PathAway version 5

Advanced Mapping Manual

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Introduction

PathAway offers a number of ways and methods of preparing maps for use for GPS navigation. The simplest form is to define the map as rectangular longitude and latitude coordinates (Top-Left/Bottom Right). The more sophisticated method is to use either the map's original projection definition (Projected Map), or specify 4 to 9 known geographical points on the map, and have the software determine the map structure and bounds (3x3 Map).

Calibrating Maps

Maps can be calibrated using any of the following tools.

- PathAway PC Tools - Map Manager.
- PathAway Developer SDK Conversion Tools.
- PathAway GPS 3 for Palm OS, Calibrate Map Tools
- Third-Party PC Mapping Tool that supports Conversion to PathAway. Ie. Touratech-QV

Calibrate Types

Top-Left / Bottom-Right

This calibration method involves simply defining the top-left and bottom right geographical coordinates. It assumes the map has horizontal latitude lines and vertical longitude, and North is straight up vertical. For performance in screen refreshes and calculations, this method is the fastest since no complex geometric transformations are required.

Known Points (Skewed)

defining from 4 to 9 known points on the map. The software then calculates the geometric structure of the map from these points. It assumes the map has North towards the top of the map within 45 degrees. This method can produce the most accurate calibration for maps that are not of a known projection and may or may not have perfectly vertical longitude lines or horizontal latitude lines.

Projection Type

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

See **Map Projection Descriptions** for more definitions of supported projections and parameters of use.

3x3 Type

The 3x3 format can currently only be defined using third-party mapping software such as Touratech-QV. This method involves defining from 4 to 9 known points on the map. The software then calculates the geometric structure of the map from these points. The calibration of these maps cannot be modified in PathAway Palm OS.

Map Projection Descriptions

Introduction

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

Conformality

When the scale of a map at any point on the map is the same in any direction, the projection is conformal. Meridians (lines of longitude) and parallels (lines of latitude) intersect at right angles. Shape is preserved locally on conformal maps.

Distance

A map is equidistant when it portrays distances from the center of the projection to any other place on the map.

Direction

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

Scale

Scale is the relationship between a distance portrayed on a map and the same distance on the Earth. *In PathAway, Scale is determined by the point calibration settings for the map*.

Area

When a map portrays areas over the entire map so that all mapped areas have the same proportional relationship to the areas on the Earth that they represent, the map is an equal-area map.

Different map projections result in different spatial relationships between regions.

Map projections fall into the following general classes.

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

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

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

· When the cylinder upon which the sphere is projected is at right angles to the poles, the cylinder and resulting projection are transverse.

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

2. Conic projections result from projecting a spherical surface onto a cone.

· When the cone is tangent to the sphere contact is along a small circle.

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

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

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

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

4. Miscellaneous projections

- Include unprojected ones such as rectangular latitude and longitude grids and other examples of that do not fall into the cylindrical, conic, or azimuthal categories

The following sections of projections are divided into the categories of cylindrical, pseudocylindrical, conic, azimuthal and miscellaneous. Each projection is described as to its classification and subclassifcation, aliases, available computational forms (i.e. elliptical, spherical, forward and/or inverse) and summary of usage options. Most projections will also have an example plot of the projection with parenthetical entries in the captions specifying options used to generate the graphic.

In some cases the aliases apply to names given special forms of the projection. For example, the Werner projection which is a special case of the Bonne projection is listed as an alias of the Bonne projection. The usage description does not list the options common to all projections such as the Earth's figure parameters and Cartesian offsets.

Supported Map Projections

PathAway 3.0 supports Map projections through the ProjLib shared library. This library is based on the publicly available projection library PROJ4. The projection parameters required in Proj4 apply to PathAway3 and must be included in the Calibration command for Projection. Note Touratech-QV does this automatically when you convert a projected map to PathAway.

PathAway supports only projections with Forward and Inverse projection capabilities.

(more to come)

Projection ID	Description	RELEASE STATUS
Aea	Albers Equal Area	
Aeqd	Azimuthal Equidistant	
Aitoff	Aitoff	
alsk	Mod. Stererographics of Alaska	
apian	Apian Globular I	
bipc	Bipolar conic of western hemisphere	

bonne	Bonne (Werner lat_1=90)	
cass	Cassini	
cc	Central Cylindrical	
cea	Equal Area Cylindrical	
collg	Collignon	
crast	Craster Parabolic (Putnins P4)	
eck1	Eckert I	
eck2	Eckert II	
eck3	Eckert III	
eck4	Eckert IV	
eck5	Eckert V	
eck6	Eckert VI	
eqc	Equidistant Cylindrical (Plate Caree)	
eqdc	Equidistant Conic	
euler	Euler	
fahey	Fahey	
fouc	Foucaut	
fouc_s	Foucaut Sinusoidal	
gall	Gall (Gall Stereographic)	
gins8	Ginsburg VIII (TsNIIGAiK)	
gn_sinu	General Sinusoidal Series	
gnom	Gnomonic	
goode	Goode Homolosine	
gs48	Mod. Stererographics of 48 U.S.	
gs50	Mod. Stererographics of 50 U.S.	
hatano	Hatano Asymmetrical Equal Area	
imw_p	Internation Map of the World Polyconic	
kav5	Kavraisky V	
kav7	Kavraisky VII	
labrd	Laborde	
laea	Lambert Azimuthal Equal Area	
latlong	**Lat/long (Geodetic)**	**ProjLib.prc**
lcc	**Lambert Conformal Conic**	**ProjLib.prc**
leac	Lambert Equal Area Conic	
lee_os	Lee Oblated Stereographic	
loxim	Loximuthal	
lsat	Space oblique for LANDSAT	
mbt_s	McBryde-Thomas Flat-Polar Sine	
mbt_fps	McBryde-Thomas Flat-Pole Sine (No. 2)	
mbtfpp	McBride-Thomas Flat-Polar Parabolic	
mbtfpq	McBryde-Thomas Flat-Polar Quartic	
mbtfps	McBryde-Thomas Flat-Polar Sinusoidal	
merc	Mercator	

mil_os	Miller Oblated Stereographic	
mill	Miller Cylindrical	
mpoly	Modified Polyconic	
moll	Mollweide	
murd1	Murdoch I	
murd2	Murdoch II	
murd3	Murdoch III	
nell	Nell	
nell_h	Nell-Hammer	
nsper	Near-sided perspective	
nzmg	New Zealand Map Grid	
ob_tran	General Oblique Transformation	
ocea	Oblique Cylindrical Equal Area	
oea	Oblated Equal Area	
omerc	Oblique Mercator	
ortel	Ortelius Oval	
ortho	Orthographic	
pconic	Perspective Conic	
poly	Polyconic (American)	
putp1	Putnins P1	
putp2	Putnins P2	
putp3	Putnins P3	
putp3p	Putnins P3'	
putp4p	Putnins P4'	
putp5	Putnins P5	
putp5p	Putnins P5'	
putp6	Putnins P6	
putp6p	Putnins P6'	
qua_aut	Quartic Authalic	
robin	Robinson	
rpoly	Rectangular Polyconic	
sinu	Sinusoidal (Sanson-Flamsteed)	
somerc	Swiss. Obl. Mercator	
stere	Stereographic	
tcea	Transverse Cylindrical Equal Area	
tissot	Tissot Conic	
tmerc	**Transverse Mercator**	**PJtmerc.prc**
tpeqd	Two Point Equidistant	
tpers	Tilted perspective	
ups	Universal Polar Stereographic	
urmfps	Urmaev Flat-Polar Sinusoidal	
utm	**Universal Transverse Mercator (UTM)**	**PJtmerc.prc**
vandg	van der Grinten I	

vandg3	van der Grinten III	
vitk1	Vitkovsky I	
wag1	Wagner I (Kavraisky VI)	
wag2	Wagner II	
wag3	Wagner III	
wag4	Wagner IV	
wag5	Wagner V	
wag6	Wagner VI	
weren	Werenskiold I	
wintri	Winkel Tripel	

Map Projections - General Parameters

This document describes the parameters of projected maps supported in PathAway. This document does not attempt to describe the parameters particular to particular projection types. Some of these can be found in the GeoTIFF Projections Transform List. This documentation is derived from the PROJ4 project at http://www.RemoteSensing.org.

Geographic Coordinates

All geographic coordinates (lon_0, lat_0, lat_1 etc.) are expressed in latitude/longitude decimal degrees. (ie. Latitude N45.6786 Longitude E8.453)

False Easting / Northing

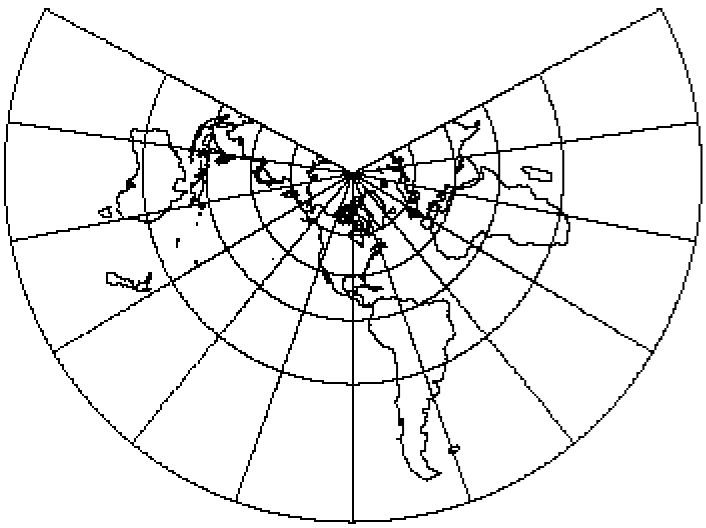
Virtually all coordinate systems allow for the presence of a false easting (x_0) and northing (y_0). These define the cartesian offsets for the respective x and y axes of the map.

These values are always expressed in meters even if the coordinate system is some other units. Some coordinate systems (such as UTM) have implicit false easting and northing values.

Conic Projections

Basic conic projections involve the transformations to a cone either secant or tangent to the Earth's surface. Specification of the latitudes of secant intersection are made with the lat_1 and lat_2 parameters.

Lambert Conic Conformal



Lambert Conformal Conic projection (2 standard parallels), with shorelines and 30 degree graticule. Central Meridian W90. and standard parallels at N20 and N60 (lon_0=W90 lat_1=N20 lat_2=N60).

LCC with 2 Standard Parallels

Name	Lambert Conic Conformal (2SP)
EPSG Code	9802
GeoTIFF Code	CT_LambertConfConic_2SP (9)
	CT_LambertConfConic (9)
OGC WKT Name	Lambert_Conformal_Conic_2SP
Supported By	EPSG, GeoTIFF, PROJ.4, OGC WKT

Projection Parameters

Param	Name	EPSG #	GeoTIFF ID	OGC WKT	Units	Notes
Lat_0	Latitude of false origin	1	FalseOriginLat	latitude_of_origin	Angular	
Lon_0	Longitude of false origin	2	FalseOriginLong	central_meridian	Angular	
Lat_1	Latitude of first standard parallel	3	StdParallel1	standard_parallel_1	Angular	

Lat_2	Latitude of second standard parallel	4	StdParallel2	standard_parallel_2	Angular	
X_0	Easting of false origin	6	FalseOriginEasting	false_easting	Linear	
Y_0	Northing of false origin	7	FalseOriginNorthing	false_northing	Linear	

LCC with 1 Standard Parallels

Usage and options: lat_1 lat_2 lon_0

Default values for lat_1 and lat_2 are respectively N33 and N45 (values normally used for maps of the conterminous United States).

Name	Lambert Conic Conformal (1SP)
EPSG Code	9801
GeoTIFF Code	CT_LambertConfConic_1SP (9)
OGC WKT Name	Lambert_Conformal_Conic_1SP

Projection Parameters

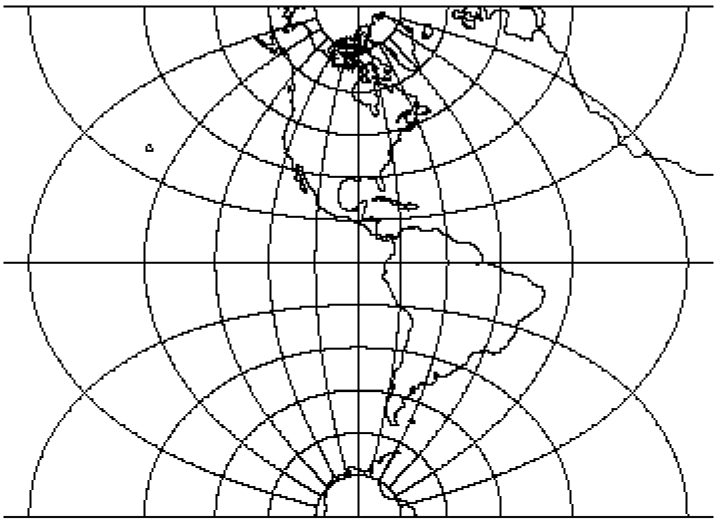
Param	Name	EPSG #	GeoTIFF ID	OGC WKT	Units	Notes
lat_1	Latitude of natural origin	1	NatOriginLat	latitude_of_origin	Angular	
lon_0	Longitude of natural origin	2	NatOriginLong	central_meridian	Angular	
x_0	False Easting	6	FalseEasting	false_easting	Linear	
y_0	False Northing	7	FalseNorthing	false_northing	Linear	

Cylindrical Projections

Cylindrical projections are based upon the various methods of projecting the Earth upon a cylinder that is either tangent to the equator (normal or equatorial form), a meridian (transverse) or obliquely aligned. Any of these classes are available in both conformal and equal area form. These projections are best used in mapping applications involving a zone near the line of tangency.

Transverse Mercator

Transverse Mercator Projection



Transverse Mercator projection, Western hemisphere with shorelines and 15 degree graticule. Central meridian W90 (lon_0=W90).

Classifications: Transverse cylindrical. Conformal.

Aliases: Gauss Conformal (ellipsoidal form), Gauss-Kr¨uger (ellipsoidal form), Transverse Cylindrical Orthomorphic

This is a common projection for large scale maps of predominantly north-south extent..

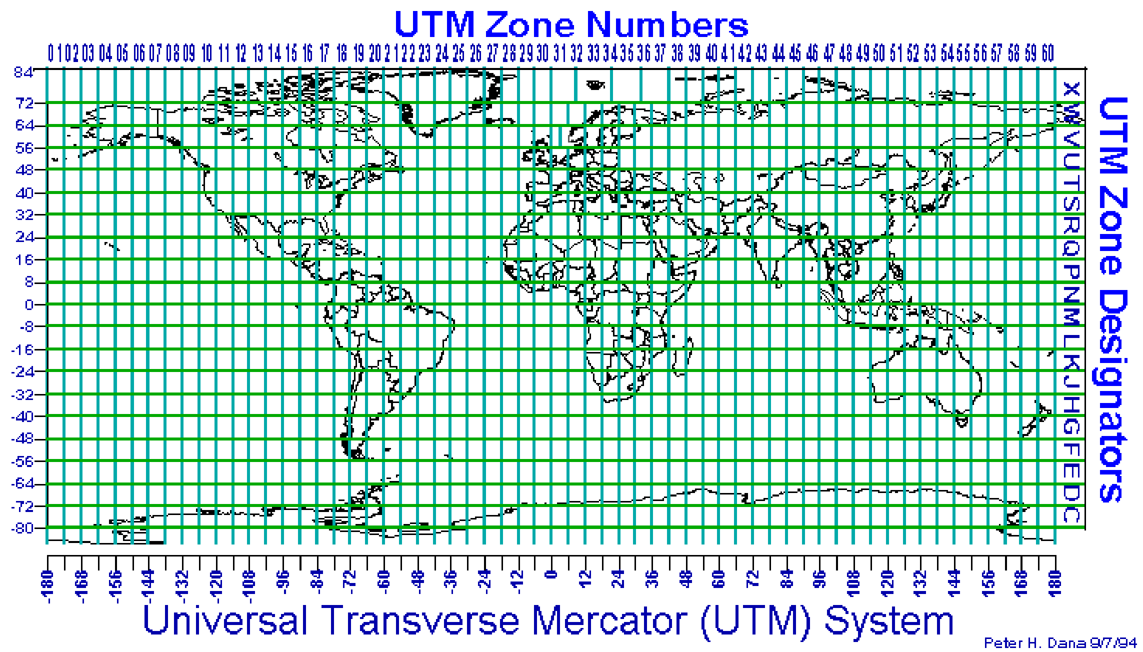
Name	Transverse Mercator
	Gauss-Kruger
EPSG Code	9807
GeoTIFF Code	CT_TransverseMercator (1)
OGC WKT Name	Transverse_Mercator
Supported By	EPSG, GeoTIFF, PROJ.4, OGC WKT

Projection Parameters

Params	Name	EPSG #	GeoTIFF ID	OGC WKT	Units	Notes
Lat_0	Latitude of natural origin	1	NatOriginLat	latitude_of_origin	Angular	
Lon_0	Longitude of natural origin	2	NatOriginLong	central_meridian	Angular	
X_0	False Easting	6	FalseEasting	false_easting	Linear	
Y_0	False Northing	7	FalseNorthing	false_northing	Linear	

Universal Transverse Mercator (UTM)

Universal Transverse Mercator (UTM) Projection



Projection: Transverse Mercator (Gauss-Krüger type) in zones 6° wide.
Longitude of Origin: Central meridian (CM) of each projection zone (3°, 9°, 15°, 21°, 27°, 33°, 39°, 45°, 51°, 57°, 63°, 69°, 75°, 81°, 87°, 93°, 99°, 105°, 111°, 117°, 123°, 129°, 135°, 141°, 147°, 153°, 159°, 165°, 171°, 177°, E and W).
Latitude of Origin: 0° (the Equator).
Unit: Meter.
False Northing: 0 meters at the Equator for the Northern Hemisphere; 10,000,000 meters at the Equator for the Southern Hemisphere.
False Easting: 500,000 meters at the CM of each zone.
Scale Factor at the Central Meridian: 0.9996.
Latitude Limits of System: From 80°S to 84°N.
Limits of Projection Zones: The zones are bounded by meridians, the longitudes of which are multiples of 6° east and west of the prime meridian.

Universal Transverse Mercator (UTM) Projection

Universal Transverse Mercator (UTM) coordinates define two dimensional, horizontal, positions. The sixty UTM zone numbers designate 6 degree wide longitudinal strips extending from 80 degrees South latitude to 84 degrees North latitude. UTM zone characters are letters which designate 8 degree zones extending north and south from the equator. Beginning at 80° south and proceeding northward, twenty bands are lettered C through X, omitting I and O. These bands are all 8° wide except for bond X which is 12° wide (between 72-84 N).

There are special UTM zones between 0 degrees and 36 degrees longitude above 72 degrees latitude and a special zone 32 between 56 degrees and 64 degrees north latitude:

UTM Zone 32 has been widened to 9° (at the expense of zone 31) between latitudes 56° and 64° (band V) to accommodate southwest Norway. Thus zone 32 it extends westwards to 3°E in the North Sea.
Similarly, between 72° and 84° (band X), zones 33 and 35 have been widened to 12° to

accommodate Svalbard. To compensate for these 12° wide zones, zones 31 and 37 are widened to 9° and zones 32, 34, and 36 are eliminated. Thus the W and E boundaries of zones are 31: 0 - 9 E, 33: 9 - 21 E, 35: 21 - 33 E and 37: 33 - 42 E.

Projection Parameters

Params	Name	EPSG #	GeoTIFF ID	OGC WKT	Units	Notes
Zone	UTM Zone Number				Decimal	
Lon_0	Longitude of natural origin	2	NatOriginLong	central_meridian	Angular	
south	Indicates map is in the southern hemisphere				“south”	

If both zone and lon_0 are used, +zone takes precedence.

For Southern hemisphere applications the option +south should be used which adds a false northing of 10,000,000m. In all cases, a false easting of 500,000m is used. Also see Universal Polar Stereographic (ups)

Map Datum Descriptions

A datum is set of map projection parameters and a set of physical control points on the earth's surface whose geometric relationships are known (geodetic survey controls). An important datum component is the spheroid. A spheroid is a shape that approximates the shape of the earth, providing very specific dimensional information to the map projection equation. Spheroids are specific to a particular locale, and over the years many different spheroids have been derived, each containing different numbers describing the earth's dimensions. Each datum is based on a particular spheroid.

The earth isn't a perfect sphere like a marble or a basketball. It's actually somewhat compressed from pole to pole which means the distance from the centre of the earth to the equator is greater than the distance from the centre of the earth to the poles. Despite this, the earth is spherical enough to be described as sphere-like, or spheroidal. To complicate matters further, thanks to geophysical irregularities (e.g. continents, oceans) the earth is not a perfect spheroid.

The three spheroids that are most common are:

- Clarke 1866
- GRS 1980 (Global Reference System of 1980)
- WGS 1984 (World Geodetic System of 1984)

The Clarke 1866 spheroid is the basis of the NAD 27 datum (North American Datum of 1927). This is the datum used by the paper National Topographic System Maps.

The GRS 1980 spheroid is the basis of the NAD 83 datum (North American Datum of 1983) which is a more accurate datum superceding the NAD 27. This is used by the NTDB. Each of these datums, although similar, are on slightly different coordinate planes. NAD 27 and NAD 83 coordinate pairs describing the same location will be slightly different. The net result is that you can't easily integrate data collected in different datums. In order to do this you must first perform a datum shift on one of the data sets so that all data lies in the same datum. This is further complicated by the fact that the means by which this is done differs between Canada and the United States.

The WGS 1984 spheroid is a world standard which has been replacing many of the local spheroids. It is the basis of the Global Positioning System (GPS).

Supported Map Datums and Ellipsoids

PathAway is configured by Datum and Ellipsoid parameters used. Each Map Datum uses a particular Elliposiod. You may configure a map by it's Datum name or by it's Ellipsoidal name.

Supported Datum Grids

Map Datum grids define both the Ellipsoid, and the conversion coordinates to WGS 84 mapping. Since PathAway stores all data in WGS 84 format, a Datum should be used if it's X,Y,Z deltas are not equivalent to WGS 84.

Datum ID	**Ellipsoid**	**Description**
WGS84	WGS84	WGS84
GGRS87	GRS80	Greek_Geodetic_Reference_System_1987
NAD83	GRS80	North_American_Datum_1983
NAD27 Canada	clrk66	North_American_Datum_1927 Canada
NAD27 CONUS	clrk66	North_American_Datum_1927 Continental US
Potsdam	bessel	Potsdam
Pulkova 1942	krass	Pulkova 1942
OSGB	airy	Ordinal Survey of Great Britain
Tokyo	bessel	Tokyo

Supported Ellipsoids

The following lists the supported Ellipsoids. Each Ellipsoid defines a value for the Earth's radius, and it's reciprocal flattening value.

Ellipsoid ID	**Description**	
MERIT	MERIT 1983	
SGS85	Soviet Geodetic System 85	
GRS80	GRS 1980(IUGG, 1980)	
IAU76	IAU 1976	
airy	Airy 1830	
APL4.9	Appl. Physics. 1965	
NWL9D	Naval Weapons Lab., 1965	
mod_airy	Modified Airy	
andrae	Andrae 1876 (Den., Iclnd.)	
aust_SA	Australian Natl & S. Amer. 1969	
GRS67	GRS 67(IUGG 1967)	
bessel	Bessel 1841	
bess_nam	Bessel 1841 (Namibia)	
clrk66	Clarke 1866	
clrk80	Clarke 1880 mod.	
CPM	Comm. des Poids et Mesures 1799	

delmbr	Delambre 1810 (Belgium)	
engelis	Engelis 1985	
evrst30	Everest 1830	
evrst48	Everest 1948	
evrst56	Everest 1956	
evrst69	Everest 1969	
evrstSS	Everest (Sabah & Sarawak)	
fschr60	Fischer (Mercury Datum) 1960	
fschr60m	Modified Fischer 1960	
fschr68	Fischer 1968	
helmert	Helmert 1906	
hough	Hough	
intl	International 1909 (Hayford)	
krass	Krassovsky 1942	
kaula	Kaula 1961	
lerch	Lerch 1979	
mprts	Maupertius 1738	
new_intl	New International 1967	
plessis	Plessis 1817 (France)	
SEasia	Southeast Asia	
walbeck	Walbeck	
WGS60	WGS 60	
WGS66	WGS 66	
WGS72	WGS 72	
WGS84	WGS 84	
sphere	Normal Sphere (r=6370997)	

Special Cases

Calibrating OSGB Maps

Most OSGB maps have horizontal and vertical OSGB Grid lines. PathAway Rectangular Calibration requires Longitude/Latitude lines to be horizontal/vertical. If this is the case for your OSGB map, you will need to either rotate the map so the Long/Lat lines are rectangular, or you will need to use a Projected map to Calibrate correctly. To calibrate OSGB maps such as this you can use the following projection parameters:

Calibration Type: Projection
Datum: OSGB
Projection: Transverse Mercator
lon_0: W2.000
lat_0: N49.00
x_0: 400000
y_0: -100000

Use at least 2 known points for the calibration points.