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Understanding Mapping Coordinate Systems

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At some point, all users of the geographic information system (GIS) or global positioning system (GPS) will have to wrestle with recognizing and understanding different coordinate system formats. The purpose of this publication is to help you understand how the four most common coordinate systems work, how to recognize them and how to convert coordinates between the formats.

The kind of mapping most GIS and GPS users do involves locating things on a round (or reasonably round) surface of the globe. Whether this is done electronically or with paper maps, a system of degrees measured along circles of latitude and longitude is often used. Because the ancient Babylonians were among the first real geniuses at geometry, we have long since based our geography math on their discoveries.

The Babylonian calendar was based on the fact that there were 360 days in a year. Consequently, the complete arc of a circle was said to have 360 degrees (one degree equals one day). While this was a great observation by the Babylonians, it creates some seemingly difficult math problems for many people.

Coordinates rarely seem to fall exactly on a whole degree. Consequently, partial degrees have to be expressed in base 60 math. There are two methods for expressing a partial degree. The first method divides each degree into 60 minutes (1° = 60'), then each minute into 60 seconds (1' = 60"). The second method expresses the partial degree as a fraction or decimal.

Before we get into the math behind different coordinate system formats, it's important to be able to recognize them. The three most commonly used formats are:

Format Type	Example Coordinate (all are same position)
Degrees, Minutes, Seconds (DMS):	61° 34'15"
Decimal Minutes (DM):	61° 34.25'
Decimal Degrees (DD):	61.5708°

Degrees are usually represented with the degree (°) symbol. Minutes are usually represented with the (') symbol. Seconds are usually represented by the (") symbol. We say "usually" because sometimes people substitute spaces for the symbols. For example:

61° 34' 15" can be the same as 61 34 15
61° 34.25' can be the same as 61 34.25

The key for knowing the difference is watching for the presence of a decimal in the coordinate string. If there is no decimal, it is DMS. If the decimal immediately follows the minutes coordinate (61° 34.25' or 61 34.25) then it's DM. If the decimal immediately follows the degrees coordinate (61.5708) then it's DD.

Just when you thought this was going to be simple, there are decimal seconds. In higher accuracy mapping situations, the "partial" second can be expressed as a decimal. For example, 61° 34' 14.88" is still in the DMS format. It's just a much more accurate coordinate. Again, the key is watching for the location of the decimal. In this case, it immediately followed the seconds coordinate.

Converting DMS to DM and DD

To convert degrees, minutes, seconds (DMS) to decimal minutes (DM) and/or decimal degrees (DD), follow these steps:

Step one: Convert the seconds to a fraction. Since there are 60 seconds in each minute, 61° 34' 15" can

be expressed as 61° 34' 15" /60' (you are dividing 60 into 15). The result in DM is 61° 34.25'.

Step two: Convert the minutes to a fraction. Since there are 60 minutes in each degree, 61° 34.25' can be expressed as 61° 34.25'/60° (you are dividing 60 into 34.25). The result in DD is 61.5708°.

Converting DD and DM to DMS

To convert decimal degrees (DD) to degrees, minutes, seconds (DMS), reverse the process above.

Step one: Subtract the number of degrees and convert the fraction to minutes. Multiply the decimal of a degree by 60. The whole number of the answer is the minutes.

S**tep two:** Subtract the minutes from the answer.

Step three: Convert the decimal number remaining to seconds. Multiply the decimal by 60. The whole number of the answer is the seconds.

Step four: If there is a decimal remaining, write it down as the fraction (decimal) of a second.

For example, convert 61.5708° to DMS.

61.5708 – 61° = 0.5708°	61 is the degrees (°)
0.5708° × 60' = 34.248'	34 is the minutes (')
0.248' × 60" = 14.88"	14.88 is the seconds (")

And the result is 61° 34' 14.88"

Recognizing UTM coordinates

There is another coordinate system commonly used and it differs greatly from a system based on 360 degrees in a circle. It is known as the universal transverse mercator (UTM) system. Describing how the system works is the topic of another paper, but in short, it's like this:

The UTM coordinate system divides the globe into 60 zones (starting at longitude 180° or approximately the International Date Line) that extend from 80 degrees south to 84 degrees north. Each zone consists of six degrees of longitude and eight degrees of latitude. The zones most Alaskans will be interested in are one through nine.

Within each zone there is a starting reference point from which a location is determined. A coordinate for a location is expressed in meters to the east (easting) and to the north (northing). The easting coordinate is in reference to the center line of the zone and is referred to as the central meridian.

Latitude is also divided into zones, but with letter designations instead of numbers. The Alaska zones are W and V. Most Alaskans live in zone V. For example, the UTM coordinates for Palmer, Alaska are:

06 V 0386720 easting
6829202 northing

So Palmer, Alaska, is 386,720 meters west of the central meridian and 6,829,202 meters north of the equator. Unlike a degree-based coordinate system, the UTM coordinate system makes it easy to mentally calculate the exact location of a coordinate.

Converting from DD, DMS or DM to UTM or vice versa

Converting degrees to UTM or vice-versa is complicated. Fortunately, there are websites that will perform these conversions for you. A simple way to handle a field situation where you need to do this is to input the coordinates into a GPS receiver and change the coordinate format to the desired output in the receiver's setup.

www.uaf.edu/ces or 1-877-520-5211

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