Elements of a Coordinate System

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Maps at their base are a visual representation in two dimensions of a section of the three-dimensional Earth. Being able to use maps in an electronic format in many ways frees us from the constrictions of the two-dimensional map because we can use mathematical formulas to compensate for the curvature of the Earth. In this document, describe the structure and application of the coordinate systems and projections that are standard in MapXtreme Java.

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Projections and Parameters

The projection is the equation or equations used by a coordinate system. The following list names the projections MapInfo uses and gives the number used to identify the projection in the micsys.txt file: The list is sorted with most recently supported projections highlighted in gray.

Number	Projection
31	Double Stereographic
30	Cassini-Soldner
29	Lambert Azimuthal Equal-Area (all origin latitudes)
28	Azimuthal Equidistant (all origin latitudes)
27	Polyconic
26	Regional Mercator (Standard Parallel 1 and 2)
25	Swiss Oblique Mercator
24	Transverse Mercator, (modified for Finnish KKJ)
23	Transverse Mercator, (modified for Danish System 34/ 45 Bornholm)
22	Transverse Mercator, (modified for Danish System 34 Sjaelland)
21	Transverse Mercator, (modified for Danish System 34 Jylland-Fyn)
20	Stereographic

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Number	Projection
19	Lambert Conformal Conic (modified for Belgium 1972)
18	New Zealand Map Grid
17	Gall
16	Sinusoidal
15	Eckert VI
14	Eckert IV
13	Mollweide
12	Robinson
11	Miller Cylindrical
10	Mercator
9	Albers Equal-Area Conic
8	Transverse Mercator, (also known as Gauss-Kruger)
7	Hotine Oblique Mercator
6	Equidistant Conic, also known as Simple Conic
5	Azimuthal Equidistant (polar aspect only)
4	Lambert Azimuthal Equal-Area (polar aspect only)
3	Lambert Conformal Conic
2	Cylindrical Equal-Area
1	Longitude/Latitude

Projection numbers in the micsys.txt may be modified by the addition of a constant value to the base number listed in the Projection table, above. Valid values and their meanings are tabulated below:

Constant	Meaning	Parameters
1000	System has affine transformations	Affine units specifier and coefficients appear after the regular parameters for the system.
2000	System has explicit bounds	Bounds appear after the regular parameters for the system.
3000	System with both affine and bounds	Affine parameters follow system's parameters; bounds follow affine parameters.

Example:

Assume you want to work with a simple system based on the Transverse Mercator projection and using the NAD 1983 datum. You might have a line such as the following in your micsys.txt file:

```
"UTM Zone 1 (NAD 83)", 8, 74, 7, -177, 0, 0.9996, 500000, 0
```

Now let's say that you want a system based on this, but with an affine transformation specified by the following parameters: Units=meters; A=0.5; B=-0.866; C=0; D=0.866; E=0.5; and F=0. The required line in the micsys.txt file is:

```
"UTM Zone 1 (NAD 83) - rotated 60 degrees", 1008, 74, 7, -177, 0, 0.9996, 500000, 0, 7,
0.5, -0.866, 0, 0.866, 0.5, 0
```

Alternatively, if you want to bound the system to (x1, y1, x2, y2)=(-500000, 0, 500000, 1000000), the required line is:

```
"UTM Zone 1 (NAD 83) - bounded", 2008, 74, 7, -177, 0, 0.9996, 500000, 0, -500000, 0,
500000, 1000000
```

To customize the system using both of these modifications, the line is:

```
"UTM Zone 1 (NAD 83) - rotated and bounded", 3008, 74, 7, -177, 0, 0.9996, 500000, 0, 7,
0.5, -0.866, 0, 0.866, 0.5, 0, -500000, 0, 500000, 1000000
```

Projection Parameters

This table indicates the parameters applicable to each projection, which are listed in the order they appear in the relevant coordinate system lines in the micsys.txt file.

	Datum	Units	Origin, Longitude	Origin, Latitude	Standard Parallel 1	Standard Parallel 2	Azimuth	Scale Factor	False Easting	False Northing	Range
Albers Equal-Area Conic	X	X	X	X	X	X			X	X	
Azimuthal Equidistant	X	X	X	X							X
Cassini-Soldner	X	X	X	X					X	X	
Cylindrical Equal Area	X	X	X		X						
Double Stereographic	X	X	X	X				X	X	X	
Eckert IV	X	X	X								
Eckert VI	X	X	X								
Equidistant Conic	X	X	X	X	X	X			X	X	
Gall	X	X	X								
Hotine Oblique Mercator	X	X	X	X			X	X	X	X	
Lambert Azimuthal Equal-Area	X	X	X	X							X
Lambert Conformal Conic	X	X	X	X	X	X			X	X	
Longitude-Latitude	X										
Mercator	X	X	X								
Miller	X	X	X								
Mollweide	X	X	X								
New Zealand Map Grid	X	X	X	X					X	X	
Polyconic	X	X	X	X					X	X	

	Datum	Units	Origin, Longitude	Origin, Latitude	Standard Parallel 1	Standard Parallel 2	Azimuth	Scale Factor	False Easting	False Northing	Range
Regional Mercator	X	X	X		X	X					
Robinson	X	X	X								
Sinusoidal	X	X	X								
Stereographic	X	X	X	X				X	X	X	
Swiss Oblique Mercator	X	X	X	X					X	X	
Transverse Mercator	X	X	X	X				X	X	X	

MapInfo supports the Azimuthal Equidistant and Lambert Azimuth Equal-Area projections for all origin latitudes. Previously only the polar aspects of these projections were supported.

Regional Mercator supports both standard parallel 1 and 2 to offer you a more precise view of your area of interest. See **Standard Parallels (Conic Projections) on page 13**.

Projection Datums

The datum is established by tying a reference ellipsoid to a particular point on the earth. The following table lists these details for each datum:

- The number used to identify the datum in the micsys.txt file.
- The datum's name
- The maps for which the datum is typically used
- The datum's reference ellipsoid

Number	Datum	Area Maps	Ellipsoid
1	Adindan	Ethiopia, Mali, Senegal, Sudan	Clarke 1880
2	Afgooye	Somalia	Krassovsky
1007	AGD 66, 7 parameter	Australia, A.C.T.	Australian National
1008	AGD 66, 7 parameter	Australia, Tasmania	Australian National
1009	AGD 66, 7 parameter	Australia, Victoria/ NSW	Australian National
1006	AGD 84, 7 parameter	Australia	Australian National
3	Ain el Abd 1970	Bahrain Island	International
118	American Samoa	American Samoa Islands	Clarke 1866
4	Anna 1 Astro 1965	Cocos Islands	Australian National

Number	Datum	Area Maps	Ellipsoid
119	Antigua Island Astro 1943	Antigua, Leeward Islands	Clarke 1880
5	Arc 1950	Botswana, Lesotho, Malawi, Swaziland, Zaire, Zambia, Zimbabwe	Clarke 1880
6	Arc 1960	Kenya, Tanzania	Clarke 1880
7	Ascension Island 1958	Ascension Island	International
9	Astro B4 Sorol Atoll	Tern Island	International
8	Astro Beacon “E”	Iwo Jima Island	International
10	Astro DOS 71/4	St. Helena Island	International
11	Astronomic Station 1952	Marcus Island	International
151	ATS77 (Average Terrestrial System 1977)	Canada	ATS77
12	Australian Geodetic 1966 (AGD 66)	Australia and Tasmania Island	Australian National
13	Australian Geodetic 1984 (AGD 84)	Australia and Tasmania Island	Australian National
151	Average Terrestrial System 1977 (ATS77)		
120	Ayabelle Lighthouse	Djibouti	Clarke 1880
110	Belgium	Belgium	International
14	Bellevue (IGN)	Efate and Erromango Islands	International
15	Bermuda 1957	Bermuda Islands	Clarke 1866
16	Bogota Observatory	Colombia	International
121	Bukit Rimpah	Bangka and Belitung Islands (Indonesia)	Bessel 1841
17	Campo Inchauspe	Argentina	International
18	Canton Astro 1966	Phoenix Islands	International
19	Cape	South Africa	Clarke 1880
20	Cape Canaveral	Florida and Bahama Islands	Clarke 1866
1005	Cape, 7 parameter	South Africa	WGS 84
21	Carthage	Tunisia	Clarke 1880

Number	Datum	Area Maps	Ellipsoid
22	Chatham 1971	Chatham Island (New Zealand)	International
23	Chua Astro	Paraguay	International
122	Co-Ordinate System 1937 of Estonia	Estonia	Bessel 1841
24	Corrego Alegre	Brazil	International
123	Dabola	Guinea	Clarke 1880
124	Deception Island	Deception Island, Antarctica	Clarke 1880
1000	Deutsches Hauptdreicksnetz (DHDN)	Germany	Bessel
25	Djakarta (Batavia)	Sumatra Island (Indonesia)	Bessel 1841
26	DOS 1968	Gizo Island (New Georgia Islands)	International
27	Easter Island 1967	Easter Island	International
115	EUREF 89	Europe	GRS 80
28	European 1950 (ED 50)	Austria, Belgium, Denmark, Finland, France, Germany, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland	International
29	European 1979 (ED 79)	Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland	International
108	European 1987 (ED 87)	Europe	International
125	Fort Thomas 1955	Nevis, St. Kitts, Leeward Islands	Clarke 1880
30	Gandajika Base	Republic of Maldives	International
116	GDA 94	Australia	GRS 80
32	Geodetic Reference System 1967 (GRS 67)	Worldwide	GRS 67
33	Geodetic Reference System 1980 (GRS 80)	Worldwide	GRS 80

Number	Datum	Area Maps	Ellipsoid
126	Graciosa Base SW 1948	Faial, Graciosa, Pico, Sao Jorge, and Terceira Islands (Azores)	International 1924
34	Guam 1963	Guam Island	Clarke 1866
35	GUX 1 Astro	Guadalcanal Island	International
150	Hartbeesthoek 94	South Africa	WGS 84
127	Herat North	Afghanistan	International 1924
128	Hermannskogel	Yugoslavia (Prior to 1990), Slovenia, Croatia, Bosnia and Herzegovina, Serbia	Bessel 1841
36	Hito XVIII 1963	South Chile (near 53°S)	International
37	Hjorsey 1955	Iceland	International
38	Hong Kong 1963	Hong Kong	International
1004	Hungarian Datum (HD 72)	Hungary	GRS 67
39	Hu-Tzu-Shan	Taiwan	International
40	Indian	Thailand and Vietnam	Everest (India 1830)
41	Indian	Bangladesh, India, Nepal	Everest (India 1830)
129	Indian	Pakistan	Everest (Pakistan)
130	Indian 1954	Thailand	Everest (India 1830)
131	Indian 1960	Vietnam	Everest (India 1830)
132	Indian 1975	Thailand	Everest (India 1830)
133	Indonesian 1974	Indonesia	Indonesian 1974
42	Ireland 1965	Ireland	Modified Airy
134	ISTS 061 Astro 1968	South Georgia Island	International 1924
43	ISTS 073 Astro 1969	Diego Garcia	International
1015	Japanese Geodetic Datum 2000 (JGD2000)	Japan	Bessel
44	Johnston Island 1961	Johnston Island	International
45	Kandawala	Sri Lanka	Everest (India 1830)
46	Kerguelen Island	Kerguelen Island	International

Number	Datum	Area Maps	Ellipsoid
47	Kertau 1948	West Malaysia and Singapore	Everest (W. Malaysia and Singapore 1948)
1016	KKJ Finnish	Finland	International
135	Kusaie Astro 1951	Caroline Islands, Federated States of Micronesia	International 1924
48	L.C. 5 Astro	Cayman Brac Island	Clarke 1866
136	Leigon	Ghana	Clarke 1880
49	Liberia 1964	Liberia	Clarke 1880
113	Lisboa (DLx)	Portugal	International
50	Luzon	Philippines (excluding Mindanao Island)	Clarke 1866
51	Luzon	Mindanao Island	Clarke 1866
52	Mahe 1971	Mahe Island	Clarke 1880
53	Marco Astro	Salvage Islands	International
54	Massawa	Eritrea (Ethiopia)	Bessel 1841
114	Melrica 1973 (D73)	Portugal	International
55	Merchich	Morocco	Clarke 1880
56	Midway Astro 1961	Midway Island	International
57	Minna	Nigeria	Clarke 1880
137	Montserrat Island Astro 1958	Montserrat, Leeward Islands	Clarke 1880
138	M'Poraloko	Gabon	Clarke 1880
58	Nahrwan	Masirah Island (Oman)	Clarke 1880
59	Nahrwan	United Arab Emirates	Clarke 1880
60	Nahrwan	Saudi Arabia	Clarke 1880
61	Naparima, BWI	Trinidad and Tobago	International
109	Netherlands	Netherlands	Bessel
31	New Zealand Geodetic Datum 1949 (NZGD 49)	New Zealand	International
62	North American 1927 (NAD 27)	Continental US	Clarke 1866
63	North American 1927 (NAD 27)	Alaska	Clarke 1866

Number	Datum	Area Maps	Ellipsoid
64	North American 1927 (NAD 27)	Bahamas (excluding San Salvador Island)	Clarke 1866
65	North American 1927 (NAD 27)	San Salvador Island	Clarke 1866
66	North American 1927 (NAD 27)	Canada (including Newfoundland Island)	Clarke 1866
67	North American 1927 (NAD 27)	Canal Zone	Clarke 1866
68	North American 1927 (NAD 27)	Caribbean (Turks and Caicos Islands)	Clarke 1866
69	North American 1927 (NAD 27)	Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua)	Clarke 1866
70	North American 1927 (NAD 27)	Cuba	Clarke 1866
71	North American 1927 (NAD 27)	Greenland (Hayes Peninsula)	Clarke 1866
72	North American 1927 (NAD 27)	Mexico	Clarke 1866
73	North American 1927 (NAD 27)	Michigan (used only for State Plane Coordinate System 1927)	Modified Clarke 1866
74	North American 1983 (NAD 83)	Alaska, Canada, Central America, Continental US, Mexico	GRS 80
139	North Sahara 1959	Algeria	Clarke 1880
107	Nouvelle Triangulation Francaise (NTF) Greenwich Prime Meridian	France	Modified Clarke 1880
1002	Nouvelle Triangulation Francaise (NTF) Paris Prime Meridian	France	Modified Clarke 1880
111	NWGL 10	Worldwide	WGS 72
117	NZGD 2000	New Zealand	GRS 80
1010	NZGD 49, 7 parameter	New Zealand	International

Number	Datum	Area Maps	Ellipsoid
75	Observatorio 1966	Corvo and Flores Islands (Azores)	International
140	Observatorio Meteorologico 1939	Corvo and Flores Islands (Azores)	International 1924
76	Old Egyptian	Egypt	Helmert 1906
77	Old Hawaiian	Hawaii	Clarke 1866
78	Oman	Oman	Clarke 1880
79	Ordnance Survey of Great Britain 1936	England, Isle of Man, Scotland, Shetland Islands, Wales	Airy
80	Pico de las Nieves	Canary Islands	International
81	Pitcairn Astro 1967	Pitcairn Island	International
141	Point 58	Burkina Faso and Niger	Clarke 1880
142	Pointe Noire 1948	Congo	Clarke 1880
143	Porto Santo 1936	Porto Santo and Madeiras Islands	International 1924
1000	Potsdam	Germany	Bessel
82	Provisional South American 1956	Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, Venezuela	International
36	Provisional South Chilean 1963	South Chile (near 53°S)	International
83	Puerto Rico	Puerto Rico and Virgin Islands	Clarke 1866
1001	Pulkovo 1942	Germany	Krassovsky
1012	PZ90	Russia	PZ90
84	Qatar National	Qatar	International
85	Qornoq	South Greenland	International
1000	Rauenberg	Germany	Bessel
86	Reunion	Mascarene Island	International
112	Rikets Triangulering 1990 (RT 90)	Sweden	Bessel
1011	Rikets Triangulering 1990 (RT 90), 7 parameter	Sweden	Bessel
87	Rome 1940	Sardinia Island	International

Number	Datum	Area Maps	Ellipsoid
88	Santo (DOS)	Espirito Santo Island	International
89	São Braz	São Miguel, Santa Maria Islands (Azores)	International
90	Sapper Hill 1943	East Falkland Island	International
91	Schwarzeck	Namibia	Modified Bessel 1841
144	Selvagem Grande 1938	Salvage Islands	International 1924
145	Sierra Leone 1960	Sierra Leone	Clarke 1880
146	S-JTSK	Czech Republic	Bessel 1841
1013	SK42	Russia	PZ90
1024	SK95	Russia	PZ90
92	South American 1969	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Venezuela, Trinidad, and Tobago	South American 1969
93	South Asia	Singapore	Modified Fischer 1960
94	Southeast Base	Porto Santo and Madeira Islands	International
95	Southwest Base	Faial, Graciosa, Pico, Sao Jorge, Terceira Islands (Azores)	International
1003	Switzerland (CH 1903)	Switzerland	Bessel
147	Tananarive Observatory 1925	Madagascar	International 1924
96	Timbalai 1948	Brunei and East Malaysia (Sarawak and Sabah)	Everest (India 1830)
97	Tokyo	Japan, Korea, Okinawa	Bessel 1841
1015	Tokyo97	Japan	Bessel 1841
98	Tristan Astro 1968	Tristan da Cunha	International
99	Viti Levu 1916	Viti Levu Island (Fiji Islands)	Clarke 1880
148	Voirol 1874	Tunisia/Algeria	Clarke 1880
149	Voirol 1960	Algeria	Clarke 1880
100	Wake-Eniwetok 1960	Marshall Islands	Hough

Number	Datum	Area Maps	Ellipsoid
101	World Geodetic System 1960 (WGS 60)	Worldwide	WGS 60
102	World Geodetic System 1966 (WGS 66)	Worldwide	WGS 66
103	World Geodetic System 1972 (WGS 72)	Worldwide	WGS 72
104	World Geodetic System 1984 (WGS 84)	Worldwide	WGS 84
105	Yacare	Uruguay	International
106	Zanderij	Surinam	International

Units

The following table lists the available coordinate units and the number used to identify the unit in the micsys.txt file:

Number	Units
6	Centimeters
31	Chains
3	Feet (also called International Feet)*
2	Inches
1	Kilometers
30	Links
7	Meters
0	Miles
5	Millimeters
9	Nautical Miles†
32	Rods
8	US Survey Feet (used for 1927 State Plane)‡
4	Yards

* One International Foot equals exactly 30.48 cm.

† One Nautical Mile equals exactly 1852 meters.

‡ One US Survey Foot equals exactly 12/39.37 meters, or approximately 30.48006 cm.

Coordinate System Origin

The origin is the point specified in longitude and latitude from which all coordinates are referenced. It is chosen to optimize the accuracy of a particular coordinate system. As we move north from the origin, Y increases. X increases as we move east. These coordinate values are generally called northings and eastings.

For the Transverse Mercator projection the origin's longitude defines the central meridian. In constructing the Transverse Mercator projection a cylinder is positioned tangent to the earth. The central meridian is the line of tangency. The scale of the projected map is true along the central meridian.

In creating a Hotine Oblique Mercator projection it is necessary to specify a great circle that is not the equator nor a meridian. MapInfo does this by specifying one point on the ellipsoid and an azimuth from that point. That point is the origin of the coordinate system.

Standard Parallels (Conic Projections)

In conic projections a cone is passed through the earth intersecting it along two parallels of latitude. These are the standard parallels. One is to the north and one is to the south of the projection zone. To use a single standard parallel specify that latitude twice. Both are expressed in degrees of latitude.

Oblique Azimuth (Hotine Oblique Mercator)

When specifying a great circle (Hotine Oblique Mercator) using a point and an azimuth (arc), the azimuth is called the Oblique Azimuth and is expressed in degrees.

Scale Factor (Transverse Mercator)

A scale factor is applied to cylindrical coordinates to average scale error over the central area of the map while reducing the error along the east and west boundaries. The scale factor has the effect of recessing the cylinder into the earth so that it has two lines of intersection. Scale is true along these lines of intersection.

You may see the scale factor expressed as a ratio, such as 1:25000. In this case it is generally called the scale reduction. The relationship between scale factor and scale reduction is:

scale factor = 1-scale reduction

In this case the scale factor would be 1-(1/25000) or 0.99996.

False Northings and False Eastings

Calculating coordinates is easier if negative numbers aren't involved. To eliminate this problem in calculating State Plane and Universal Transverse Mercator coordinates, it is common to add measurement offsets to the northings and eastings. These offsets are called False Northings and False Eastings. They are expressed in coordinate units, not degrees. (The coordinate units are specified by the Units parameter.)

Range (Azimuthal Projections)

The range specifies, in degrees, how much of the earth you are seeing. The range can be between 1 and 180. When you specify 90, you see a hemisphere. When you specify 180 you see the whole earth, though much of it is very distorted.

Polyconic Projection

The following description is copied from "Map Projections – A Working Manual", USGS Professional Paper 1395, by John P. Snyder.

The Polyconic projection, usually called the American Polyconic in Europe, achieved its name because the curvature of the circular arc for each parallel on the map is the same as it would be following the unrolling of a cone which had been wrapped around the globe tangent to the particular parallel of latitude, with the parallel traced onto the cone. Thus, there are many ("poly-") cones involved, rather than the single cone of each regular conic projection.

The Polyconic projection is neither equal-area nor conformal. Along the central meridian, however, it is both distortion free and true to scale. Each parallel is true to scale, but the meridians are lengthened by various amounts to cross each parallel at the correct position along the parallel, so that no parallel is standard in the sense of having conformality (or correct angles), except at the central meridian. Near the central meridian, distortion is extremely small.

This projection is not intended for mapping large areas. The conversion algorithms used break down when mapping wide longitude ranges. For example, WORLD.TAB, from the sample data shipped with MapInfo Corporation mapping products, may exhibit anomalies if reprojected using Polyconic.

More Information on Projections

The first three publications listed are relatively short pamphlets. The last two are substantial books. We've also given addresses and phone numbers for the American Congress of Surveying and Mapping (the pamphlets) and the U.S. Geological Survey (the books).

American Cartographic Association. *Choosing a World Map—Attributes, Distortions, Classes, Aspects*. Falls Church, VA: American Congress on Surveying and Mapping. Special Publication No. 2. 1988.

American Cartographic Association. *Matching the Map Projection the Need*. Falls Church, VA: American Congress on Surveying and Mapping. Special Publication No. 3. 1991.

American Cartographic Association. *Which Map is Best? Projections for World Maps*. Falls Church, VA: American Congress on Surveying and Mapping. Special Publication No. 1. 1986.

John P. Snyder. *Map Projections—A Working Manual.* Washington: U.S. Geological Survey Professional Paper 1395. 1987

John P. Snyder and Philip M. Voxland. *An Album of Map Projections*. Washington: U.S. Geological Survey Professional Paper 1453. 1989.

Contact Information

The Department of Geography at the University of Colorado at Boulder has made available "The Geographer's Craft" project, a website devoted to explanations of map projections, geodetic datums, and coordinate systems. It is particularly valuable because many of the explanations were presented using MapInfo Professional.

The materials may be used for study, research, and education. If you link to or cite the materials below, please credit the author: Peter H. Dana, The Geographer's Craft Project, Department of Geography, The University of Colorado at Boulder.

For geodetic datum information and explanations, go to:

http://www.colorado.edu/geography/gcraft/notes/datum/datum.html

For information on coordinate systems and associated topics, go to:

http://www.colorado.edu/geography/gcraft/notes/coordsys/coordsys.html

For information on map projections, go to:

http://www.colorado.edu/geography/gcraft/notes/mapproj/mapproj.html