transformations using this method includes parameters specifying the required grid files. If the system cannot find the specified file the shift will be marked unusable in the Datasource, and may not be selected for use.

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.

Note: The definition of datum transformations using this method includes parameters specifying the required grid files. If the system cannot find the specified file the shift will be marked unusable in the Datasource, and may not be selected for use.

POLYNOMIAL

The Polynomial datum shift methods use a collection of parameters that 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.

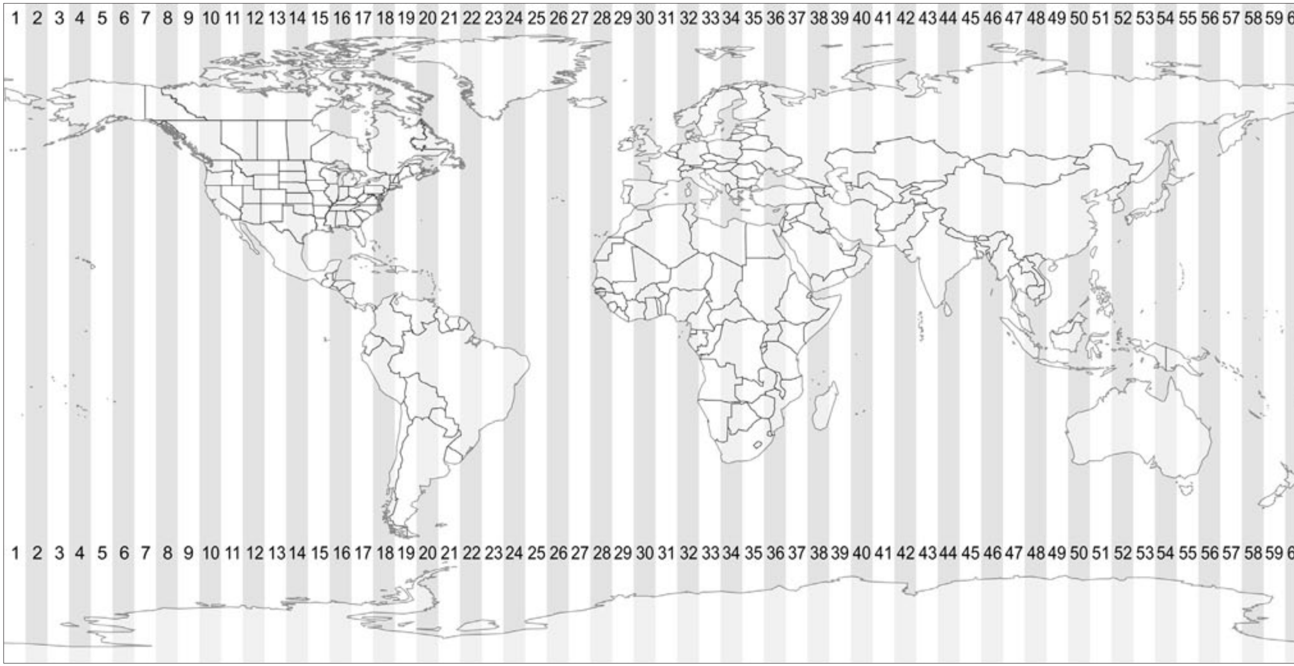
The Six parameters needed, are:

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

TOKYO TO JGD2000

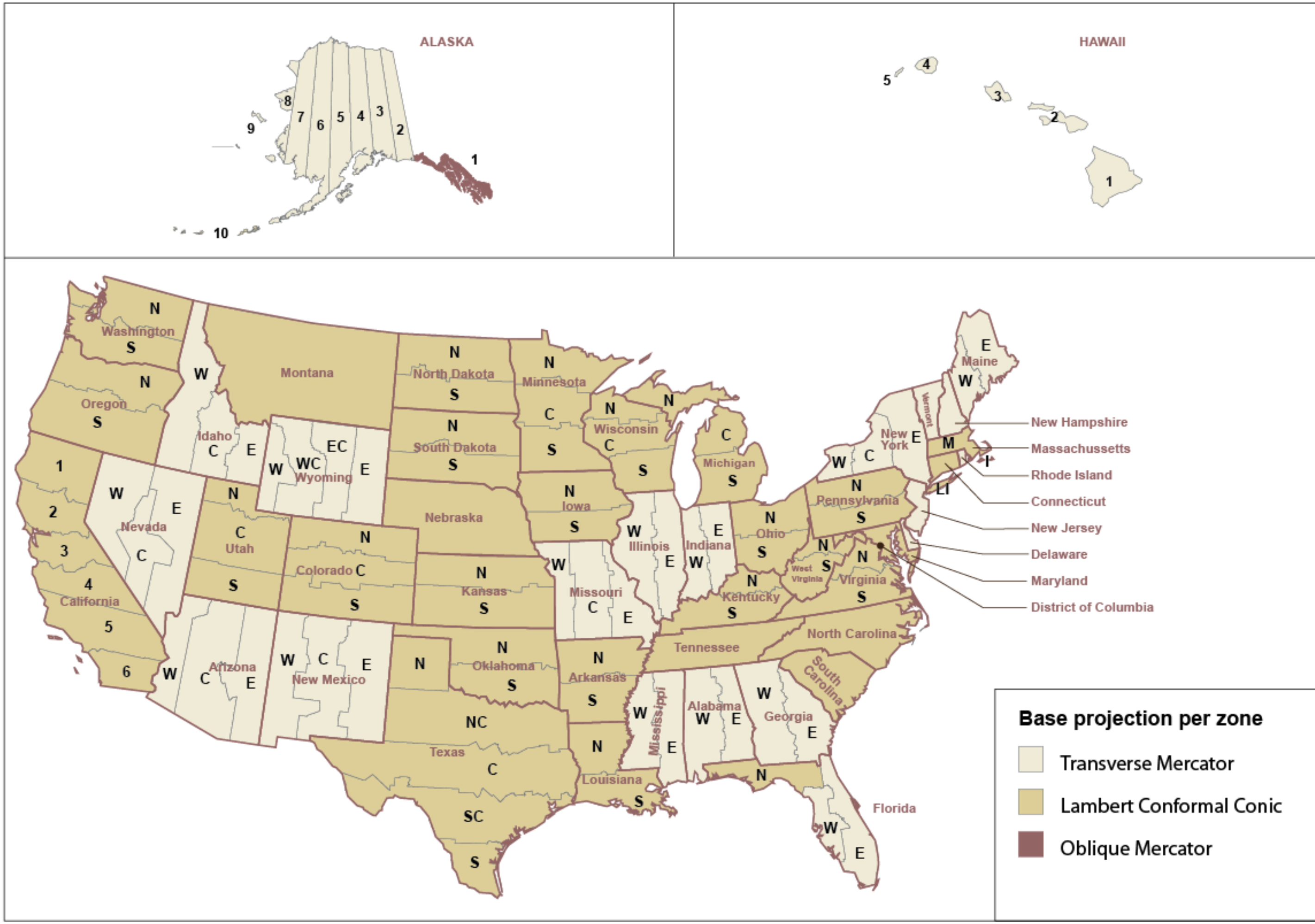
Converts coordinates from the Tokyo datum to the JGD 2000 (Japan Geodetic Datum of 2000) using a grid file defined by GSI (Japanese Geographical Survey Institute).

UTM Zones Map



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

US State Plane Zones Map



Note: For each zone, the projection's parameters vary — e.g. the Florida East zone and Georgia West zone coordinate systems create a different geometry, although both are based on *Transverse Mercator*. For example, see the specific definitions in **Coordinate Systems** > **Projected** > **North America** > **United States** > **US State Plane NAD83** > **NAD83 (US Feet)** in the MAPublisher and Geographic Imager libraries.

Projections Index