Projections

Understanding and Using Projections in Oasis montaj 7.0

Tutorial and Technical Note

Projection

curved earth

"flat" map

GEOSOFT
Oasis montaj

www.geosoft.com
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Projections

Oasis montaj™ features "smart projections" that reprojects data "on-the-fly" as it is displayed. This functionality enables maps to have several views, each containing a different set of projection coordinates. In addition, dynamic links between maps and data are maintained, even if different projections are used.

What is a Map Projection?

A projection is a systematic construction of features on a plane surface (a map) that represents corresponding features on a spherical (or curved) surface (the earth). Projections include actual objects (highways, coastlines) as well as constructs (meridians, political boundaries).

Parts of a Map Projection

Understanding how projections work requires a basic knowledge of the different components. When working with projections, you should be familiar with some terms. The terms below represent different components of a projection:

- **Ellipsoid**: A solid figure (shaped like an egg or oval) for which every vertical cross-section is an ellipse.
- **Spheroid**: A spheroid is an oblate ellipsoid of revolution (basically an ellipsoid) that is used to model the surface of the earth for the purpose of making maps.
- **Datum**: A reference value to which other measurements are referred. Also, an arbitrary reference level to which measurements are corrected. For example, a datum for elevation would be sea level.
- **Local Datum Transform**: A datum adjusted for use in a specific location on the earth. Earth centre offset, rotation, scale factor relative to the WGS84 datum.
- **Projection Method**: The mathematical algorithm used to transform points on a spheroid to their relative locations on a flat surface (i.e. Transverse Mercator, Lambert Conformal).
Understand Geosoft Projections

When dealing with map projections, it is important to be aware that the geographic map location (X,Y) of any objects are either an implied or a known map projection. If you do nothing to define map projections in your data, Oasis montaj will assume that all locations (X,Y) are in the same map projection, which is unknown.

However, you must define map projections if you want to:

- Annotate maps with longitude, latitude locations.
- Convert the location of information (data or grids) from one map projection to another.
- Display information on a map that is in a different map projection.
- Defined a warped coordinate system to fit data to a desired map coordinate system.

If you do not need to do any of these things, you do not have to deal with map projections.

In Oasis montaj, working with map projections requires that the map projection information be attached to coordinate information of a database, grid or map. Once you have attached a map projection to a set of coordinates, Oasis montaj will deal with any re-projections that may be required to properly display data together on maps.

Map projections can be defined for any pair of channels in a database, for a grid coordinate system, and for a data view in a map. In most cases, all that is required is to define the map projection of the "X" and "Y" channels of an original database. This map projection will then be passed on to grids when data is gridded, and map views will inherit this projection when they are created. Map projections of data channels, grids and views can also be viewed and modified at any time, although the modification of map projections does require specific and accurate knowledge of the projection information.

Define a Projection in Oasis montaj

1. In Oasis montaj a projection is always attached or applied to something. This can be a coordinate pair on a database, a grid, or a map view. Before you can apply a projection, you will need to know the following information about your data. The type of projection coordinates that contain the location information for your data:

   - **Projected (x,y)** The coordinates are in a known projected coordinate system, such as UTM, or some other map-based projection.
   - **Geographic (long, lat)** The coordinates are longitudes and latitudes in degrees. Only a datum is required
   - The coordinate subset to use (e.g. UTM, USA State Plane).
   - The units of measurement you want to use (e.g. feet, metres).
   - The Datum (or ellipsoid) to use (i.e. WGS 84 / UTM zone 44N) and local datum to use.

**Important Note:** When you define (or modify) a projection the coordinates of the data (database, grid or map view) remain unchanged. This process only sets the "projection label". However, when
you reproject data into another coordinate system the numerical representation of the coordinates will change.

**Define X, Y Channels**

Once your data has been successfully imported into Oasis montaj you can set the coordinate system and projection information for your database.

One of the first steps in setting a projection is defining your X and Y channels. (This can be done during the import process, or will be automatically set if your coordinate channels are called X and Y by default.) Note that, you cannot create a map until your X and Y channels are defined.

In Oasis montaj we have introduced "current" X and Y (and Z) channels. This feature enables users to select the channels that they would like to use as the current X and Y (and Z) channels (for example, East, North, and Relative Level).

Markers have been added to the channel header to indicate which channels are currently defined to be the "current" X, Y (and Z) channels. The markers are little rectangles on the right side of the header cell, and contain "x", "y" (or "z") in reversed display (like the triangle protection symbol on the left).

When you alter the current coordinate channels, these markers change too. Normally, users will just get "x" and "y", but if you have a "Z" channel it will get the "z". The "z" will be used in Wholeplot databases, where DH_EAST = "x", DH_NORTH = "y" and DH_RL = "z".

*Note:* All grids, maps, and databases derived from a database that has projection information attached to it, will also include the projection information.

**To Define X and Y Channels:**

1. When you first import your data, your X and Y coordinate channels may be called East and North (or any other valid naming system).
2. To define X and Y channels select the Coordinates/Set Current X, Y, Z, Coordinates menu item. The Set current X, Y channels dialog box is displayed.

![Set current X,Y channels](image)

3. Select your X and Y channels (in this example, you would select the *East* and *North* channels) from the database, and click [OK].
4. Your database now has set X and Y channels (titled East and North) which can be seen by the inverse x and y on the right side of the channel header cell.
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Set a Projection to a Coordinate Pair in a Database

The Oasis montaj Coordinate System interface has been redesigned to make creating, editing or viewing projections a simple, one-step process. Oasis montaj uses a single dialog to set and modify projection settings.

The Coordinate System tool also now supports ESRI projection files (PRJ).

**Before you begin...**

To define a projection, you must know the type of projection that is used for the data. If the wrong projection type is specified, Oasis montaj may return strange results or take an unusually long time to process the data.

A projection can be defined from any pair of channels in a database. These two channels must contain coordinate information. Normally, the X and Y coordinate channels are used. Users can define projection from any of the following sources:

- Projected (x,y)
- Geographic (long,lat)
- No Projection
- Copy from channel
- Copy from a grid
- Geosoft PRJ file (projection file)
- ESRI projection files (PRJ).
- Geosoft warp file

**Setting a Projected (x,y) Projection to a Database**

You would use the Projected (x,y) projection if your database coordinates are in a known projected coordinate system, such as UTM, or some other map-based projection.

As an example for this section of the technical note, we imported the “geochem.xyz” file, which can be found in the “../Geosoft/Oasis montaj/data/various” directory, into a new database (geochem.gdb).

**To Set a Projected (X, Y) Projection for Database Channels:**

1. Open a Database (geochem.gdb) that contains at least two channels with coordinate information (X, Y).
2. On the Coordinates menu, click Set Projection. The Georeference database channels dialog is displayed.
3. Select the \textbf{X} and \textbf{Y} coordinate channels that you will use to set the projection, and select \textit{Set as current X,Y?} as \textbf{Yes}, then click the \textbf{[Projection]} button. The \textit{Coordinate System} dialog is displayed. This dialog displays the current projection information for the database. If the database contains no projection information, the \textit{Unknown} radio button is selected in the \textit{Coordinate System} section of the dialog.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{coordinate_system_dialog.png}
\caption{Coordinate System dialog.}
\end{figure}

\begin{itemize}
\item \textbf{Note:} Whenever you work with projections in \textit{Oasis montaj}, the projection information for the current database, grid, or view is displayed in this dialog. When the fields in the dialog are shaded grey, you can only view the information. If the dialog box fields are white, you may edit the values.
\item 4. In the \textit{Coordinate System} section of the dialog, select the coordinate reference system for the data. For example, if the data in your database is organized by \textit{X} and \textit{Y} locations, you would choose the \textit{Projected (x,y)} option, however if the data in your database is organized by \textit{latitude}, \textit{longitude} locations, you would choose \textit{Geographic (long,lat)}.
\end{itemize}
5 The Coordinate System section also includes a [Copy from] button that displays the Copy Coordinate System From dialog.

![Copy Coordinate System From dialog]

6 Use this dialog to copy a coordinate system from another file. The file types supported include, Database, Grid, Geosoft Voxel, Geosoft projection (*.prj), ESRI projection (*.prj), Geosoft warp (*.wrp), Geosoft polygon (*.ply) and GMSYS model.

7 In our case, as our data is organized by X, Y locations we will select the (Projected (x,y)) radio button to set the projection reference system. The appropriate dialog parameters will become enabled.

![Coordinate System dialog]

8 Using the dropdown lists you can select the Datum, Local datum transform and Projection method. Note that, the Local datum transform dropdown list provides all the local datum transforms, which apply to the selected Datum.

9 For our tutorial data, select the following coordinate system parameters:
Datum: **NAD 27**
Local datum transform: [NAD 27] (8m) Canada (Northwest Territories; Nunavut; Saskatchewan

**Projection Method:** Alaska CS27 zone 7

**Note:** If the projection method you want to use does not exist, but you know the parameters for it, you can click the *Projection method* dropdown menu (казано), which along with displaying the *Projection method* information includes a [New] button that displays the *New Projection Method dialog.*

**New Projection Method**

- **Method name:** NewMethod
- **Length units:** US survey foot
- **Projection type:** Transverse Mercator
  - Latitude of natural origin: 54
  - Longitude of natural origin: -162
  - Scale factor at natural origin: 0.9999
  - False easting: 700000
  - False northing: 0

*Use this dialog to create a new (custom) projection method.*

Your *Coordinate System* dialog should now look like the following:
You will note that the *Length units* have been set to match the units used by the projection, in our case *(US survey foot)* and should not usually be changed.

You can use the dropdown menus (») to display the detailed information for each of the coordinate system parameters, as shown below:
If all the projection settings are correct, click [OK] to apply the projection.
Setting a Geographic (Long, Lat) Projection to a Database

You would use a Geographic (long, lat) projection if your database coordinates are in longitudes and latitudes degrees and only a datum is required.

Important Note: When you select a “Geographic (long,lat)” projection the geographic coordinates will be displayed as a Cartesian system with units of degrees. This means that you will not be able to display latitude and longitude annotations in the base map because the X, Y coordinate system of the map will be represented by the long, lat coordinates.

As an example for this section of the technical note, we imported the “projtest.xyz” file, which can be found in the “../Geosoft/Oasis montaj/data/various” directory, into a new database (projtest.gdb).

To set a Geographic (Long, Lat) Projection for a Database:

1. Open a Database that contains at least two channels with geographic (long, lat) coordinate information e.g. (projtest.gdb).

2. Using the Edit Channel dialog (highlight the channel header, right-click and from the popup menu, select Edit), specify the Display Format as Geographic, as shown below:

   ![Edit Channel dialog](image)

   Note: If your Longitude, Latitude channels display double astricks (**), that only indicates that the channels are too narrow to display the data. Widen the channels and the data will be properly displayed.

3. On the Coordinates menu, click Set Projection. The system displays the Georeference database channels dialog box.
Select the X and Y coordinate channels that you will use to set the projection (Note that, in this case the selected X, Y coordinate pair are called Longitude and Latitude) and then click the [Projection] button. The Coordinate System dialog is displayed.

Note: Whenever you work with projections in Oasis montaj, the projection information for the current database, grid, or view is displayed in a dialog box similar to the one above. When the fields in any dialog box are shaded grey, you can only view the information. If the dialog box fields are white, you may edit the values.

Using the Coordinate system radio buttons, select the coordinate reference system for the data. For example, if the data in your database is organized by latitude and longitude locations, you would choose the Geographic (long, lat) option, however if the data in your database is organized by X, Y, you would choose Projected (x,y).
6 In this case, as our data is organized by *Longitude, Latitude* locations and we will select the (**Geographic (long, lat)**) radio button to set the projection reference system. The appropriate dialog parameters will become enabled.

![Coordinate System dialog](image)

7 Using the dropdown lists you can select the *Datum* and *Local datum transform*. Note that, the *Local datum transform* dropdown list provides all the local datum transforms, which apply to the selected *Datum*.

8 For our tutorial data, select the following coordinate system parameters:

   - **Datum:** **NAD 27**
   - **Local datum transform:** 
     
   - **NAD 27** (8m) Canada (Northwest Territories; Nunavut; Saskatchewan

9 Your **Coordinate System** dialog should now look like the following:
You will note that the **Length units** have been set to match the units used by the projection, in our case **(degree POSC)** and cannot be changed.

You can use the dropdown menus to display the detailed information for each of the coordinate system parameters, as shown below:
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12. If all the projection settings are correct, click [OK] to apply the projection.

Define the Map Projection of a Grid

When you create a grid from a database that already has location (coordinate) channels with a defined projection, the projection information in the database is automatically applied to the grid.

Note: To ensure consistency between your databases and grids it’s good practice to define a projection in your database before creating grids from it.

For this example, we are using the “mag.grd” file, which can be found in the “../Geosoft/Oasis montaj/data/various” directory.
TO MODIFY OR DEFINE THE MAP PROJECTION OF A GRID:

1. On the Grid and Image menu, select Properties. The Grid Properties dialog is displayed.

2. Using the Browse button, locate the grid you want to modify. Click the Next button to display the Grid Properties dialog. This dialog reports all of the basic information about the selected grid.

3. Click the Modify button to display the Modify Grid Properties dialog. This dialog displays the information that is used to locate the grid in a real coordinate system. Note that, changing anything in this dialog will have the effect of moving or changing the apparent size of the grid when displayed on a map.
4 Click the [CoordSys] button to modify (or define) the map coordinate system of the grid file.

5 The Coordinate System dialog is displayed. This dialog displays the current projection information for the grid. As this grid has no projection information set, the Unknown radio button is selected.

6 Whenever you work with projections in Oasis montaj, the projection information for the current database, grid, or view is displayed in this dialog box. When the fields in any dialog box are shaded grey, you can only view the information. If the dialog box fields are white, you may edit the values.
7 Using the Coordinate system radio buttons, select the coordinate reference system for the data. In this case, as the data in our grid is organized by Longitude, Latitude locations we will select the (Geographic (long, lat)) radio button to set the projection reference system. The appropriate dialog parameters will become enabled.

![Coordinate System Dialog]

8 Using the dropdown lists you can select the Datum and Local datum transform. Note that, the Local datum transform dropdown list provides all the local datum transforms, which apply to the selected Datum.

9 For our tutorial data, select the following coordinate system parameters:

- **Datum:** NAD 27
- **Local datum transform:** [NAD 27] (8m) Canada (Northwest Territories; Nunavut; Saskatchewan

10 Your Coordinate System dialog should look like the dialog above.

11 You will notice that the Length units have been set to match the units used by the projection, in our case (degree POSC) and can not be changed.

12 You can use the dropdown menus to display the detailed information for each of the coordinate system parameters, as shown below:
If all the projection settings are correct, click [OK] and the Modify Grid Properties dialog will again be displayed. Click the [OK] button to apply the changes to the grid file and the Grid Properties dialog will be displayed. Click the [Exit] button to close the dialog.

Defining the Map Projection of a Map View

In Oasis montaj maps have several views that contain information about the map. Projection information for a map is contained in a data view. Base map information is contained in the base map view.

There are two choices available when you create a new map, from X, Y or from latitude-longitude coordinates. When you create a new map, the system either reads the manually entered coordinates, or scans a users specified database or grid file and attaches their projection and coordinate attributes to the specified map view.
Note: The projected base map created from a latitude-longitude range will be windowed based on lines of latitude and longitude, not X and Y, and the data window will be oriented so that North is up at the centre of the map.

Create a New Map from X, Y Coordinates

Use the *New map from x,y* menu item to create a new blank map to fit the data range specified. The data range can be entered manually, or it can be determined from the range of selected data in a database or from a grid range.

To Define a Map Projection for a New Map from X, Y

1. The first step is to create a new map using the projection coordinates from an existing database or grid. On the *Map Tools* menu, select *New Map|New map from x,y*. The *Data range to map* dialog will be displayed.

2. This dialog shows the data range (coordinate), units and projection information from the last projection that was used. To change the projection information, you will need to scan an existing database or grid for the projection and coordinate information.

   To scan a database for the data range and projection information:
   a. Click the [Scan Data] button.
   b. The system will scan the current database open in your project.
   c. The system will re-display the *Data Range to Map* dialog box showing the new data range, coordinate information and projection information obtained from the database.

   To scan a grid for the data range and projection information:
   a. Click the [Scan Grid] button.
   b. The system will prompt you to specify a grid file that contains projection information.
   c. Select a grid file, and click [OK].
   d. The system will display the *Data Range to Map* dialog box showing the new data range, coordinate information and projection information obtained from the grid.
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3 Click the [Projection] button to view the projection information. The Coordinate System dialog is displayed. This dialog will display the known projection information as defined in the scanned database or grid file. The example below shows the projection information for a map containing no projection information.

![Coordinate System dialog](image)

**Note:** Whenever you work with projections in Oasis montaj, the projection information for the current database, grid, or view is displayed in the Coordinate System dialog. When the fields in any dialog box are shaded grey, you can only view the information. If the dialog box fields are white, you may edit the values.

4 For information on defining a projection using the Coordinate System dialog go to Step 4 of the Setting a Projected (x,y) Projection on page 4.

5 Once the projection has been defined, the Coordinates System dialog will display the projection information. Note to display the Datum, Local datum transform and Projection method details, as shown below, click the dropdown menus (⋯).
6 If all the projection settings are correct, click **OK** to apply the projection and the *Data range to map* dialog will again be displayed.
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7 Click the [Next>] button to continue. The Create a New Map dialog box will be displayed.

8 Specify a Map name for the new map. You can also select a Map template to use for your map layout. To automatically calculate the map scale, click the [Scale] button.

9 The default scale that will fit the defined data range to the specified template will be displayed. You can modify this value to a more appropriate scale (e.g. 60000).

10 Click the [Finish] button when you are done. The system will create a new (blank) map with projection information in the Data View.

New Map from Latitude – Longitude Coordinates

To create a new map from Latitude-Longitude requires a database that has a Projected (x,y) coordinate system.

When using latitude-longitude degrees as the coordinates of your data and/or a geographic projection you need to use New map from x,y menu item. The resulting map will have latitude and longitude displayed in a right angled Cartesian coordinate system.

Note that, with a Projected (x,y) coordinate system, you can display Latitude and Longitude annotations on the basemap of a new map created from x,y coordinates.
TO DEFINE A MAP PROJECTION FOR A NEW MAP FROM LAT/LONG:

1. The first step is to create a new map using the projection coordinates from an existing database or grid. On the Map Tools menu, select New Map|New map from lat,long. The Data range to map dialog will be displayed.

   ![Image of Data range to map dialog]

   - Minimum Longitude: -67.849503
   - Maximum Longitude: -66.508003
   - Latitude: 46.553632
   - Maximum Latitude: 47.286665
   - Make map center N-S: yes
   - Projection: NAD27

2. This dialog shows the data range (coordinates), units, and projection information from the current (selected) database in your project. To change the projection information, click the [Projection] button and the Coordinate System dialog will be displayed.

   To scan a database for the data range and projection information:
   a. Click the [Scan Data] button.
   b. The system will scan the current database open in your project.
   c. The system will re-display the Data Range to Map dialog box showing the new data range, coordinate information and projection information obtained from the database.

   To scan a grid for the data range and projection information:
   a. Click the [Scan Grid] button.
   b. The system will prompt you to specify a grid file that contains projection information.
   c. Select a grid file, and click [OK].
   d. The system will display the Data Range to Map dialog box showing the new data range, coordinate information and projection information obtained from the grid.

Note: After creating a map from Longitude/Latitude the data view of the new map will have a warp attached to it. This is because when we create a Longitude/Latitude map we warp the view so that North is at the top and centred. If you remove the warp on your map, new elements may not be positioned correctly.
Displaying Data with Different Projections on a Map

Since grids, images, data and maps can have different projection information, you may want to display one or more types of projections on a map. The following is a list of data types that you can attach projection information to and place on a map:

- A grid or image
- Located data
- ArcGIS LYR
- ArcView SHP
- MapInfo data
- Vector files such as DXFs
- etc

When displaying different projections on a map:

1. Identify the projection for each data type (i.e. grids, images, maps, or located data). Data types with different projections can be placed on the same map. However, make sure the data cover the same geographical area.

2. Data that is imported into a map is re-projected into the map projection when it is displayed. For example, if you place a grid with latitude/longitude projection coordinates on a map defined in UTM coordinates, the system will display the grid on the map in the map’s projection while preserving the grid’s projection information. In this example, the lat/long meridians on the grid would appear curved, while the UTM meridians would appear straight.

Applying a Warp to a Grid

Warping is useful when you have an un-referenced grid file in an unknown coordinate system or an un-referenced image.

- To relocate data, define one control point.
- To scale and rotate data, define two points.
- To scale in X and Y and rotate, define 3 control points.
- To perform a quadrilateral warp, define 4 control points.

To Define a Warp:

1. On the Coordinates menu, select Georeferencing|Define a Warp. The Warp file Creation dialog is displayed.
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2 Specify an Output Warp file name (.wrp) and from the dropdown lists select the Warp type and Definition Mode. Note that, the 4-point warp requires the points are in a clockwise order. The multi-point warp (more than 4 points) is best for small translations relative to the units of distance on the map.

Note: The Semi interactive mode is a good method, it enables you to select the points on the map that you are warping from (for example, the corners of a bitmap) and then manually input the points (in UTM) that you are translating to. If you find that you cannot accurately select these points, try the other modes (interactive and manual) to enter the four points. Remember, that you can use the right mouse menu to zoom, shrink, and pan around the map while you are selecting the points.

3 Click the [OK] button. The Map projection dialog is displayed, asking if you want to "Define the output coordinate projection".

4 At this stage, you can define the coordinate system of the map, for the purposes of this tutorial, we will click [No] button to continue applying the warp. The Define Warp control points dialog is displayed.

5 This dialog tells you to click on the point location for each point in your warp file, and then specify the new "warped" location in the following dialog. Click the [OK] button to continue.

6 The cursor will change to a crosshair ( ) enabling you to locate the first point. Once you have located the first point, the Assign new coordinate 1 of 4 dialog(s) will be displayed.
7 Specify the New X Y coordinates and click the [Next>] button to specify the next coordinate point location. Continue this until you have specified the 4 coordinates.

**Note:** Temporary circles will be placed on the locations that you select with the crosshair cursor. These circles will be removed once all of the control points have been set and the warp control file has been created.

8 To apply the warp to the grid, on the Coordinates menu, select Georeferencing|Warp a grid. The Warp a grid dialog is displayed.

9 Using the dropdown list, select the Grid file to warp. Using the Browse () button, locate the Warp definition file (.wrp) from your project directory and then specify a New warped grid file. Click the [Next>] button to continue. The New warped grid dialog is displayed.
If all of the parameters are correct, click the [Finish] button to warp the specified grid file.

### Warping Image Files

If you want to warp an image file (i.e. tiff, bmp) and the file is large, you may only want to attach the warp to the file. "Attaching" the warp is suitable if you have a very large file that is stored on a CD, for instance. The warp process is repeated every time you display the file to a projected map but the original file remains unchanged.

When you warp an image, the warped output image must be a Geosoft COLOR grid (*.grd) File type in order to keep the colours of the original image.

If the image of the new warped grid appears twisted or is an incorrect size, check the warp points are in a circular order and the points are correctly located within the defined map area.

### Converting Elevations

The Geoid height menu option enables you to convert GPS elevations to elevations relative to the geoid. Geoid height (GEOID GX) will create a channel of the geoid height relative to the GRS 80 spheroid for a given pair of coordinate channels. This GX requires a grid of the geoid model, which is the elevation of the geoid in metres relative to the GRS 80 spheroid, which is found in the Oasis montaj/etc directory. For more information, see the GEOID GX help topic.
Projection Concepts and FAQs

A "Datum" defines the earth model used to represent the "Geoid", which is effectively the surface that would be defined by the sea level throughout an area being mapped. At this point, we should all understand that the "geoid" undulates according to the gravitational field; hence, it cannot be defined perfectly by a simple mathematical expression. The business of cartography is to map features that exist on a local geoid to a flat piece of paper.

Q 1.) How do we get from a geoid to a map?

A 1.) The first step is the "datum". The datum consists of an ellipsoid, a prime meridian, and a specific part of the earth for which the datum applies. The datum ellipsoid is a perfect mathematical surface that best approximates the shape of the earth over the area of a datum. Latitude, longitude locations on a datum is the closest match of the geoid location to the datum ellipsoid surface. For example, latitude, longitude coordinates on the NAD27 datum use the Clarke 1866 ellipsoid with Greenwich as the prime meridian. One should note that the mapping of the geoid shape to the ellipsoid is not perfect because of the afore-mentioned imperfections in the geoid.

At this point, it is worth pointing out that many datums share the same ellipsoid. The difference between them is that a specific datum only applies to a specific area of the earth, and the geoid of that area is implied by the datum name. For example, "Luzon 1911", "Mound Dillon" and "NAD27" are all datums based on the "Clarke 1866" ellipsoid, but are used to map the geoid from the Philippines, the island of Tobago, and the North (and central) America respectively.

Once we have a longitude, latitude on a specific datum, it is the job of a map projection to convert the latitude, longitude of the round earth to a Cartesian X,Y coordinate for a flat piece of paper.

The next piece of the puzzle is to understand why we need a refinement of the datum into what Geosoft calls "local datums". The advent of GPS and satellite mapping required the definition of a single datum that best approximates the entire earth. After a bit of evolution, we have settled on WGS 84, which is truly a "perfect" datum that represents an exact ellipsoid, and the centre of that ellipsoid is at the gravitational centre of the earth. A fundamental problem in modern cartography is how to convert a latitude, longitude on the WGS 84 datum to, say, NAD27 so that a location can be used on NAD27 maps, or vice versa.

Because datums like NAD27 represent a geoid, and WGS represents a perfect ellipsoid, we need a way to convert the imperfect geoid shape of NAD27 to the perfect WGS27. The best way to do this is to measure the difference between known latitude, longitude locations on the NAD27 datum and the WGS84 location that one receives from a GPS measurement. This has been done throughout Canada to produce the NTv2 model of NAD27, and throughout the United States to produce the NADCON model. This process is also being carried out at continental scale in other parts of the world. Both NTv2 and NADCON are implemented as gridded corrections models, that given a location, one can look up the correction (both are supported in Geosoft).

A second way to make the correction is to force the surface of the WGS 84 ellipsoid to lie as closely as possible to the surface of the datum ellipsoid (which in turn approximates the geoid), such that a simple mathematical conversion is within acceptable accuracy. This can be done by adjusting the location of the
centre of the earth of the datum ellipsoid relative to WGS84, which is the basis of
the Molodenski and Bursa Wolf corrections (parameters are in datumtrf.csv).
However, such simple conversions are only accurate over a relatively small part of
the datum, depending, of course, on the complexity of the geoid of that datum.
For datums that cover a large region, such as NAD27, one needs many different
adjustments depending on which part of the NAD27 datum you are on. For
example, the very large area approximations such as "MEAN Canada" are much
less accurate in the Yukon than "Canada (Yukon)". Both are less accurate than the
NTv2 correction lookup.

Q 2.) When I buy a topographic map of Canada (of say B.C.) it says it uses the
NAD27 ellipsoid. It doesn't say what local transformation it uses?

A 2.) First, NAD27 is a datum, not an ellipsoid, and the NAD27 datum uses the
Clarke 1866 ellipsoid. You must choose which local datum transform is most
appropriate for your needs. We would recommend always selecting the local
transform that is most specific to your area, in this case "[NAD27] Canada
Alberta; British Columbia". You could also choose "[NAD27] Canada NTv2 (20
min)" if the highest accuracy is required, but this is slower and more demanding
of system resources.

In our "Datum" list, we also include the names of all the common earth ellipsoids
(with a "*" prefix). This is because practitioners have commonly confused
ellipsoids with datums, and one often only knows the ellipsoid. By including the
ellipsoid names in the list, we make life a bit easier for you when you receive a
map and the information that it is "Clarke 1850, UTM 42S". However, if you need
to do a local datum transform, you must determine (or guess) at the real datum
name, which is also why we list the local transforms by area of use.

Q 3.) I found where the ldatum.csv file calls the datum for say [NAD 27] Canada
(Ont.&Man.) but couldn't find the call to the appropriate datum for [NAD27]
Canada (BC/AB). Did I just not look hard enough?

A 3.) Yes, these transforms are in the tables. When maintaining the tables, we
load the tables into Excel and use the Data/Sort function to sort by datum or area
of use (or any column) to help find things. The ldatum.csv file is used only by the
projection wizard to provide a list of the available projections by datum and by
area of use. This file refers to the actual local datum transform name and
parameters in "datumtrf.csv". Note that, the tables are only used to construct the
projection information the first time something requires a projection. Once
constructed, the parameters become part of the object in question, and changing
the tables later has no effect.

You can find more information on how the tables are constructed and related in
the Coordinate System help.
Understanding Spheroids and Datums

Spheroids

A spheroid is an oblate ellipsoid of revolution (basically an ellipsoid) that is used to model the surface of the earth for making maps. A spheroid is defined by an earth radius, which is the major axis of the ellipsoid, and the flattening (f), which can also be expressed as the eccentricity (e) or ellipticity (l).

\[
\begin{align*}
  l &= \frac{1}{f} \\
  e &= \sqrt{\frac{2}{l} - \frac{1}{(l^2)}} \\
  e &= \sqrt{2f - f^2}
\end{align*}
\]

In the past, as cartographers created maps of different parts of the earth, spheroids were chosen to best approximate the shape of the earth in the region of the map. This led to a number of different spheroids or ellipsoids (such as Clarke 1866, Hayford 1910, etc.) that are in common use for different parts of the world.

In some cases, maps of a particular region of the earth have been created with different spheroids and it is necessary to convert coordinates from one spheroid to another. This only works if both spheroids share the same earth centre, which they normally will for older maps. This is because map survey work has normally used gravity as the reference for the earth centre, and maps of the same area will clearly have used the same gravity field.

Datums

The problem with using spheroids alone to define an earth model becomes apparent when working with satellite locations from GPS receivers. GPS systems commonly base locations on a spheroid known as World Geodetic System 1984 (WGS 1984), which naturally places the centre of the earth at the true centre of gravity. Unfortunately, this differs from the earth centre that has been used for most local maps of the world because these maps use an assumed earth centre based on the local gravity field, which is perpendicular to the geoid at that location.

To account for this we need a **datum**. A datum includes a spheroid and an earth centre offset from WGS 1984. Some datums may also include a rotation of the minor axis of the spheroid relative to WGS 1984. Datums for various countries and regions of the world have been compiled and defined in the MAPPROJ.DTM file.

**What does this mean?**

What this means is that longitude/latitude in one datum is not necessarily the same as in another datum (there may be an offset and rotation). Before the earth centre was introduced, all we needed was a spheroid (ie. Hayford 1910). This worked fine for projections within the same country or region of the earth because the earth centre was the same. Note that Hayford 1910 is not a datum, it is a spheroid. If the spheroid alone is specified, an earth offset (X,Y,Z) of (0,0,0) with no rotation (see MAPPROJ.DTM) is required.
Understanding and Using Projections in Oasis montaj

Working with Spheroids and Datums

A common mistake that is made when using projections in Oasis montaj is to mix projections based on a spheroid with projections that use a datum. For example, you may be in South America and you have data that is defined as using the Hayford 1910 spheroid, and you wish to convert this to a local map datum, say the Brazil Corrego Alegre datum, which is based on the International 1924 spheroid with an earth centre offset of (206, -172.6). In this case, your input projection datum should be HAYF1910 (Hayford 1910), and your output projection datum should be INT1924 (International 1924), NOT 55INT924 (Brazil Corrego Allegre). This is because you only know the spheroid of the input, not the full datum, so you must only use the spheroid of the output system and assume that both coordinates use the same earth centre, which is usually the case.

The only exception is when dealing with GPS locations based on WGS 1984 as the input coordinate. Here, you in fact do know the full datum of the input because all WGS 1984 has a (0,0,0) offset. In this case, specify the input projection as WGS1984 and the output projection as 55INT924.

Understanding Local Datums

Local datum transforms are used to convert coordinates between different map datums. For example, a local datum transform is required to convert longitude, latitude coordinates on the WGS 84 datum to longitude, latitude coordinates on the NAD27 (North American Datum 1927). The difference in location that arises between map datums can be up to several hundred metres.

The key to understanding local datum transforms is an understanding of the geoid and its relationship to a Datum. A geoid is the actual shape of the earth at mean sea level, which is everywhere normal due to the earth’s gravitational force. Because of local and regional variations in the earth’s gravity field, the geoid is not a perfect mathematical form, but rather it has local variations. These variations are illustrated in the following diagram (from Verhoogan, John, Francis J. Turner, Lionel E. Weiss, Clyde Wahrhaftig, William S. Fyfe (1970), The Earth, Holt, Rinehart and Winston, Inc., New York.):

To make maps, an ellipsoid is used to approximate the geoid for a specific region of the world. An ellipsoid is an ellipse rotated about its shorter axis (also called an oblate spheroid), which is what the geoid would be if the mass of the earth were uniformly distributed. A datum is the earth model that is used to map a specific region of the world. A datum includes an ellipsoid (described by the major axis and flattening), the prime meridian (location of 0 longitude, normally Greenwich England), and a tie point, which is the location on the earth at which
the ellipsoid and the geoid are the same for the region that the Datum is used. The ellipsoid and tie point have been chosen so that the differences between the surface of the ellipsoid and the geoid are minimised. Most common mapping operations within the same datum are only concerned with the ellipsoid, which is why an ellipsoid name is often used interchangeably with a datum name.

With the advent of satellites and later the Global Positioning System, it became necessary to define datums tied to the gravitational centre of the earth (as opposed to being tied to a location on the earth’s surface). Such datums are called geocentric, and the most common example is WGS 84. Most of the difference between an earth surface ties datum and a geocentric datum can be described by a shift in the location of the centre of the ellipsoid (the assumed earth centre). However, there can also be a small rotation difference caused by differences in the direction of North, and a scale factor caused by differences between the elevation of the tie point and mean sea level. In addition, local perturbations of the geoid that result from local gravity variations within a Datum will produce additional “residual” differences.

To convert between datums requires knowledge about all aspects of both datums (the ellipsoids, prime meridians and the local perturbations of the Geoid). There are a number of methods used to transform coordinates between datums (see http://www.petroconsultants.com/products/geodetic2.html), although in practice, the following two methods supported in Oasis montaj are the most commonly used:

**Method 1**

The most familiar method is to perform an earth centre shift, rotation and scale, commonly referred to as the Bursa Wolf 7-parameter transform (parameters are X,Y,Z offsets, X,Y,Z rotations and a scale factor). The Molodenski transform is a simplification that deals with three parameters only (X,Y,Z offsets). These transforms are only close approximations to the true perturbations, and datums that cover a large region often require a number of different "local" definitions (for example, NAD27 has at least 6 different transforms to WGS 84).

The Bursa Wolf transform is supported in Oasis montaj. Parameters of the transform are listed in the file "datumtrf.csv" for different local datums, and the file "ldatum.csv" contains a reference list based on the common area of use for each datum transform.

**Method 2**

Some national mapping agencies have carefully measured accurate “residual” differences across a Datum. This is done by measuring the differences between local map coordinates and WGS 84 at numerous locations. Such differences are described by "correction "grids”, which contain longitude, latitude and elevation shifts as a function of location. Examples are NADCON in the US and NTv2 in Canada, both of which are supported in Oasis montaj (NTv2 in Oasis montaj is a 20 minute approximation of the full NTv2 transform). Note that NADCON and NTv2 are not accurately defined for offshore areas and should not be used for offshore mapping purposes.

In Oasis montaj, the residual grids are stored as compressed look-up tables in files with extension ".ll2" in the Oasis montaj/etc directory. The name of the table is found in the square brackets that are part of the local datum transform
Understanding and Using Projections in Oasis montaj

name. For example, the lookup tables used for local datum transform "*NAD27 NTv2 (20 min) [NTv2]" are found in the file "NTv2.ll2".

Note that Bursa Wolf transforms are very much faster than NADCON or NTv2, and will normally be accurate to the sub-metre level for local regions. In future, as more correction grid models are defined, they will be added to the model list.

**Choosing a Local Datum Transform**

A local datum transform is used to convert coordinates between different datums. The most common example of this is the conversion of GPS locations on the WGS-84 datum to a local map datum. The list below shows the options for the *Choose local datum transform* dialog box.

<table>
<thead>
<tr>
<th><strong>Datum</strong></th>
<th>The currently selected datum name is displayed for your information. You must go back to the previous dialog to change the datum.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local datum transform</strong></td>
<td>Select a local datum transform name from the list. Normally, the list will only include known local datum(s) for the Datum specified. If there are no local datum for the datum specified, all datums will be available in the list and the default transform will be &quot;&lt;unknown&gt;&quot;. If you do not know the local datum transform to use, or if you will always be working the same datum, you will want to select the &lt;unknown&gt; option in this box. When this option is applied, no local transform is used.</td>
</tr>
<tr>
<td><strong>[List All]</strong></td>
<td>If the specified datum has a set of known local datum transforms, these will appear in the list by default. However, if you have chosen the wrong datum, and you know the local datum transform, you may choose to list all known local datum transforms.</td>
</tr>
</tbody>
</table>

**Local Datum CSV Files**

Local datum transforms are listed in the files "ldatum.csv", which is the list used by this dialog. The local datum **EPSG/POSC** name is referenced in the "Datum_trf" column of this file, and the "datumtrf.csv" file contains the actual local datum transform parameters. If you add your own custom local datum, it must be added to both files.

Each local datum transform has an associated Datum (such as NAD27). If you choose a local datum transform that is for a datum different from the one selected previously, the datum will be changed. This is allowed, but under normal circumstances it means that there is probably something wrong about the coordinate system you are using. Changing the datum should therefore only be done with caution and an understanding of datum issues.

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1 **EPSG (European Petroleum Survey Group) / POSC (Petrotechnical Open Software Corporation).**
Adding Your Own Local Datum Transform

You cannot add lookup-based local datum transforms. You can add your own 7-parameter local datum transforms to the datum tables. For example, perhaps we want to define a special version of the “Luzon 1911” datum that we have used which is part of the Philippines.

To Add a Local Datum Transform:

1. To add this datum, you need to modify two CSV files in the Geosoft directory using the following information:

   **EPSG datum name**  The name of the datum on which the local transform is based. This should be an accepted EPSG name, one of the datum names listed in the table “datum.csv”. In this case, the datum is “Luzon 1911”.

   **Transform name**  Choose a name that describes the datum. Since your name is not an EPSG name, you must start the name with a “*” character. For example, “*Luzon special”.

   **Area of use**  Describe the area of use so that the transform can be chosen based on the area. For example, “[Luzon 1911] Philippines -special”. By convention, we include the datum name in square brackets at the beginning of each area of use description.

   **dX, dY, dZ**  Translation vector in metres to be added to a geocentric Cartesian coordinate point in the projection to produce WGS 84 geocentric Cartesian coordinates. For example, “-130,-77,-50”. Note that the sign convention is important, and Geosoft conforms to EPSG convention as described here. The inverse sign convention is also in common use elsewhere.

   **rX, rY, rZ**  Rotations in arc-seconds (degrees/3600) to be added to a geocentric Cartesian coordinate point vector in the projection to produce a WGS 84 geocentric Cartesian coordinate vector. The sign convention is such that a positive rotation about an axis is defined as a clockwise rotation of the position vector when viewed from the positive direction of the axis. A positive rotation about the Z axis (Rz) will result in a larger longitude. Most transforms (all Molodenski based projections) will use “0,0,0”.

   **Scale**  The scale correction to be multiplied by the geocentric Cartesian coordinate in the map projection to obtain the correct scale in WGS 84 coordinates. This scale is expressed in ppm so that the actual scale is (1 + scale/1,000,000). For example, “0.225”.

2. Once you have gathered this information, edit the file “datumtrf.csv” (this can be edited in Excel or in a text editor). The first line of the file contains the column header that describes each data field as follows:
DATUM_TRF,CODE,MAPINFO,AREA_OF_USE,DATUM,TARGET,DX,DY,DZ,RX,RY,RZ,SCALE

For the transform described in the example above, the line would be:

"*Luzon special",,,"[Luzon 1911] Philippines - special","Luzon 1911","WGS 84",-130,-77,-50,0,0,0.225

The "CODE" and "MAPINFO" columns are used to reference the EPSG code and MapInfo code when exporting data to these systems. In this case, these codes are not known and are left blank. Unknown MapInfo codes can also be set to “0”. The “WGS84” is specified as the “TARGET” since these transform parameters are relative to WGS84 (by far the most commonly used geocentric datum).

3. Now edit the “ldatum.csv” file and add an entry so that the transform will be visible to the user in the projection wizard dialogue screens. This table contains the following columns:

AREA_OF_USE,DATUM,DATUM_TRF

The new entry would be:

"[Luzon 1911] Philippines - special ","Luzon 1911","*Luzon special"

The DATUM_TRF in this file must match exactly the DATUM_TRF column in the “datumtrf.csv” file.
Oasis montaj Projection Files and Reference Tables

This section is for users who want to develop their own projections or know the details of the projection methods used in Oasis montaj. The section contains information on the various files used by Oasis montaj for projections.

GL Projection Files (*.gi)

Map views and databases have the projection information imbedded in the file.

Oasis montaj stores all the projection information for a particular grid file (.grd) in a GI (.gi) file. For example, the grid file mag.grd, would have an associated projection file named mag.grd.gi.

Important! When copying a grid file to another directory, you must copy any existing (grd.gi) files associated with the data file in order to maintain the projection information for the grid.
Projection Table Files

**Oasis montaj** uses CSV files as lookup tables for projection information. These reference files are described in the list below:

- **areapcs.csv**: Table of projected coordinate systems by their area of use
- **ipj_pcs.csv**: Table of known projected coordinate systems. This table is not directly used by the projection libraries, but it can be used as a reference by GX’s that are constructing projections, and it is used to resolve the datum and projection given an EPSG projected coordinate system code
- **transform.csv**: Table of map transform methods and parameters. New projection methods will be added to this file
- **datum.csv**: Table of EPSG/POSC compliant datums. This table includes MapInfo datum numbers, the area of use and the prime meridian for each datum
- **ellipsoid.csv**: Table of ellipsoid parameters
- **datumtrf.csv**: Table of local datum transforms parameters
- **ldatum.csv**: Table of local datum transforms by area-of-use
- **mapinfo.csv**: Table of MapInfo transform mappings
- **units.csv**: Table of units and factors to convert units to metres
- **esridatumtrf.csv**: Table of Esri datum transforms parameters
- **geosoft_to_esri_fill.csv**: Table of transform parameters from Geosoft to Esri fill sinks

All names in the tables are POSC (Petrotechnical Open Software Corporation) compliant, unless they begin with an *. The asterix usually signifies that the projection is a custom projection.
Projection Name Tables

The following tables are used to define a common set of key parameters for projections and units used in GXF. The first column of each table is a key name, which is unique within each table. Key names that are not POSC compliant start with an (asterisk) character.

Table 1: Projection Transformation Methods

This table identifies all defined projection transformation methods. The parameters are listed in the order required in the #MAP_PROJECTION data object.

This table was compiled using EPSG (as of 2000/12/28) as data sources. The order of parameters is based on the enumerated parameter order specified in the EPSG table "TRF_METHOD", with unused parameters omitted. Should EPSG add new methods in the future, GXF support for those methods implied, and order of required parameters will be as defined by EPSG.

EPSG "Transverse Mercator (South Orientated)" is the same as POSC "Transverse Mercator (South Oriented)", which corrects the spelling of "Oriented".

Parameter Notes:
  - All distance references must be specified in metres.
  - All geographic references (latitudes and longitudes) are specified in degrees.
  - Longitudes in the Western hemisphere are negative.
  - Latitudes in the Southern hemisphere are negative.
  - Longitudes are relative to the prime meridian of the datum

<table>
<thead>
<tr>
<th>Projection method</th>
<th>Required parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geographic</strong></td>
<td>No parameters. This indicates that coordinates are longitudes and latitudes.</td>
</tr>
<tr>
<td><strong>Hotine Oblique Mercator</strong></td>
<td>Latitude of projection centre</td>
</tr>
<tr>
<td></td>
<td>Longitude of projection centre</td>
</tr>
<tr>
<td></td>
<td>Azimuth of initial line</td>
</tr>
<tr>
<td></td>
<td>Angle from Rectified to Skew Grid</td>
</tr>
<tr>
<td></td>
<td>Scale factor on initial line</td>
</tr>
<tr>
<td></td>
<td>False Easting</td>
</tr>
<tr>
<td></td>
<td>False Northing</td>
</tr>
<tr>
<td><strong>Laborde Oblique Mercator</strong></td>
<td>Latitude of projection centre</td>
</tr>
<tr>
<td></td>
<td>Longitude of projection centre</td>
</tr>
<tr>
<td></td>
<td>Azimuth of initial line</td>
</tr>
<tr>
<td></td>
<td>Scale factor on initial line</td>
</tr>
<tr>
<td></td>
<td>False Easting</td>
</tr>
<tr>
<td></td>
<td>False Northing</td>
</tr>
<tr>
<td>Projection Type</td>
<td>Parameters</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Lambert Conic Conformal (1SP)</td>
<td>Latitude of natural origin, Longitude of natural origin, Scale factor</td>
</tr>
<tr>
<td></td>
<td>at natural origin, False Easting, False Northing</td>
</tr>
<tr>
<td>Lambert Conic Conformal (2SP)</td>
<td>Latitude of first standard parallel, Latitude of second standard parallel,</td>
</tr>
<tr>
<td></td>
<td>Latitude of false origin, Longitude of false origin, Easting at false origin,</td>
</tr>
<tr>
<td></td>
<td>Northing at false origin</td>
</tr>
<tr>
<td>Lambert Conformal (2SP Belgium)</td>
<td>Latitude of first standard parallel, Latitude of second standard parallel,</td>
</tr>
<tr>
<td></td>
<td>Latitude of false origin, Longitude of false origin, Easting at false origin,</td>
</tr>
<tr>
<td></td>
<td>Northing at false origin</td>
</tr>
<tr>
<td>Mercator (1SP)</td>
<td>Latitude of natural origin, Longitude of natural origin, Scale factor</td>
</tr>
<tr>
<td></td>
<td>at natural origin, False Easting, False Northing</td>
</tr>
<tr>
<td>Mercator (2SP)</td>
<td>Latitude of first standard parallel, Longitude of natural origin, False</td>
</tr>
<tr>
<td></td>
<td>Easting, False Northing</td>
</tr>
<tr>
<td>New Zealand Map Grid</td>
<td>Latitude of natural origin, Longitude of natural origin, False Easting,</td>
</tr>
<tr>
<td></td>
<td>False Northing</td>
</tr>
<tr>
<td>Oblique Stereographic</td>
<td>Latitude of natural origin, Longitude of natural origin, Scale factor</td>
</tr>
<tr>
<td></td>
<td>at natural origin, False Easting, False Northing</td>
</tr>
<tr>
<td>Projection Type</td>
<td>Key Parameters</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>----------------</td>
</tr>
</tbody>
</table>
| Polar Stereographic               | Latitude of natural origin  
                                 | Longitude of natural origin  
                                 | Scale factor at natural origin  
                                 | False Easting  
                                 | False Northing  |
| Swiss Oblique Cylindrical         | Latitude of projection centre  
                                 | Longitude of projection centre  
                                 | Easting at projection centre  
                                 | Northing at projection centre  |
| Transverse Mercator               | Latitude of natural origin  
                                 | Longitude of natural origin  
                                 | Scale factor at natural origin  
                                 | False Easting  
                                 | False Northing  |
| Transverse Mercator (South Oriented) | Latitude of natural origin  
                                 | Longitude of natural origin  
                                 | Scale factor at natural origin  
                                 | False Easting  
                                 | False Northing  |
| Equidistant Conic                 | Latitude of first standard parallel  
                                 | Latitude of second standard parallel  
                                 | Latitude of false origin  
                                 | Longitude of false origin  
                                 | Easting at false origin  
                                 | Northing at false origin  |
| Polyconic                         | Latitude of false origin  
                                 | Longitude of false origin  
                                 | Scale factor at natural origin  
                                 | Easting at false origin  
                                 | Northing at false origin  |
Table 2: Length Units

The following table is compiled from the UNIT_OF_LENGTH table in the EPSG tables. The unit names are the abbreviations defined in POSC. This table is for convenient reference only, and the EPSG table is considered the primary reference.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
<th>Factor to metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>metre</td>
<td>1.0</td>
</tr>
<tr>
<td>ft</td>
<td>foot</td>
<td>0.3048</td>
</tr>
<tr>
<td>ftUS</td>
<td>US survey foot</td>
<td>0.3048006096012</td>
</tr>
<tr>
<td>ftMA</td>
<td>modified American foot</td>
<td>0.3048122529845</td>
</tr>
<tr>
<td>ftCla</td>
<td>Clarke's foot</td>
<td>0.3047972651151</td>
</tr>
<tr>
<td>ftInd</td>
<td>Indian foot (Clarke)</td>
<td>0.3047995102481</td>
</tr>
<tr>
<td>ftSe</td>
<td>foot (Sears)</td>
<td>0.3047994715387</td>
</tr>
<tr>
<td>lkCla</td>
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